Nature-Inspired Optimization Algorithms

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Nature-Inspired Optimization Algorithms

Recent Advances in Natural Computing and Biomedical Applications

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Preface

This book begins with the basics about nature-inspired optimization techniques and introduces the methodologies, processes and analytics associated with the same. Due to the evolution and knowledge discovery of natural computing, related meta-heuristic or bioinspired algorithms have gained increasing popularity in the recent decade because of their significant potential to tackle computationally intractable optimization dilemma in medical, engineering, military, space and industry fields. The main reason behind the success rate of nature-inspired algorithms has the capability to solve the nondeterministic polynomial time-hard problems. The nature-inspired optimization techniques provide adaptive computational tools for the complex optimization problems and diversified engineering applications. This book focuses on the involvement of data mining and intelligent computing methods' state of the art and recent advances in applications and algorithms of nature-inspired computing or bioinspired hybrid algorithms related to any discipline of science, engineering and technology. The proposed meta-heuristic or nature-inspired techniques should be an enhanced, hybrid, adaptive or improved version of basic algorithms in terms of performance and convergence metrics. This is an exciting and emerging interdisciplinary area in which a wide range of theories and methodologies are being investigated and developed to tackle complex and challenging problems. Application-oriented papers are expected to contain a deep analytic evaluation of the proposed solutions. The book further illustrates the possible challenges in its applications and suggests ways to overcome them. The topic is wide in nature, and hence, every technique and/or solution cannot be discussed in detail. The primary emphasis of this book is to introduce different optimization techniques, applications, challenges, and concepts to researchers, students and academicians at large.

Objective of the book

The main aim of this book is to provide a detailed understanding of natural computing with distinct optimization algorithms and focus on its applications in the field of computer science. This book endeavors to endow with significant frameworks and the latest empirical research findings in the area of optimization techniques to foster interdisciplinary works that can be put to good use.

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Organization of the book

The book is organized in nine chapters with the following brief description:

1 Selecting and assessing the importance of malware analysis methods for web-based biomedical services through fuzzy-based decision-making procedure

Malware is penetrating the current digital world continuously. A prevention mechanism is much required for malware attacks in the biomedical or healthcare industry. This research initiative tries to provide an overview and recent attack statistics of malware issues in the current web-based biomedical applications and services. The chapter discusses a helpful mechanism called malware analysis for preventing malware issues and analyzing the malware analysis approach for better and easy understanding and adoption in the biomedical industry.

2 A medical intelligent system for diagnosis of chronic kidney disease using adaptive neurofuzzy inference system

In this chapter, chronic kidney disease has been detected, which is a deadly and serious disease, by using a neurofuzzy inference system. The main objective of this study is to enhance the accuracy of diagnostic systems used for the recognition of chronic kidney disease. The developed diagnostic system shows better results when compared with a fuzzy inference system with an accuracy of 96%.

3 Contrast enhancement approach for satellite images using hybrid fusion technique and artificial bee colony optimization

In the past, the categorization of images into different categories related to remote sensing is a challenging task. This chapter highlights the satellite image's contrast improvements using hybrid fusion and ant colony optimization approach.

4 Role of intelligent IoT applications in fog computing

This chapter discusses the different analyses and techniques which enable fog computing in solving real-time problems that involve optimization techniques.

5 Energy-efficient routing employing neural networks along with vector-based pipeline in underwater wireless sensor networks

This chapter discusses the energy-efficient routing employing neural networks along with vector-based pipeline in underwater wireless sensor networks. Neural network and weight optimization are used to achieve efficient routing.

6 A review of global optimization problems using meta-heuristic algorithm

Due to local exploitation and global exploration capability, population-based meta-heuristic algorithms are particular for global researches. In this chapter, a review of the performance of the meta-heuristic algorithm in continuous and discrete exploration space and explanation has been examined. The objective of this work is to analyze the performance of meta-heuristic algorithms.

7 Secure indexing and storage of big data

This chapter proposed redundancy prediction over the transmitted huge volume of data. The algorithm makes use of meta information, topical relation in between the file parameters, SHA-2 for signing information and outperforms the high-level prediction when compared with the existing techniques.

8 Genetic algorithm and normalized text feature-based document classification

This chapter proposes a document classification technique where instead of using any prior information or training, classification was done. In this work, probable solutions were updated twice in one iteration step; hence, reaching a good solution was easy.

9 Nature-inspired optimization techniques

This chapter presents the state of the art on some of the most popular optimization techniques widely used presently – ant colony optimization, particle swarm optimization, artificial bee colony and bat algorithm. The authors also suggest a preliminary analysis of the performance of the framework.

Contents

About the editors

Dr. Aditya Khamparia has expertise in teaching, entrepreneurship and research and development of 8 years. He received his Ph.D. from Lovely Professional University, Punjab, in May 2018. He has completed his M.Tech. from VIT University and B.Tech. from RGPV, Bhopal. He has completed his PDF from UNIFOR, Brazil. He has around 45 research papers along with book chapters including more than 15 papers in SCI-indexed journals with a cumulative impact factor of above 50 to his credit. Additionally, he has authored and edited five books. Furthermore, he has served the research field as a keynote speaker/session chair/reviewer/TPC member/guest editor and many more positions in various conferences and journals. His research interest includes machine learning, deep learning, educational technologies and computer vision.

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Prof. Nguyen Nhu Gia received his Ph.D. in computer science from the Hanoi University of Science, Vietnam, and he is vice dean of the Graduate School at Duy Tan University. He has over 17 years of teaching experience and has published more than 40 publications in various conference proceedings and leading international journals. His research interests include algorithm theory, medical imaging, network optimization and wireless security. He was the organizing chair of (Springer LNAI) IUKM 2016 held in Vietnam. He is an associate editor of the *International Journal of Synthetic Emotions* (*IJSE*).

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1 Selecting and assessing the importance of malware analysis methods for web-based biomedical services through fuzzy-based decision-making procedure

Abstract: Malware is continuously penetrating the current digital world. Even more alarming are the statistics that reveal that the biomedical industry is presently the most susceptible target of the attackers. The main reasons behind this disquieting situation of attacks on the biomedical industry are its sensitivity level and impact of harm. Moreover, the high cost of medical records is also a major reason for the upsurge in penetration and exploitation. This scenario calls for an effective prevention mechanism to ward off malware attacks on the biomedical or healthcare industry. This research initiative provides an overview of recent statistics of malware attacks in web-based biomedical applications and services. The study also provides a helpful mechanism called *malware analysis* for preventing malware issues. Further, the study analyzes the malware analysis approach for better and easy understanding and, more importantly, its adoption in biomedical industry. It also provides a ranking assessment/priority assessment of different malware analysis techniques for identifying the most prioritized approach through fuzzy analytic hierarchy process methodology. The study uses a scientifically proven approach for prioritization of analysis techniques and provides a novel idea and path for future researchers.

Keywords: malware, malware analysis, fuzzy logic, AHP, prioritization

1.1 Introduction

Malware is the biggest threat for every web-based industry and service. Malware can be more aptly described as the termite that infests digital systems in the current computer era. From sensitive data manipulation to a system failure condition, malware

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attacks cause all types of damage. The damage percentage is relatively very high in the case of malware exploits when compared with other vulnerability exploits and attacks. A study shows that there has been a sizeable growth of 61% in malicious activities in 2019, when compared with December 2018 [1]. About 61% growth is not small, and the figure reflects the success ratio of malware among the bad actors.

Therefore, an effective and novel security mechanism is necessarily required for preventing malware attacks in every field. The biomedical industry is the recent hot target for bad actors. The impact ratio in biomedical industry is much higher in comparison to other industries. The reason behind this is that new technologies make the production of medicines an accurate and easy process for companies. Every biomedical organization is adopting new web-based production and marketing services to make the process easy and less tedious. Thus, the use of computer and web services in biomedical industry is much higher than in other industries. This gives the attackers ample opportunities to intrude upon highly sensitive data for commercial exploits.

The next section of this chapter discusses the current malware attack scenario in the biomedical industry. The authors of this chapter cite several articles and relevant literature that attempted to outline effective solutions for malware problems. However, a comparative analysis of the attack statistics and the techniques that have evolved till now seem to be ineffective against the very potent malware. The key reason behind this lacuna is the continuous update process in malware creation and implementation.

Hence, this study aims to address the need for a novel and an appropriate approach for pre-malware identification and security layering in biomedical web-based services. To achieve this outcome, the authors' focus is on the malware identification approach called *malware analysis*. Malware analysis is a process of identifying malware and its behavior through various analysis approaches. A study of a security company declares that the false positive rate of malware analysis is 97% in the general analysis process and, thereafter, if any examiner uses some special kind of analysis (after identifying malware class specifically), they can achieve a 100% success ratio [2]. The study tries to establish a novel approach for pre-identification of malware in biomedical web-based applications through malware analysis. The authors of this study have used the fuzzy AHP (analytic hierarchy process) methodology for ranking procedure in malware analysis through which the future researchers can identify the best analysis process and its subprocess for work.

The core objective of the researchers in this study is to provide a better and easy path for malware analysis as an identification approach for malware from a web-based biomedical applications perspective. The study provides a ranking of different malware analysis techniques via fuzzy AHP ranking methodology. Hence, this outcome will be the most useful reckoner for future researchers, because with the help of these rankings, researchers can mold and systematize their work and provide a standard, common, and novel unified malware analysis model.

The first segment of this chapter provides an overview of the present situation in malware attacks and its implications in biomedical industry. The second part of the chapter discusses the malware analysis approaches and its different types for easy understanding of and knowledge on the topic. The third section of the chapter gives an overview of the fuzzy AHP methodology that is used for prioritization assessment. The ensuing section tabulates the calculations enlisted to rank different malware analysis approaches for providing informative knowledge to future researchers. Finally, the authors have discussed the significance and limitations of the chapter. The study concludes by citing future possibilities for research in this domain.

1.2 Need and importance

Currently, malware attacks are at their peak level. The reason for the burgeoning malware attacks is an easy access to the Internet. To draw an analogy, in a beehive, if a honeycomb has a large number of bees in comparison to others, the bear first attacks the larger one and then the small ones. Similarly, since the users are feeding the malware platform with a large amount of data, the attackers target it first for their unethical intentions. The biomedical industry is associated with the most phenomenal and elemental human assets, that is, health. Ever since the industry took on a digital transformation, all data including the highly classified information about the health record of the patients are now stored digitally. Hence, in the current context of data extraction, the industry has become the most prioritized target for data breaches. The cost of medical data on the dark web is also a major lure for the data predators. A report describes that the cost of medical information on a deep/dark web platform, based on the amount and sensitivity of the information, ranges from $1 to $1,000 per record [3]. Before talking about the critical attack scenario and statistics related to the biomedical industries, it is important to understand the overall malware attack scenario for a better understanding.

The situation is not just confined to issues related to the malware attack scenario. There are several other technical and organizational vulnerabilities that are easily exploited by the attackers to invade systems through malware. Any large infrastructure needs more security, and this makes the task of the security practitioners even more challenging. The current digitalization process requires far more enhanced security mechanisms, thus, compelling the experts to invent effective safeguards. Figure 1.1 shows a year-wise graphical representation of the malware attack ratio.

Figure 1.1 describes the year-wise attack statistics of the previous 9 years. The above statistics show that in 2013, the attack ratio of malware rose tremendously, nearly twice what it was in 2012. In 2018, the attack scenario was at its peak level, and if we compare the statistics of 2018 with 2009, there is a 67% growth in the

malware attacks [4]. All these numbers point to massive growth rates and the impact of these attacks is very high.

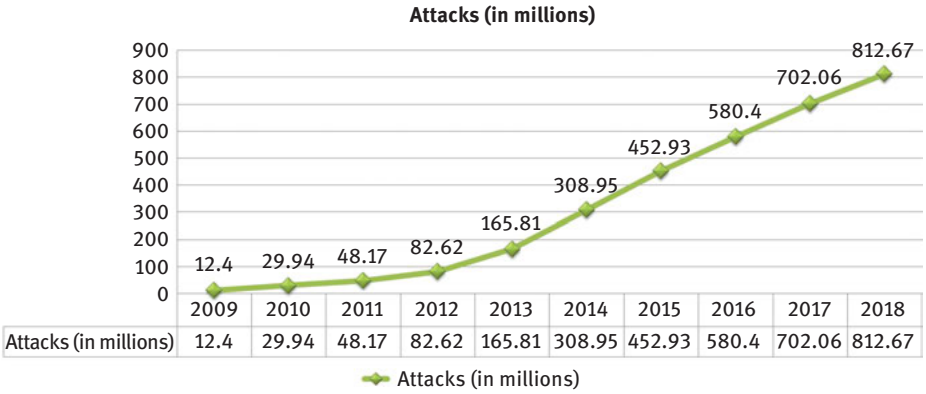

Figure 1.1: Attack ratio (year-wise).

Similarly, if we analyze the malware scenario in the biomedical industry or healthcare industry, the statistics are even worse and worrisome. A survey of the biomedical industry presents data on the targets of the attackers in the last few years. The report shows that 57% of the attacks were implemented through IT infrastructure [5]. The ratio of exploitation of web-based services in the biomedical industry is not a small one. If an examiner compares the exploitation rate and the current cyberattack scenario as well as the criticalness of the biomedical industry, the statistics map is a terrifying nightmare. Manipulation by attacking a biomedical company's database can jeopardize the production of medicines. A wrong proportion of medicine through data manipulation can create an epidemic situation. An analytical report on the medical industry that discusses the attacks cites that the scenario of malware attacks has tripled since 2017 [6].

This dangerous scenario is in imminent need of efficacious solutions. Malware analysis is the only approach that is suitable for the prevention and identification of malware. But malware analysis approach has its implications and complexities. The most common and big implication of malware analysis is the lack of a common malware analysis framework. There is no unified standard malware analysis framework available for the identification and prevention of malware attacks. Hence, this study is an attempt at outlining a malware analysis framework that can be the means for highly accurate identification and containment of malware.

1.3 Malware analysis

Malware analysis is a process of identifying the malicious activity of software or code through various analysis tools and methodologies. In the earlier sections, the authors discussed the success ratio of malware analysis [4] and a few of its normal challenges. Malware analysis has never been used as a security mechanism for preventing malware attacks before. To fill this research gap, our study enlists different categorization of malware analysis approaches in Figure 1.2.

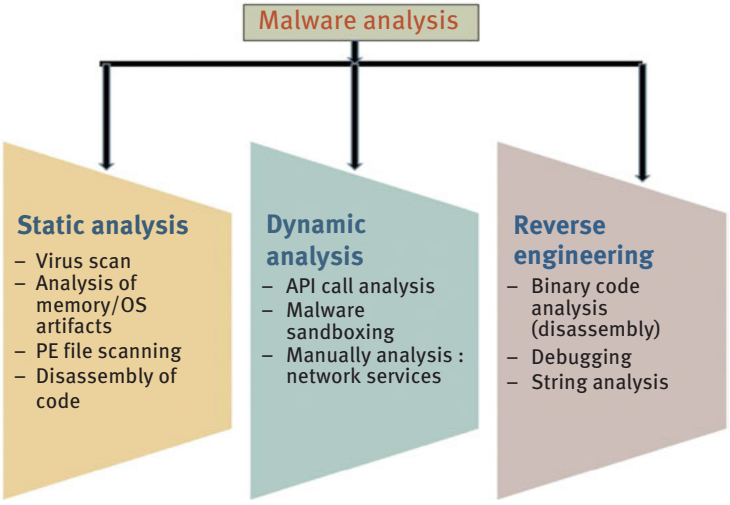

Figure 1.2: Malware analysis approaches.

Figure 1.2 illustrates different malware analysis approaches and the techniques that are used in a specific approach. Malware analysis approaches can be classically categorized into two basic methodologies: (i) static analysis and (ii) dynamic analysis. A third analysis approach that is used as an advanced malware analysis approach is "reverse engineering." For clear and solid knowledge of the topic, the authors have added reverse engineering as a third malware analysis approach in the hierarchy shown in Figure 1.1. A brief explanation of these approaches is given as follows:

Static analysis: Analyzing malware samples without executing them is called "static malware analysis" [7]. The static malware analysis procedure is the primary step that an examiner must take at the initial stage to identify the malicious attribute of the file. Some initial processes that are taken in the static malware analysis procedure are comparing with old databases (virus scan), analyzing memory artifacts of file or code and analyzing the header extension and portable executable examinations. All these

scanning techniques are employed in the resting stage of the malicious file. In simple words, all the examination processes that are described in the static analysis approach are carried out only when the malicious file is not running or active. Many researchers find the static analysis process a useful approach and try to enhance it through various updates. A research study provides a network traffic-based artifact ordering process of analysis of malicious activity over the network [8]. There are several other researchers who consider static analysis as the most useful methodology in all the approaches [7]. A senior researcher and author on advanced malware analysis believes that the manual code analysis of a malware sample is the most useful and effective malware analysis approach of all. However, few research studies also cite that static analysis is not feasible for current malware codes due to their large code size and complexity [7].

***Dynamic analysis*:** Analyzing malicious samples in a controlled environment in running mode is referred to as "dynamic analysis" of malware samples. In the current context, the dynamic analysis approach is the most effectively adopted approach by all researchers and examiners. The reason behind this rapid adoption is the availability of automated tools that makes every work easier and effective when compared with manual analysis [7]. A running malicious sample is dangerous and harmful for the testing system. That is why the examiners strictly recommend a controlled, restricted environment for executing the dynamic analysis. Several researchers prefer employing dynamic malware analysis instead of static analysis. Research proposes a taint sandboxing approach for accurate malware identification and removal [9]. Similarly, many researchers also focus on the dynamic analysis process for effective and better results.

***Reverse engineering process*:** Reverse engineering is an approach that is taken as the last option in malware analysis process by an examiner [7]. In simple words, if the static and dynamic analysis approaches do not provide sufficient evidence and outcomes for taking a decision, then the examiners choose to use a software engineering approach called reverse engineering. Analyzing software or code at a binary level or low-level languages and extracting the malicious activities from a low level are included in this approach. Reverse engineering is not a part of the classical classification malware analysis, but its continuous use and trend have made it a part of malware analysis in the modern classification. Every researcher is now adopting reverse engineering with a classical approach, which is, using reverse engineering with dynamic analysis or static analysis. This is a new trend in the malware analysis industry. This scenario has created a new analysis classification called the "hybrid analysis approach." A hybrid analysis is a combination of two different malware analysis approaches, either static and dynamic, or dynamic and reverse engineering, or static and reverse engineering.

This chapter has proposed a ranking process. This would be an innovative and highly useful reference for researchers to adopt and develop a hybrid malware analysis model for effective outcomes in biomedical applications. The description of different malware analysis approaches provides an initial overview of malware analysis and its different subtechniques.

1.4 Fuzzy analytic hierarchy process

To eliminate the uncertainty and ambiguity of practitioners and academicians, authors have used a hybrid version of AHP (also known as fuzzy AHP), which includes the fuzzy set theory with AHP method in this chapter, to evaluate malware analysis approaches. Before beginning the assessment process, it is most important to comprehend the ranking process through fuzzy AHP. This segment details the technique.

Triangular fuzzy numbers: Lingual data is transformed into perceptible data referred to as "triangular fuzzy numbers (TFNs)." TFNs are used to specify the parameters and make them precise. *M* and *F* are fuzzy numbers and they are called TFNs. The membership equations of *M* and *F* are given as follows:

$$\mu_a(x) = F \rightarrow [0,1] \tag{1.1}$$

$$\mu_a(x) = \begin{cases} \dfrac{x}{\mathrm{mi}-\mathrm{lo}} - \dfrac{b}{\mathrm{mi}-\mathrm{lo}} x \in [\mathrm{lo}, \mathrm{mi}] \\ \dfrac{x}{\mathrm{mi}-\mathrm{up}} - \dfrac{u}{\mathrm{mi}-\mathrm{up}} x \in [\mathrm{mi}, \mathrm{up}] \\ 0 \qquad\qquad \text{Otherwise} \end{cases} \tag{1.2}$$

where lo, mi, and up are defined as a minor, average, and highest limits, respectively, in the triangular membership function. Equations (1.3)–(1.5) help to aggregate TFN values.

Let us assume, *M*1 and *M*2 are two TFNs, $M1 = (\mathrm{lo}_1, \mathrm{mi}_1, \mathrm{up}_1)$ and $M2 = (\mathrm{lo}_2, \mathrm{mi}_2, \mathrm{up}_2)$.

The precedent of activity is written as follows:

$$(\mathrm{lo}_1, \mathrm{mi}_1, \mathrm{up}_1) + (\mathrm{lo}_2, \mathrm{mi}_2, \mathrm{up}_2) = (\mathrm{lo}_1 + \mathrm{lo}_2, \mathrm{mi}_1 + \mathrm{mi}_2, \mathrm{up}_1 + \mathrm{up}_2) \tag{1.3}$$

$$(\mathrm{lo}_1, \mathrm{mi}_1, \mathrm{up}_1) \times (\mathrm{lo}_2, \mathrm{mi}_2, \mathrm{up}_2) = (\mathrm{lo}_1 \times \mathrm{lo}_2, \mathrm{mi}_1 \times \mathrm{mi}_2, \mathrm{up}_1 \times \mathrm{up}_2) \tag{1.4}$$

$$(\mathrm{lo}_1, \mathrm{mi}_1, \mathrm{up}_1)^{-1} = \left(\frac{1}{\mathrm{up}_1}, \frac{1}{\mathrm{mi}_1}, \frac{1}{\mathrm{lo}_1}\right) \tag{1.5}$$

The alpha cut method has been adopted for defuzzification of fuzzified weights in this work. The function of the alpha cut method is shown in the following mathematical statements:

$$\gamma\alpha, \beta\left(\eta_{ij}\right) = \left[\beta.\eta\alpha\left(\mathrm{lo}_{ij}\right) + (1-\beta)\,.\,\eta\alpha\left(\mathrm{up}_{ij}\right)\right] \tag{1.6}$$

where $0 \le \alpha \le 1$ and $0 \le \beta \le 1$ such that

$$\eta\alpha\left(\mathrm{lo}_{ij}\right) = \left(\mathrm{mi}_{ij} - \mathrm{lo}_{ij}\right).\alpha + \mathrm{lo}_{ij} \tag{1.7}$$

$$\eta\alpha\left(\mathrm{up}_{ij}\right) = \mathrm{up}_{ij} - \left(\mathrm{up}_{ij} - \mathrm{mi}_{ij}\right).\alpha \tag{1.8}$$

AHP: It is one of the most important techniques for assessment with multicriteria having multiple levels. It also helps in making decisions in case of multiple conflicting criteria [10]. In daily life, the multiple criteria problems such as selection of one criterion from different criteria can be solved by using AHP.

For assessment, first, methods or attributes of the concerned problem should be identified. Second, a hierarchy of these methods needs to be created. Thereafter, a pair-wise comparison matrix is generated. This matrix is helpful for experts who can refer to it for taking decisions easily. The inputs given by the experts are used for pair-wise comparisons that produce the decision matrix. Number a_{ij} demonstrates the corresponding significance of standard i (A_i) in comparison with standard j (A_j). Saaty proposed a decision matrix that is used in the AHP technique through pair-wise comparisons [11] and is shown in eq. (1.9):

$L_1\ L_2 \ldots\ldots L_n$

$$A = [a_{ij}] = \begin{matrix} L_1 \\ L_2 \\ \vdots \\ L_n \end{matrix} \begin{bmatrix} 1 & a_{11\ldots\ldots} & a_{1n} \\ 1/a_{21} & 1\ldots\ldots & a_{2n} \\ . & . & . \\ . & . & . \\ 1/a_{n1} & 1/a_{n2} & 1 \end{bmatrix} \tag{1.9}$$

where $i = 1, 2, 3 \ldots\ldots\ldots., n$ and $j = 1, 2, 3 \ldots\ldots\ldots\ldots\ldots., n$ and $a_{ij} = 1$: when $i = j$; and $a_{ij} = 1/a_{ij}$: when $i \neq j$; where $\left[a_{ij}\right]$ denotes the corresponding significance of two criteria L_i and L_j. The linguistic scale for membership functions (1 to 9) is given in Table 1.1.

Table 1.1 describes the linguistic rate and defines the corresponding numeric values. After constructing the pair-wise matrix of the expert input, consistency ratio (CR) is calculated to curb the outcome of the AHP technique. CR is calculated with the help of eqs. (1.10) and (1.11):

$$\mathrm{CR} = \frac{\mathrm{CI}}{\mathrm{RI}} \tag{1.10}$$

Table 1.1: Linguistic variable and corresponding numeric value.

S. no.	Linguistic values	Numeric values	Fuzzified numbers (TFNs) $[a_{ij}]$	$1/[a_{ij}]$
1	Equal important (Eq)	1	(1,1,1)	(1,1,1)
2	Intermediate value between equal and weakly (E and W)	2	(1,2,3)	(1/3,1/2,1)
3	Weakly important (WI)	3	(2,3,4)	(1/4,1/3,1/2)
4	Intermediate value between weakly and essential (W and E)	4	(3,4,5)	(1/5,1/4,1/3)
5	Essential important (EI)	5	(4,5,6)	(1/6,1/5,1/4)
6	Intermediate value between essential and very strongly (E and VS)	6	(5,6,7)	(1/7,1/6,1/5)
7	Very strongly important (VS)	7	(6,7,8)	(1/8,1/7,1/6)
8	Intermediate value between very strongly and extremely (VS and ES)	8	(7,8,9)	(1/9,1/8,1/7)
9	Extremely important (ES)	9	(7,9,9)	(1/9,1/9,1/7)

where consistency index (CI) is calculated from eq. (1.11):

$$\mathrm{CI} = \frac{\lambda}{(n-1)} \tag{1.11}$$

where Table 1.2 shows the amount of total responses (n) and random index (RI).

Table 1.2: Random index.

N	1	2	3	4	5	6	7	8	9
Random index	0.00	0.00	0.58	0.90	1.12	1.24	1.35	1.41	1.49

If CR is less than 0.1, then the weight of each input is calculated. The refined pair-wise matrices are arranged, and the process is repeated if CR is greater than or equal to 0. Aggregating the pair-wise comparison matrix is done from eq. (1.12); thereafter, the CR value is verified:

$$m_{ij} = \left(B_{ij1}.B_{ij2} \ldots\ldots\ldots\ldots\ B_{ijk}\right)1/k \tag{1.12}$$

where B_{ijk} shows the decision of expert's k for the significance of two criteria that is L_i and L_j. . The aggregated pair-wise comparison matrix is shown in eq. (1.13):

$$\rho\alpha,\beta.(\tilde{A}) = \rho\alpha,\beta\left[\tilde{a}_{ij}\right] = \begin{array}{c} L_1 \quad L_2 \ldots\ldots\ldots\ldots L_n \\ \begin{matrix} L_1 \\ L_2 \\ . \\ . \\ . \\ . \\ L_n \end{matrix} \begin{bmatrix} 1 & \rho\alpha,\beta(\tilde{a}_{11}) \ldots\ldots & \rho\alpha,\beta(\tilde{a}_{1i}) \\ 1/\rho\alpha,\beta(\tilde{a}_{21}) & 1\ldots\ldots & \rho\alpha,\beta(\tilde{a}_{2i}) \\ . & . & . \\ . & . & . \\ 1/\rho\alpha,\beta(\tilde{a}_{j1}) & 1/\rho\alpha,\beta(\tilde{a}_{j2}) \ldots\ldots & 1 \end{bmatrix} \end{array} \tag{1.13}$$

After aggregating the pair-wise comparison matrix, CR is calculated and verified, again. Determining the eigenvalue and eigenvector of the pair-wise comparison matrix is the next step after calculating CR. Estimation of the eigenvector is significant in determining the aggregated weightage of specific norm. Let us assume that W represents the eigenvector, I represents the unitary matrix and λ represents the eigenvalue of pair-wise comparison matrix $\tilde{A}$ or $[\tilde{a}_{ij}]$, then the equation is

$$\left[\left(\rho_{\alpha,\beta}\times\tilde{A}\right) - \lambda\times\mathrm{I}\right].W = 0 \tag{1.14}$$

where $\tilde{A}$ is a matrix containing the numeric value of $(\tilde{A})$. Equation (1.14) is positioned on the linear metamorphosis of vectors. The eigenvectors are calculated as follows:

$$\left[\left(\rho_{\alpha,\beta}\times\tilde{A}\right) - \lambda\times I\right].W = \begin{bmatrix} 1 & \rho\alpha,\beta\ (\tilde{a}_{11}) \ldots\ldots & \rho\alpha,\beta\ (\tilde{a}_{1i}) \\ 1/\rho\alpha,\beta\ (\tilde{a}_{21}) & 1\ldots\ldots & \rho\alpha,\beta\ (\tilde{a}_{2i}) \\ . & . & . \\ . & . & . \\ 1/\rho\alpha,\beta\ (\tilde{a}_{j1}) & 1/\rho\alpha,\beta\ (\tilde{a}_{j2}) \ldots\ldots & 1 \end{bmatrix} \tag{1.15}$$

For producing an identity matrix, the practitioners need to multiply the eigenvalue λ with the unitary matrix I. For that reason, the notation λI is neglected in this case. Employing eqs. (1.14) and (1.15), the results are shown as follows:

$$\begin{bmatrix} 1 & \rho\alpha,\beta(\tilde{a}_{11}) \ldots\ldots & \rho\alpha,\beta(\tilde{a}_{1i}) \\ 1/\rho\alpha,\beta(\tilde{a}_{21}) & 1 \ldots.. & \rho\alpha,\beta(\tilde{a}_{2i}) \\ . & . & . \\ . & . & . \\ 1/\rho\alpha,\beta(\tilde{a}_{j1}) & 1/\rho\alpha,\beta(\tilde{a}_{j2}) \ldots\ldots & 1 \end{bmatrix} \mathrm{X} \begin{bmatrix} W_1 \\ W_2 \\ . \\ . \\ . \\ . \\ W_n \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ . \\ . \\ . \\ 0 \end{bmatrix} \tag{1.16}$$

By employing eqs (1.1)–(1.16), the weightage of a specific norm has been paralleled with all the other possible norms. The work assesses dependent weights and priorities (ranks) through the hierarchy described in Figure 1.2, after calculating the standalone weights.

1.5 Priority assessment of malware analysis methods

AHP is a more effective approach for taking exact decisions, with the weights for analyzing a decision in a group. Furthermore, AHP has been an important tool that is broadly used to complete priority analysis and is adopted by many practitioners; it is also rapidly used and verified by authors through their previous work [12]. In this chapter, the authors opted for a modified version of AHP known as fuzzy AHP for tackling the uncertainties and ambiguity of human judgment [10].

The authors have chosen 90 experts from different fields of industry and institutions for gathering data. The inputs of 90 experts were collated to assess the malware analysis methods. Figure 1.2 shows the hierarchy of malware analysis methods. Further, for assessing TFNs, eqs. (1.1)–(1.2) are used. After assessing the decisions from the three malware analysis approaches that are shown in Tables 1.3–1.5, the aggregated fuzzy pair-wise comparison matrix is prepared for reference.

Table 1.3 shows the fuzzy aggregated comparison matrix of level 1 that includes static analysis, dynamic analysis and reverse engineering, and is shown here as *M*1, *M*2 and *M*3.

Table 1.3: Fuzzy aggregated pair-wise comparison matrix at level 1.

	***M*1 (static analysis)**	***M*2 (dynamic analysis)**	***M*3 (reverse engineering)**
***M*1**	1.00000, 1.00000, 1.00000	0.23000, 0.28000, 0.36000	0.30000, 0.44000, 0.80000
***M*2**	–	1.00000, 1.00000, 1.00000	0.66000, 1.17000, 1.69000
***M*3**	–	–	1.00000, 1.00000, 1.00000

Table 1.4 shows the fuzzy aggregated pair-wise comparison matrix at level 2 that contains methods such as virus scan, analysis of memory/OS artifacts, PE file scanning and disassembly of code and is shown here as *M*11, *M*12, *M*13 and *M*14.

Table 1.4: Fuzzy aggregated pair-wise comparison matrix at level 2 for static analysis.

	***M*11 (virus scan)**	***M*12 (analysis of memory/OS artifacts)**	***M*13 (PE file scanning)**	***M*14 (disassembly of code)**
***M*11**	1.00000, 1.00000, 1.00000	0.69000, 0.89000, 1.10000	0.23000, 0.28000, 0.36000	0.70000, 0.95000, 1.35000
***M*12**	–	1.00000, 1.00000, 1.00000	0.49000, 0.64000, 1.00000	0.27000, 0.35000, 0.52000
***M*13**	–	–	1.00000, 1.00000, 1.00000	1.00000, 1.32000, 1.55000
***M*14**	–	–	–	1.00000, 1.00000, 1.00000

Table 1.5 shows the fuzzy aggregated pair-wise comparison matrix at level 2 that contains methods such as API call analysis, malware sandboxing and manual analysis: network services and is shown here as *M*21, *M*22 and *M*23.

Table 1.5: Fuzzy aggregated pair-wise comparison matrix at level 2 for dynamic analysis.

	***M*21 (API call analysis)**	***M*22 (malware sandboxing)**	***M*23 (manually analysis: network services)**
***M*21**	1.00000, 1.00000, 1.00000	0.66000, 1.17000, 1.69000	1.15000, 1.44000, 1.70000
***M*22**	–	1.00000, 1.00000, 1.00000	1.00000, 1.52000, 1.93000
***M*23**	–	–	1.00000, 1.00000, 1.00000
***M*24**	–	–	–

Table 1.6 shows the fuzzy combined pair-wise comparison matrix at level 2, which contains methods as binary code analysis, debugging and string analysis and is shown here as *M*31, *M*32 and *M*33. According to the hierarchy, Tables 1.3–1.6 depict the fuzzy aggregated pair-wise comparison matrix at levels 1 and 2. With the help of eqs. (1.6)–(1.16), this chapter used α-cut method for defuzzification and CR values. After that, stand-alone weights of malware analysis methods and CR ratio have been described in Tables 1.7–1.10.

Table 1.6: Fuzzy aggregated pair-wise comparison matrix at level 2 for reverse engineering.

	***M*31 (binary code analysis (disassembly))**	***M*32 (debugging)**	***M*33 (string analysis)**
***M*31**	1.00000, 1.00000, 1.00000	1.19000, 1.58000, 2.15000	0.49000, 0.64000, 1.00000
***M*32**	–	1.00000, 1.00000, 1.00000	0.22000, 0.29000, 0.42000
***M*33**	–	–	1.00000, 1.00000, 1.00000

Table 1.7 illustrates the defuzzified combined pair-wise comparison matrix and local weights of level 1 characteristics through the ordering system described in Figure 1.2.

Table 1.7: Combined pair-wise comparison matrix at level 1.

	*M*1	*M*2	*M*3	Weights
***M*1**	1.00000	1.17300	0.49400	0.27486
***M*2**	0.85252	1.00000	1.17200	0.32959
***M*3**	2.02429	0.85324	1.00000	0.39556
CR = 0.04876				

Table 1.8 illustrates the defuzzified combined pair-wise comparison matrix and local weights of level 2 for static analysis characteristics through the ordering system described in Figure 1.2.

Table 1.8: Aggregated pair-wise comparison matrix at level 2 for static analysis.

	*M*11	*M*12	*M*13	*M*14	Weights
***M*11**	1.00000	0.89200	1.17300	0.99400	0.24632
***M*12**	1.12108	1.00000	0.69100	0.37200	0.18198
***M*13**	0.85252	1.44718	1.00000	1.29800	0.27241
***M*14**	1.00604	2.68817	0.77042	1.00000	0.29929
CR = 0.03485					

Table 1.9 illustrates the defuzzified combined pair-wise comparison matrix and local weights of level 2 for dynamic analysis characteristics through the ordering system described in Figure 1.2.

Table 1.9: Aggregated pair-wise comparison matrix at level 2 for dynamic analysis.

	*M*21	*M*22	*M*23	Weights
***M*21**	1.00000	1.17200	1.36300	0.38428
***M*22**	0.85324	1.00000	1.49100	0.35620
***M*23**	0.73368	0.67069	1.00000	0.25952
CR = 0.00245				

Defuzzified aggregated pair-wise comparison matrix and local weights of level 2 characteristics are described in Table 1.10 on the basis of hierarchy. Total calculated

Table 1.10: Aggregated pair-wise comparison matrix at level 2 for reverse engineering.

	*M*31	*M*32	*M*33	Weights
***M*31**	1.00000	1.63300	0.69100	0.31591
***M*32**	0.61237	1.00000	0.30300	0.17307
***M*33**	1.44718	3.30033	1.00000	0.51102
CR = 0.00521				

weights and assessed ranking of the hierarchy are mapped in Table 1.11. These final and overall weights are assessed based on the hierarchy of malware analysis methods.

Table 1.11: Summary of the results.

Level 1 methods	Local weights of level 1	Level 2 methods	Local weights of level 2	Overall weights	Overall ranks of the methods
***M*1**	0.27486	*M*11	0.24632	0.06770	9
		*M*12	0.18198	0.05002	10
		*M*13	0.27241	0.07487	7
		*M*14	0.29929	0.08226	6
***M*2**	0.32959	*M*21	0.38428	0.12665	2
		*M*22	0.35620	0.11740	4
		*M*23	0.25952	0.08554	5
***M*3**	0.39556	*M*31	0.31591	0.12496	3
		*M*32	0.17307	0.06846	8
		*M*33	0.51102	0.20214	1

According to Table 1.11, the authors have classified different malware analysis approaches and their overall ranks according to the fuzzy AHP method. Table 1.11 shows that method *M*33 has the top rank, so the practitioners should use *M*33 in the malware analysis process in the first phase for better results. Thereafter, method *M*21 has the second highest rank in the table according to the fuzzy AHP process, so the researchers should also *M*21 in phase 1. The researchers can use the ranks of method in creating a hybrid malware analysis process by combining all approaches of the three basic methods of modern malware analysis. Combining all approaches of the three basic methods of malware analysis process (static, dynamic and reverse engineering) through the above ranking can enhance the outcome for future researchers.

Accuracy and timing are key features of any identification model, and combining malware analysis approaches based on fuzzy AHP opens the door for the researchers to achieve that.

1.6 Significance and limitations of work

This study focuses on providing the initial empirically proven first step in order for the future malware researchers to develop a novel approach for standard malware analysis. Using fuzzy AHP for priority assessment enhances the validity of the calculations, and the scientific model that is provided by the authors in this study facilitates that process. The results of the calculation describe that reverse engineering approaches and dynamic malware analysis approaches have secured the top 5 ranks in Table 1.11. This result clearly reflects that researchers should use the dynamic malware analysis approach along with the reverse engineering approach for the desired outcome.

In a nutshell, this study develops a unique standard malware analysis approach ranking that can be used in a constructive manner by researchers.

While the authors have conclusively mapped their findings, a possible limitation of this study is that the chapter does not provide a systematic model for the identification of malware through malware analysis.

1.7 Conclusion and future directions

The core intention of the authors in the research initiative has been to provide an initial path to the researchers for preventing malware issues through a scientifically proven methodology in biomedical applications. To fulfill this aim, the authors selected the fuzzy AHP methodology and used it on malware analysis processes for providing a tabulated outcome in respect of secure web-based biomedical applications. These outcomes provide a possible avenue to the examiners to prepare a feasible technique for malware analysis from a security mechanism perspective. The chapter also discusses different malware analysis approaches and the AHP methodology. Malware analysis is an evolutionary methodology for tackling the malware issue. Use of malware analysis as a security mechanism is not widely adopted currently. But authors strictly believe that the outcomes of the methodology of their study would result in effective evolutions in the biomedical industry as well as in other industries. To summarize, the following nodal points are key reckoners:

The authors' priority assessment results will benefit researchers working in the domain of malware analysis approaches.

Researchers can work specifically on any one analysis process for enhancing the malware analysis process.

This research initiative also provides an idea of current malware issues in the digital era, so the researchers can also find a novel and purely new remedy for preventing malware issues.

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2 A medical intelligent system for diagnosis of chronic kidney disease using adaptive neuro-fuzzy inference system

Abstract: Chronic kidney disease (CKD) occurs when the kidney fails to perform its functions and does not filter or purify the blood accurately. Various factors increase the risks of developing CKD. Hence, to detect this life-threatening disease at the fresh or initial stage, one has to monitor these risk factors regularly before the condition of the individual worsens. In this chapter, the detection of CKD, a deadly and serious disease, is discussed by using an adaptive neuro-fuzzy inference system (ANFIS). The main objective of this study is to enhance the accuracy of the diagnostic systems used for the detection of CKD. The developed ANFIS uses nephron functionality, blood sugar, diastolic blood pressure, systolic blood pressure, age, body mass index and smoking as input variables. The output variable describes the stage of the CKD of a particular patient. The proposed neuro-fuzzy inference system is implemented using the MATLAB software. The developed diagnostic system shows better results, an accuracy of 96% when compared with a fuzzy inference system.

Keywords: adaptive neuro-fuzzy inference system, artificial intelligence, chronic kidney disease, medical diagnostic system

2.1 Introduction

Chronic kidney disease (CKD) is a kidney disease in which the kidneys are damaged and are not able to filter the blood as they are supposed to [1]. The word "chronic" in the name of the disease implies that the kidneys are gradually damaged over a long period [2]. This disease can also cause more problems in the human body. The main operation of the kidney is to purify the blood – filtering the extra water and waste from it – and then convert it to urine. Kidneys also help to balance the salt and minerals such as sodium, calcium and potassium in our body. This helps the organs of the body to work accurately and properly [3]. The kidneys help control the blood pressure of the body, make RBCs strong and hold the bones together. If the kidney disease is not detected earlier, it may lead to kidney damage or kidney failure. Therefore, the sooner the kidney disease is detected in an individual, the

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sooner the person can protect his/her kidney from this threatening and dangerous disease.

Many risk factors are attributed to CKD [4]. In this study, the following risk factors are considered for the diagnosis of CKD:

- Nephron functionality
- Blood sugar
- Diastolic blood pressure
- Systolic blood pressure
- Age
- Body mass index (BMI)
- Smoking

A nephron is the kidney's basic unit which helps to filter out the toxins and waste products as well as remove extra water from the blood and give back the needed molecules to the blood. If the value of nephron functionality is greater than 0.48, then it is in a safe zone.

Blood sugar is the amount of glucose present in the blood of an individual. Blood sugar level is considered normal if it lies between 100 and 140 mg/dL. The blood sugar level varies according to what a person consumes, postexercise and many other factors.

Diastolic blood pressure is the pressure when the heart rests. At this time, the heart gets oxygen and also fills with the blood. It is the bottom or lower number of the blood pressure reading. The normal range of diastolic blood pressure is lower than 80. If the reading is higher than 90, then an individual has high blood pressure.

Systolic blood pressure is the pressure of the heart during the contraction of the heart muscles. The top value of the blood pressure reading is referred to as the systolic blood pressure. A reading of the systolic blood pressure below 120 is normal. It will be considered as high blood pressure if the top value of the reading is above 130.

Age is the duration during which a person or an individual has lived. In other words, age can be the length of life of an individual. The kidney is also affected by age, gradually. Over time, the kidney will not able to operate or performing its task with the same power and immunity.

BMI is the calculation of the amount of a mass by dividing a person's weight divided by the square of height. If the body contains excess fat, then it might be harmful to the person's health. The BMI of a body is considered normal if its value is in the range of 18–25. If the value exceeds 30, then the condition is referred to as "obese."

Smoking is also a risk for the kidney. The kidney is affected by smoke. It allows many toxins to enter the body. According to the Center for Disease Control and Prevention, smoking harms probably every organ of the body. According to the Multiple Risk Factor Intervention Trial (MRFIT), smoke is the major risk factor that affects the kidney and leads to dangerous kidney diseases such as CKD.

2.1.1 The need for the study

India is a country that is still developing; the rate of death is increasing steadily due to deadly and terrible diseases and CKD is one of them [5]. In India, 40–60% of the population suffers from CKD [6]. According to information from the Taiwan Society of Nephrology, there are over 1,100,000 CKD patients in Taiwan and this number is increasing every day [7]. Moreover, the data from the United States Renal Data System (USRDS) discovered that Taiwan has an extreme incidence of end-stage kidney disease when compared with countries around the world. According to the United Nations Children's Emergency, in India, 28% of children have very low weight. This is caused due to lack of nutrition during pregnancy, leading to reduced power of blood filtration and a small volume of kidneys in children. It is estimated that until 2030, 50% of India's population will suffer from CKD. The age of people who suffer from CKD ranges between18 and 98 years in which 55.1% are men and 44.9% are women [8]. This study is all about the analysis and categorization of CKD patients and non-CKD patients in the correct class by using intelligent systems. The study focuses on the detection of CKD at an early stage; hence, the neuro-fuzzy expert system that has been developed gives better results for the detection of CKD.

2.1.2 Artificial intelligence

Artificial intelligence enables the machine to mimic the human, perform tasks and make decisions as the human brain can do. Such an intelligence of the machine is known as artificial intelligence [9]. Artificial intelligence is an integrated domain consisting of many fields such as computer science, mathematics, and neuroscience. The process of artificial intelligence comprises three main steps. First, learning, in which the required information is gathered from the source. This acquired information helps to generate rules. Second, reasoning, in which the generated rules are fired according to the given inputs and the machine gives a definite conclusion that corresponds to the given inputs after mapping all the rules. Third, self-correction, in which the machine corrects itself from the heuristic information. The intelligent system takes inputs and, based on the inputs, gives an output. The knowledge is stored in the memory and this knowledge is analyzed by rules and after analyzing it, the machine upgrades its capabilities. Artificial intelligence is well known in problem-solving fields because it provides a reason as well as the solution to a particular problem given to it by using numerous concepts and methods. An expert system for decision making is a commonly used application of artificial intelligence.

2.1.3 Intelligent system

An intelligent system is a machine with the capability to acquire the required data, analyze that gathered data and can communicate with other systems [10]. One of the common parts of artificial intelligence is expert systems. An expert system is a computer program that deals with imprecise and incomplete data. The expert system can get the knowledge from its experience and can make predication using that knowledge to give probable results by using the process of natural evolution. About 70% of the problems can be solved by using expert systems. The main components of an expert system are:

- Knowledge-based
- Inference engine

Knowledge is collected in the knowledge-based by the knowledge engineer. All the acquired necessary knowledge is stored in it. All facts and rules are generated by using the knowledge stored in the knowledge-based. An expert system should have highly accurate and precise data for correct output.

The inference engine acquires knowledge from the knowledge-based and after manipulating this knowledge, it arrives at a particular solution. In other words, the inference engine uses rules and facts for reasoning and debugging capabilities. The inference engine is responsible for the conclusion or final output that corresponds to given inputs.

2.1.4 Simple rule-based medical expert system

An expert system is usually used in medical diagnosis. The main objective of a medical expert system is to classify the disorders. A medical expert system for diagnosis is the collection of gathered knowledge stored in the knowledge-based and in the program. The result obtained from a medical expert system is similar to the decision by a specialist of that particular problem field. The knowledge of specialists or experts is very important for the development of a medical expert system. The rules of the expert system depend upon the knowledge gathered from the experts. The facts of an expert system consist of two stages. In the first stage, the doctor reports the knowledge or situation from the patient. This may be from the personal interaction between the doctor and the patient. In the second stage, the rules are developed in the form of IF–THEN. In the IF component, there are conditions, and in THEN, there is a result according to the condition. These rules are stated as:

IF. . . . . Symptom 1 AND Symptom 2. . . . . THEN. . . . . .Output.

2.1.5 Fuzzy logic

Fuzzy logic is a technique for estimating values that lie between 0 and 1 or completely false and completely true. In other words, it is a technique to define the logic with fuzzy values. The word "fuzzy" means incomplete and imprecise data.

2.1.6 Fuzzy expert system

The medical expert system for diagnosis using fuzzy logic is the set of rules and membership functions [11]. It is also tilted toward processing using mathematics. It is a developing tool that uses crisp values and then converts them into fuzzy values. It is based on the data processing methodology. This methodology is suitable for problems where there is indefinite and incomplete information and also where it is very difficult to conclude accurately using this information. There are three steps in fuzzy expert systems:

- Fuzzification
- Inference mechanism
- Defuzzification

In fuzzification, the input is given to an expert system in nonfuzzy values and this input is transformed or converted into fuzzy sets or fuzzy values.

In an inference mechanism, the expert system maps the rules according to the given input and after firing a suitable rule, it generates the output in fuzzy value.

In defuzzification, the output generated by the inference mechanism is transformed from fuzzy values to the crisp values.

2.1.7 Neural network

A neural network is a parallel computing device that can perform various computations and arrive at a decision just as a human brain. The main idea behind a neural network is the biological nervous system of humans. It is the set of various interconnected processing elements. A neural network discovers by examples [12]. A neural network is trained for a particular application through a training process. The synaptic weights are adjusted in the training phase for decreasing the error. These adjustments are carried out between the neurons. The error, in the case of a neural network, is the difference between the observed value and the target value. There are three main layers in the neural network: one input layer, one or more hidden layers and one output layer. A neural network is also used for classification by analyzing the given data. It can analyze the difficult and complex patterns that are so difficult to observe by the human brain or other mechanisms. The trained neural

network can be considered as a professional because a trained network can classify the given pattern into the correct and accurate class by analyzing that pattern.

2.1.8 Adaptive neuro-fuzzy inference system

A fuzzy expert system is very suitable for medical applications but after a certain time, the fuzzy inference system is not simple for complex computational problems. This happens because sometimes the membership function, and the rules of the fuzzy inference system become very exhaustive. After that, the need for a learning algorithm in a fuzzy inference system is observed. Hence, a neural network is used to overcome this need by developing a learning algorithm, and the shortcoming of the fuzzy inference system is addressed [13]. Therefore, a hybrid system is developed using a fuzzy inference system to solve those problems that become exhaustive [14]. An adaptive neuro-fuzzy inference system (ANFIS) is a set of two soft computing methods: neural network and fuzzy inference system [15]. The capabilities of a neural network and a fuzzy inference system are merged to develop a hybrid system. The ANFIS is suitable for many domains of information such as data classification, decision-making, data analysis, and pattern recognition. It is also used in medical applications to cure human diseases with better results as compared to a neural network and fuzzy inference system or a fuzzy expert system.

2.2 Background

Kubota et al. [16] proposed a methodology using an image-processing technique in which the kidney failure of a patient has largely been detected in the early stage based on the information obtained from the CT image of using a dynamic grayscale value refinement method. The image of the kidney is segmented into a number of regions to collect correct and accurate information.

Raghavan et al. [17] reviewed on the problems faced by practitioners in managing the data of end-stage CKD. This paper also described the development of decision support techniques that help in the detection of diseases by using information that exists or is stored already in a particular system.

Rovenţa and Roşu [18] developed a medical expert system to diagnose 27 different kidney diseases from 9 different categories. The identification of the kidney disease is carried out by observing the symptoms in the clinical examination and the result obtained in the laboratory test. The system was developed by using Visual Prolog 5.2, which helps the doctor to diagnose the disease more accurately.

Shen et al. [7] developed a low-cost method for dialysis patients. This method is used to identify the risks of cardiovascular disease (CVD) in CKD patients. ECG features

and heart rate variability of a patient were taken into account. It uses the decision-based neural network structure for the feature fusion. The overall accuracy of developing a method for detecting CVD due to CKD is 71.07%.

Adam and Hashim [19] used the artificial neural network (ANN) technique for the detection of early stage kidney problems. This method predicts various symptoms of the kidney problems and then compares these symptoms with the mental behavior of an individual. The ANN is first trained by providing training samples and then tested for the same. The method is proposed by using MATLAB software.

Bondor et al. [4] developed the approach to rank the risk factors of CKD. The data of diabetic patients was analyzed using the TOPSIS method and this data was then compared with other risk factors of CKD. After comparison, all the risks for CKD were ranked in order. This developed approach gave better and accurate results to rank the various risks of CKD.

Ahmed et al. [20] proposed a fuzzy expert system for the diagnosis of CKD. Seven inputs were considered and by using the values of these inputs, a membership function is generated. The rules are developed by using the IF–THEN rules. This method was simulated by using Mamdani fuzzy in Matlab software. The output is predicted by the expert system by using rules and knowledge and it gave similar results as a human expert.

Chetty et al. [21] predicted CKD in an individual by using classification algorithms. This algorithm is a completely different one from other algorithms in classifying patients suffering from CKD and those who are not. The classification method gave better performance if the dataset is reduced.

Dulhare [22] developed a method to detect the CKD stage by using naïve Bayes. The rules in this method are extracted based on the CKD stage. The glomerular filtration rate (GFR) was evaluated to identify the correct stage of the patient suffering from CKD. To prevent the patient from progressing to the further CKD stages, the OneR algorithm was used with naïve Bayes.

Kunwar et al. [23] used the two classification techniques for the prediction of CKD: naïve Bayes and ANN. The results of both algorithms were compared with each other to find out which algorithm gave better and accurate results. The results were implemented in the Rapidminer tool. Based on the result from the Rapidminer tool, the naïve Bayes gave accurate and better results than the ANN.

Avci et al. [24] compared the classification algorithms used in data mining for the detection of CKD. The algorithms that were compared are naïve Bayes, K-star, support vector machine (SVM) and J48 classifiers. The performance of these classifiers is compared according to various parameters such as accuracy, precision, sensitivity and *F*-measure. The results were obtained using the WEKA software, and according to the observed results, the J48 algorithm is the best classifier algorithm among all of them and it has a 99% accuracy.

2.3 Development of neuro-fuzzy system

The medical diagnostic intelligent system for the identification of CKD is proposed by using the neuro-fuzzy technique. The input variables used in this medical diagnostic system are nephron functionality, blood sugar, diastolic blood pressure, systolic blood pressure, age, BMI and smoking. The output variable is the CKD stage. All the input variables have been elaborated in Section 2.1. The relevant input variable data of the CKD patient have been gathered from experts. In the development of the diagnostic system, the input variables are assigned as input1, input2, input3, input4, input5, input6 and input7; similarly, the output variables have been represented as output. Figure 2.1 shows the development of the neuro-fuzzy intelligent system for the diagnosis of CKD.

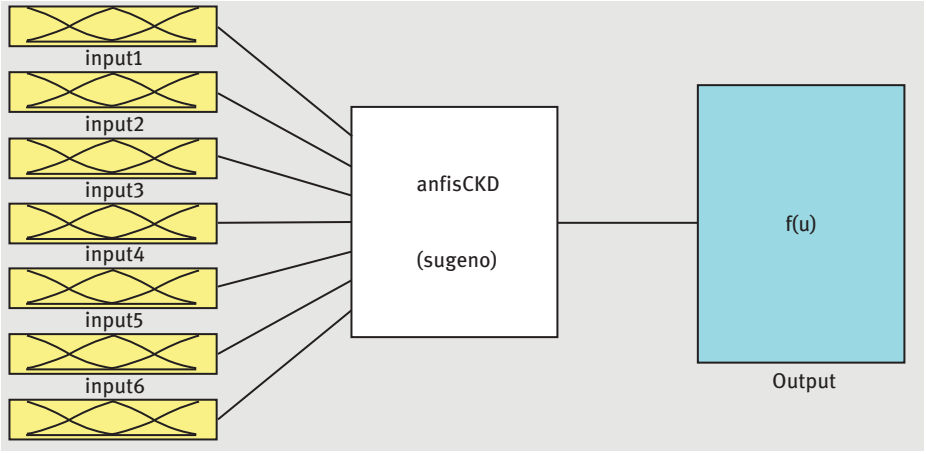

Figure 2.1: Structure of the neuro-fuzzy system.

2.3.1 Membership functions

The triangular membership function is taken for every input variable. Each of input1, input2, input5 and input7 has three triangular membership functions. Similarly, each of input3, input4 and input6 has four triangular membership functions. For example, the input variable "nephron functionality" has been divided into three groups. These three groups are very risky, moderately risky and safe zone. These groups were automatically generated from the dataset of training data. Every group is part of the membership functions for input1, that is, Nephron functionality. Similarly, for the other input variables, the membership functions corresponding to each input variable depend upon the range acquired from the dataset of training samples during the training phase automatically. Figures 2.2, 2.3, 2.4 and

2.5 show the membership functions for input1, input5, input6 and input7, respectively. When the ANFIS is used, all the rules and membership functions of the input and output variables are generated by it. These rules and membership functions are not manually defined; they are automatically generated from the training dataset during the training phase of ANFIS.

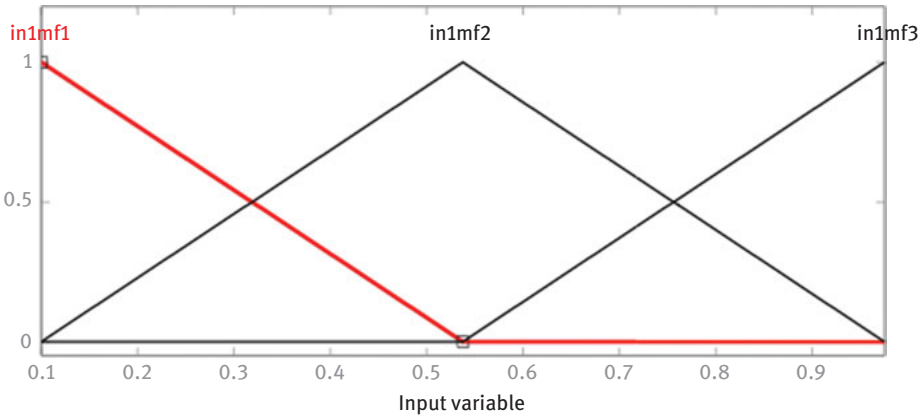

Figure 2.2: Membership function for input1, that is, nephron functionality.

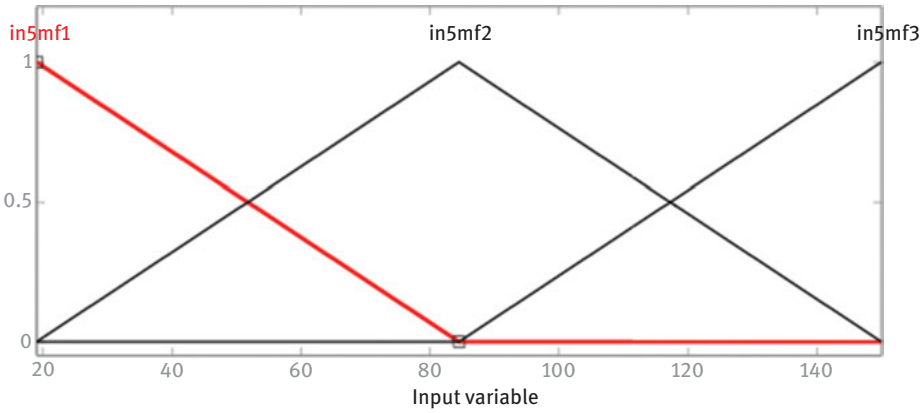

Figure 2.3: Membership function for input5, that is, age.

2.3.2 Rules

The rules in an ANFIS are developed by taking all the possible number of combinations of membership functions of every input variable. The number of rules in the developed ANFIS for diagnosing CKD is 5,184.

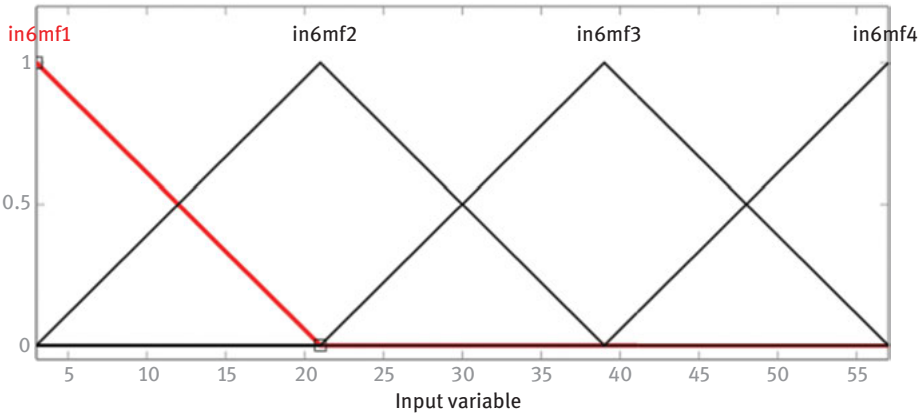

Figure 2.4: Membership function for input6, that is, BMI.

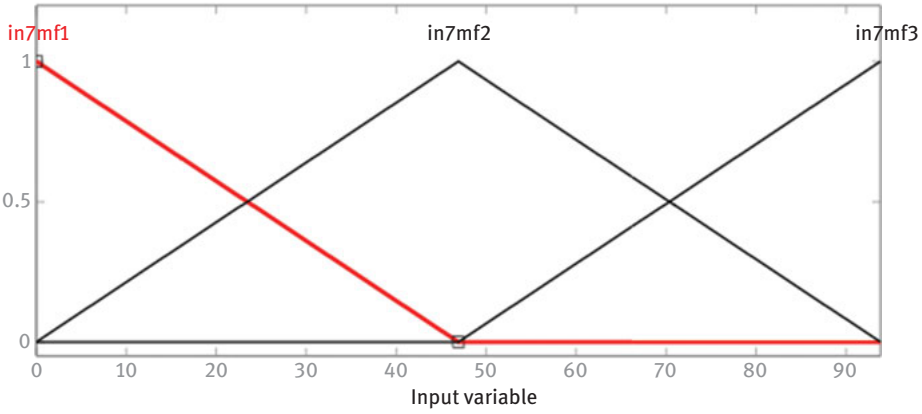

Figure 2.5: Membership function for input7, that is, smoke.

Total number of rules = membership function of input1 × membership function of input2 × membership function of input3 × membership function of input4 × membership function of input5 × membership function of input6 × membership function of input7.

$$\text{Therefore, total number of rules} = 3 \times 3 \times 4 \times 4 \times 3 \times 4 \times 3$$
$$= 5,184$$

2.3.3 Training

This section describes the training phase of an ANFIS. In Figure 2.6, the training error at three epochs is shown. For the training phase of CKD diagnosis, 80% of the dataset is acquired from experts. The hybrid algorithm is used to increase the speed of diagnosing so that the life of a patient can be saved at the early stage of this threatening disease.

2.3.4 Testing and validation

After the training phase, the testing dataset is used. To validate the accuracy of the developed ANFIS for the diagnosis of CKD, the dataset that is not the part of training data is to be used in the testing phase. The remaining 20% of the dataset is taken for testing and validation. This dataset must be different from the training dataset because, in the validation step, it is studied how well the developed ANFIS is trained by the training data to correctly classify new data and give accurate and correct output for an unseen dataset.

Figure 2.6: Training error at three epochs.

2.4 Result

The performance of the ANFIS, professionals compared the output provided by an ANFIS for the diagnosis of CKD with the target values. It is observed that the output provided by ANFIS for the diagnosis of CKD is quite similar to the decision taken by expert doctors or professionals corresponding to the given input or symptoms of an individual suffering from CKD. The performance of the medical diagnostic system using ANFIS models is given in Table 2.1.

Table 2.1: Performance of the developed medical diagnostic system.

S. no.	Disease	Model	Membership function	Sensitivity (%)	Specificity (%)	Accuracy (%)
1.	Chronic kidney disease	Adaptive neuro-fuzzy inference system	Triangular	97.22	92.86	96

2.5 Conclusion

The developed medical diagnostic system for CKD using an ANFIS can help experts as well as nonexperts in the detection of different stages of CKD. This proposed system is like a supportive tool for professionals that helps them to keep their patients stable. The system has been trained by the dataset during the training phase. The performance of the given medical diagnostic system is evaluated by considering various parameters such as sensitivity, specificity and accuracy. After this calculation, it is concluded that the results provided by the developed medical diagnostic system by using an ANFIS are more accurate and correct. This research work is implemented using the MATLAB software. The proposed system can be used in hospitals for the detection of the stage of CKD in a patient. This type of decision-making system is very beneficial for developing countries as the death rate is increasing rapidly due to these deadly diseases.

In the future, medical study and research can identify more risk factors that affect the kidney of an individual, resulting in the use of more parameters for the detection of the CKD stage so that the precious life of a patient can be saved from these types of dangerous diseases by detecting it at early or initial stages.

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3 Contrast enhancement approach for satellite images using hybrid fusion technique and artificial bee colony optimization

Abstract: Image fusion is a combination of two or more images into one image to obtain essential information from the trigger images. The lousy or horrible information found in the resource images is reduced by image fusion. It can be broadly used in healthcare imaging, remote sensing, computer vision and military applications. The achievements of the fusion method are despite the noise within the resource images. An ABC (artificial bee colony) checks satellite-based images better using fusion enhancement by combining two multitemporal satellite images. Due to fusion, an enhanced contrast of images is available in the ABC. A cross-breed variation enhancement approach combines the gamma and histogram equalization modification techniques utilized for enhancing the resource images. In the contrast-enhanced approach, images have to be fused utilizing principal component analysis, discrete wavelet transform and hue, saturation and intensity (HSI) transform techniques individually. The proposed work is comparable to other fusion techniques on quality parameters such as structural similarity index, entropy, feature similarity index metric, peak signal-to-noise ratio and mean square error. The qualitative and quantitative outcomes demonstrate that the HSI image fusion method is well beyond acceptable levels. Therefore, these systems are designed in a computationally simple and efficient manner.

Keywords: hue, intensity, saturation transform, image fusion, histogram equalization, multitemporal gamma correction, principal component analysis, remote sensing

3.1 Introduction

Development is visible in image preprocessing strategies used in diverse sectors such as diagnosis in the medical sector with the aid of X-rays and magnetic resonance imaging, and exploration using satellite images, laptop computer eyesight

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and others. Enhancement-based methods are being used worldwide to improve screen quality. Thus, images can be studied without any loss of information. The most common method for contrast enhancement is histogram equalization. The biggest disadvantage of using this method is the simple fact that it leads to information loss and hence delivers an extremely awful appearance by overenhancing the image [1]. The histogram equalization technique has its drawbacks and, therefore, improvements to the methods of histogram modifications need to be implemented. Improvement to infrared expectations is suggested in the histogram equalization applications. Using the threshold limit, the histogram is split into the foreground and background components [2].

Gamma correction is another preferred way to improve image contrast. Many researchers are utilizing the various improvements produced in gamma correction. It motivates the adoption of an approach that allows the exploration of images in its various forms. In comparison, the output image is much better scanned naturally, especially using histogram equalization [3].

Enhancing the distinction of images can be significantly achieved by the equalization of the histogram related to the images as well as gamma correction. The development range is unlimited and cannot be simplified in a majority of the images [4]. To address the constraint, adjustable enhancement of the images using the popular optimization method called the artificial bee colony (ABC) indicated that the best possible values are chosen within the inadequate beta interface, which ideally corresponds to the curve of the grayscale transformation. While the histogram equalization was the initial method to achieve this objective, it was an enormous challenge to preserve the image's rigorous brightness [5]. The enhancement of the processing facility is accomplished to generalize the approach. This method can preserve the image's moderate brightness [6].

A significant inference from these early approaches is that the same strategy for diverse images does not yield successful outcomes, as the features of the images vary. Such a situation leads to the utilization of a fused strategy that ensures that traditional approaches are combined to produce an optimal performance. A procedure that combines adaptive gamma and histograms with weighted division of equalizing changes is recommended [7]. The above-mentioned boundaries are resolved through an evaluation of the image attributes and an implementation of the improvement strategy that is based on the image features. The main benefit of this specific method is its use in a variety of purposes such as processing of videos and digital photographs due to its constant processing time. Essentially, this approach does not require an iterative strategy. This approach is time-intensive but can produce images very easily that are accurate for outstanding image restoration. Apart from the usual approaches, the functionality of parametric transformation implies contrast development using ABC [8]. The study also introduces additional heat by adding a special method of contrast. The key advantage of this approach, in

comparison to other modern techniques, is its high-speed performance and more aspects of the last image.

A source image from a personal sensor does not provide any information about the function to be analyzed to enhance the individual view and further improve the limits of each single image category [9] by having the images from various receivers. The fused image must be such that the characteristic source images reflect the details and does not include any additional items that can confuse the viewer. Experts in satellite image fusion areas made several attempts. This technique is a game-changer mainly due to the convenience as well as one of the most apparent fusion strategies feasible [10]. The curve transformation learns outstanding utilization away from the wavelet transition generally attributed. However, a limitation of these transformations is that they cannot symbolize images adequately because of the subsampling. The main characteristics of the contourlet transformation are its adjustment version and the lack of information on the fusion [11].

In the recent past, the popular approach is the sparse representation (SR) approach. It is very helpful for the categorization of images, performance extraction from images, deblurring of images and fusing the images. Scientists have fused several images with minimal representation and well-defined dictionaries using exceptional or equivalent sensors [12]. Exactly similar images are supplied in a cluster. By using only a few of the most appropriate components, an image is produced with a dictionary that can easily describe all the common position clusters [13]. This method is considered cheap when a small dictionary is used. The objective of an image fusion machine in the sparsity-based versions is to produce a useful and remarkable dictionary. This situation leads to another minimal overall structure that is of use for images with the aid of a dictionary. Here, the image fusion changes by the use of the decomposition and the SR of the cartoon sense [14].

The cartoon segment uses electric power mainly based on fusion techniques but according to the sparse illustration, it is felt that things are mainly based on fusion guidelines. It could most likely be that this spectral data within the frame efficiently preserves, but lacks the energy to demonstrate these spatial features correctly. Still, the unresolved challenge is the inability to connect the single effort causing images to create the fused images despite the open image fusion strategies. Fusing of images that have various resolutions such as spatial resolution and spectral resolution has an extremely critical use as image modification is detected. Character recognition and multispectral image fusion are used mostly to develop the usefulness of modifying information [15]. A technique about CNN (convolutional neural network) photo fusion, which is based along with shearlet definite exchange, is recommended [16]. However, the completeness of the strategy limits the use of its existing purposes to several additional diagnosis devices and treatment. The limitations of using CNN to real-time plans are overcome with an intuitionist-fused image fusion that is mostly used in diagnosis [17].

These principal limits within the present fusion methods used are the inefficiency in coping with noise information inside the input image, moreover, forget about the best of the fused image. This specific chapter explores a superior satellite image evaluation enhancement incorporated in a fusion approach.

3.2 Materials and methods

The proposed approach evaluates the effectiveness of remote sensing images to enforce their datasets obtained from the same sensor at times that can be distinctive. This scenario consists of 10 images from the LANDSAT dataset and surveys from around the world. Among these samples, a pair of 70 images can be identified, with 10 samples used for analysis.

The satellite image details used for the evaluation are shown in Table 3.1. For evaluation, satellite images are considered from the same places. Since the captured images use the same receptors, photo registration is not necessary during photo fusion.

Table 3.1: From dataset, 10 satellite images taken for analysis.

Satellite images	Spatial resolution	Source dataset
LANDSAT	30 m	Global land survey
		Earth explorer

3.2.1 Methodology

The recommended approach is to improve the inventory of images by using a fake honeybee enhancement process and then combined with the use of various famous hybrid techniques. The phenomenal hybrid techniques used include the mixture of DWT, IHS and PCA. This proposed approach can be explained as shown in Figure 3.1. A gamma corrective histogram gradient enhanced with fake honeybee enhancement technique is pre-processed for the obtained satellite images from an identical area to enhance the images. This allows the control parameters built inside the image or the image histogram to be changed. Thus the need for manual intervention will be easily reduced. For encouraging improvement, the regularly used strategy uses regional strengthening.

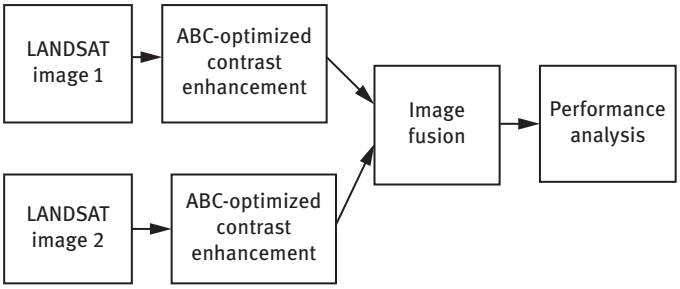

Figure 3.1: Flowchart of the proposed approach.

3.2.2 Improve contrast of satellite image

Image improvements are transformed by an evaluation of the existing models with few key steps. It requires strength to be increased within the image or the image histogram to be changed; thus it could be interpreted swiftly by the method for individuals. The regularly used strategy, conversely, makes use of worldwide significant changes.

The original image was obtained through overall histogram adjustment. For improving degraded images, a single fragment of histogram leveling is not sufficient because it can reduce the magnificence quantities within the image. Another improvement to the moderate evaluation of images remains the increasing appeal of an increasingly appealing gamma constitution approach (Figure 3.2).

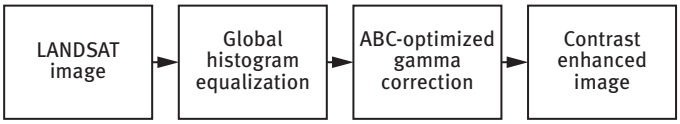

Figure 3.2: Flowchart of the proposed enhancement approach.

3.2.2.1 Global histogram equalization

This approach is used to enhance the imperatives of an image. The intensity values in sample images are such that the intensity distribution is equal in the output images.

Here, J sample images and $J(x,y)$ indicate the intensity for the corresponding pixels. The overall pixel values in J, represented by n, L levels $\{J_o, J_1, J_2, \ldots \ldots \ldots, J_L\}$, is the value of depth in J [2].

J_k inside an image might be detailed as depicted in eq. (3.1):

$$p(J_k) = \frac{n_k}{n} \tag{3.1}$$

where $k = 0, 1, \ldots \ldots \ldots, L-1$ and n_k represent the quantity with the pixel force level J_k.

Depending on the probability density function (PDF), the total circulation work is determined as follows:

$$c(J_k) = \sum_{s=0}^{k} p(J_s) = \sum_{s=0}^{k} \frac{n_s}{n} \tag{3.2}$$

$T(x)$, an exchange work for shape based at the cumulative distribution function (CDF), is obtained as follows:

$$H(J_k) = J_0 + (J_{L-1} - J_0)^* c(J_k) \tag{3.3}$$

The yield photograph Y, an upgraded image, is obtained as follows:

$$Y = H(J) = H(J(x,y)|\forall I(x,y) \in I_0, I_1, \ldots\ldots, I_{L-1} \tag{3.4}$$

The disadvantage of this methodology is the inability of the global histogram equalization technique to hold the mean magnificence of the images. Various modifications may be carried out to achieve brilliance in the optimal proportions. The use of gamma feedback can be accomplished.

3.2.2.2 Gamma correction

An image-based additive to the exponential neighborhood correction was organized for this image evaluation upgrade technology. This is a cautious technique that is effective in tracking noisy diminishing images by the thousands. The image collection of the magnificent gamma is a standardized test of time, especially in the satellite case [7].

For an ordinary gamma adjustment, the yield image is acquired as follows:

$$I_{\text{out}} = cI_{\text{in}}^{\gamma} \tag{3.5}$$

The info and yield images individually represent the powers of I_{in} and I_{out}.

Substitute systems that differentiate improvement and pressure in power levels toward darker stages and expand together with the powers toward more brilliant stages.

Images are medium and low assessment, and the revised change capacity can be given as follows:

$$I_{\text{out}} = \alpha I_{\text{cp}} + (1 - \alpha) I_{\text{ex}} \tag{3.6}$$

I_{cp} is the source image packed in the direction of darker phases and I_{ex} is sample image extended to more splendid levels as follows:

$$I_{\text{cp}} = I_{\text{in}}^{\gamma} \tag{3.7}$$

I_{ex} is obtained using eq. (3.8):

$$I_{\text{ex}} = 1 - (1 - I_{\text{in}})^{\gamma} \tag{3.8}$$

I_{in} refers to the histogram evened out image.

From eqs. (3.6), (3.7) and (3.8), the contrast is improved, which is managed by both α and γ variables. The parameters of α and γ are managed within the transformation feature. As a result, the α frame is enhanced in addition to γ. ABC is utilized for enhancing the control parameters.

3.2.2.3 Improvement of contrast by utilizing the approach of ABC optimization

The estimation technique of artificial bees involves a set of meta-heuristic rules. This estimation is entirely dependent on bumblebee behavior. With reference to honeybees, people may also be restricted as (i) honeybees used, (ii) spectator honeybees and (iii) honeybees search.

Figure 3.3 shows the ABC set of rules.

The darting bees get the data from those honeybees that search for food. The highest scored and quality having food sources has more potential for selection through the spectator's use of honeybees. Food with the least appreciated fuse have minimal chance of being selected. It can also reject the possibility that the penalty will be reduced. Right now, the Scout Honeybees are searching for another food supply self-assertively. Three necessary steps toward optimization have been followed at each stage throughout the mission to food sources:

I. Honeybees search for food supplies and identify the food with remarkable quality.
II. When information is transmitted about the food supplies, the supplies are evaluated by the spectator bees.
III. When the food supplies are rejected, scout honeybees are sent for fresh supplies of food.

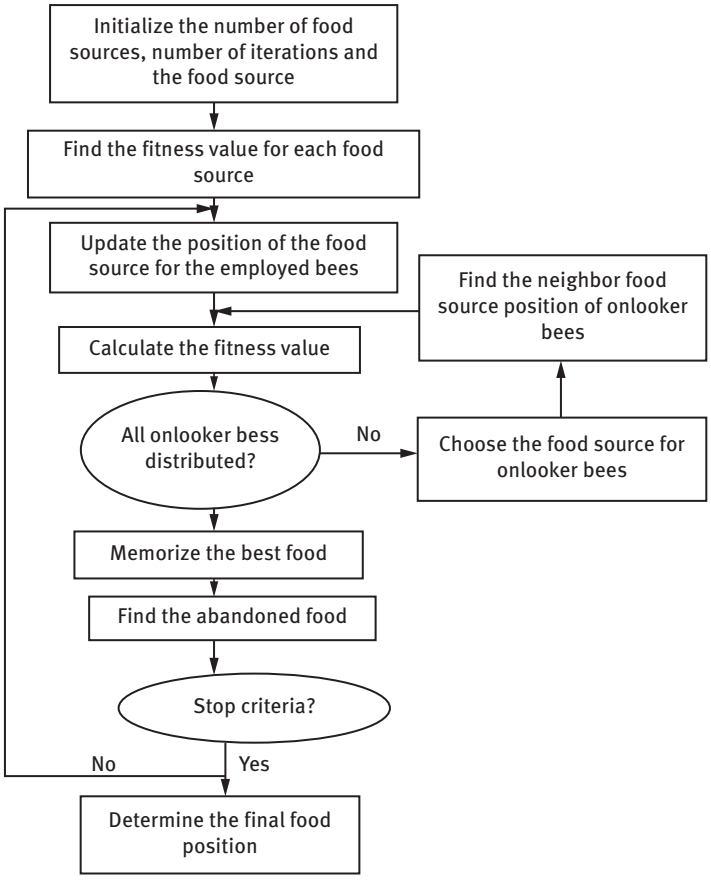

Figure 3.3: Enhancement using ABC optimization approach.

Although the algorithm performs global and local searches in all stages of iteration, the main benefit of using ABC in comparison to optimization techniques is that local optimal solutions are not taken into account and the chances of finding an optimal solution are huge.

A transformation and fitness function are necessary for the application of ABC. Using a gamma-based transformation mechanism, the proposed method enhances the image. α and y of the picture should be optimized here. In the search field, the bees shift toward the optimum α and y values to increase the image contrast by analyzing the fitness function.

Fitness is a meaningful function that measures the quality of the image created. The effectiveness of entropy is one such metric. Compared to the original image, the entropy of the improved image would be higher.

The implementation of the ABC algorithm utilizes these phases:

- The population has started. The origins of food are regarded as the solution problem with optimization. This algorithm is used to find the best α and y values. The ABC optimization parameters are also defined. The colony has several bees in multiples of 100 and in an iteration of 100. The amount of nectar not updated is 5.
- To initialize the parameters of control, α and y, is $(\alpha, y) = [[0,1], [1,5]]$

$$X_i = \{\alpha_i, \gamma_i\}$$

- X_i^{n+1} is the new solution of their neighborhood X_i^n in each iteration equation (3.9):

$$X_i^{n+1} = X_i^n + \varphi X_i^n - X_j^n, \quad \varphi \text{ is } a\ random\ index \tag{3.9}$$

- Our goal is to maximize the entropy it is utilized with eq. (3.10):

$$H = -\sum_{i=0}^{L} P(i)\log_2 P(i) \tag{3.10}$$

- In the passerby honeybee stage, when the recruited honeybees complete their hunt, spectator honeybee considers the arrangement using the roulette wheel determination technique in eq. (3.11) as:

$$P(X_i^n) = \frac{F(X_i^n)}{\sum_{i=1}^{N} F(X_i^n)} \tag{3.11}$$

where F represents the fitness expense of X_i^n in the whole arrangement.

- If there were zero advancements in real fitness cost over numerous decades, a new explanation would be found.
- The emphasis can halt if the absolute best intensities come to, and physical fitness esteem has combined.

Initially, utilizing the equalization of the histogram approach, the contrast of images in the RGB filters is improved. The underlying parameters of ABC and the control are the modified gamma correction parameters. I_{out} value is determined from eq. (3.6). Fitness for all the possible solutions is evaluated and choose the most appropriate solution. The optimized (α, β) is therefore used to ultimately improve the RGB image.

3.2.3 Satellite image fusion

Multiple images, images from sensors of the same area or from the same sensor atvarious times can be combined through image fusion. In this chapter, images from the same sensor are considered and consequently, no image recording is carried out.

Satellite images can be disturbed by interference with the atmosphere such as noise. The quality of the input images determines the success of image fusion. This requires pre-processing techniques before image fusion. Improving images is an essential part of the preprocessing process. The over-improvement of the image may impact the quality of the image and, thus, does not maintain the original image information. They are susceptible by assigning the approaches for attaining the brightness of intermediate sources enhances the contrast of the images, such as histogram equalization and gamma correction. Optimization of the control factors in gamma correction with the help of the ABC optimization approach result in improved images. The input for the fusion phase is the improved images.

Three key image fusion techniques are explored in this work. They are the DWT-, PCA-, IHS-based image fusion techniques. This section discusses each fusion technique in detail.

3.2.3.1 Image fusion using PCA transform technique

To translate certain associated values into an uncorrelated set of variables, PCA is useful. It tends to decrease a large number of variables to a smaller subset, which can still hold the data of the larger dataset. This approach allows the creation of a small set of parameters and the use of the reduced variable set. The reduced number of variables is referred to as the main factor.

The PCA approach is mainly used to compress images, enhance the image, recognize objects and fuse images.

The PCA fusion process takes each pixel of the source image from one location to another. Weight is applied to each pixel of the source images and the overall weighted value is calculated to generate the fused image.

The PCA-based fusion approach enhances image resolution by dividing the two images that are to be fused into subimages with different frequencies. The main components of the subimages from various sources are now combined so that the information in the images exist in the resultant image. The subimages are restructured. In comparison to the individual images, the resultant image has improved information.

Therefore, corresponding weights allocated to specific images obtained from various sources will be used to fuse large number of images with the help of PCA methodology. In the present scenario, the most common and popular image fusion method is PCA while dealing with multisourced images that are multispectral and pan-chromatic. Figure 3.4 demonstrates the flow chart of the methodology for the fusing of images based on PCA.

The essential advantage of using PCA-driven fusion is that the correlation among the various images of satellites can be removed. The process only needs a

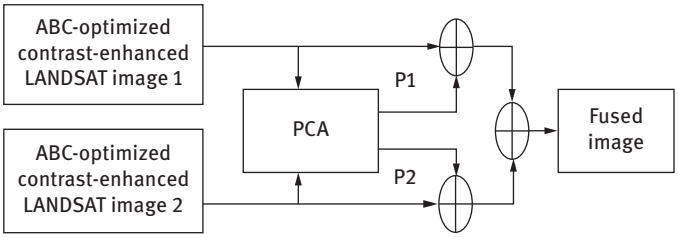

Figure 3.4: Flowchart of image fusion using PCA transform technique.

sub-set of detail to display the information on the ultimate image fuse. But the only disadvantage of using only one small dataset is that information is lost when the fused picture is generated. But the only disadvantage of using only one small dataset is that information is lost when the fused picture is generated. Thus, the procedure for image fusion is much less reliable.

3.2.3.2 Image fusion using DWT transform technique

One of the most well-known approaches for the processing of images is by utilizing the wavelet transformation for image fusion that produces multiresolution images. By minimizing color distortion, it is able, to generate very high spectral and spatial pictures. Among the fusion methods available in the multiscale transformation,, DWT is the simplest and fundamental fusion method. It is commonly used in large research zones such as image fusion, video and audio compression and pattern recognition. The high quality of the fused image makes it the most used in contrast to discrete cosine.

Transform. DWT can use images of various resolution rates as a multiresolution technology.

Transforming a wavelet is an allowance of the high-pass filtering process. For its implementation, DWT uses filter banks. The picture is broken down into low-frequency and high-frequency components. Before the appropriate resolution level is reached, the low-frequency components can be additionally degraded. The image is down-sampled at every level of transformation. The filters, following a decomposition phase, will be applied on the rows and then the columns of the image, at each point. As a consequence, 4 images are produced, a rough picture and three wavelet coefficients. This image results from the low-pass filtering methods used on the columns and the rows of the image. The transformation's next phase is also added to the image approximation.

After the application of the transformation wavelet, wavelet coefficients and an approximation of each image are produced. The next step would be to combine, pixel

by pixel, the two images obtained from the source using the approximated wavelet coefficients. The images can be combined using specific fusion rules. The reverse transform of the fused image is obtained when the coefficients are combined.

For classification of the standard coefficients of the wavelet transform in decomposed origin images, discrete wavelet transform (DWT)-built fusion of the images is performed with the help of the average law to avoid loss of low-frequency data. The DWT image fusion method is represented in Figure 3.5.

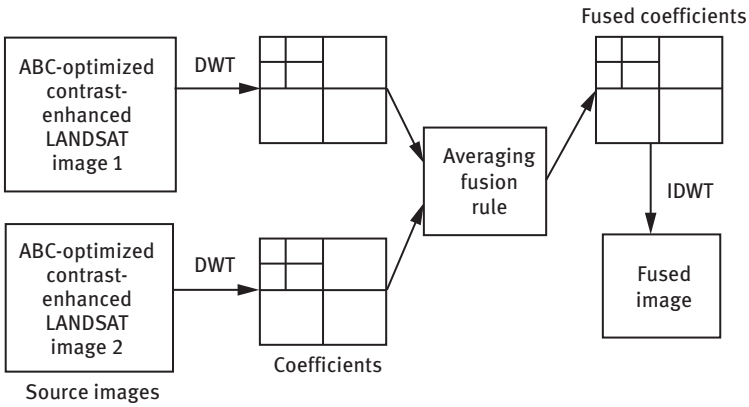

Figure 3.5: Based on discrete wavelet transform image fusion.

For combining the maximum pixels, the coefficients in the original and the individual images, the minimum in each source image and the average in each source image can be used randomly. Different rules can be applied.

The preference based on the rules of the fusion to combine the coefficients of the wavelet is a significant component. According to the resolution and the quality of each source image, the framed rules of the fusion should be chosen. The quality of the image that was fused is bad and further analysis of the image cannot be carried out when the framed rule of fusion is randomly selected.

The main downside of using DWT is that multiple decomposition rates improve the quality of the image. An increase in the number of decomposition rates increases the difficulty of the calculation and researchers have to consider alternative methods of satellite image fusion due to the overhead of high image volume.

3.2.4 Image fusion using IHS transform technique

The intensity, hue, saturation (IHS) transformation is a frequently used image fusion transformation. It can be used to improve color within an image, to improve

the image's features and/or to improve the spatial resolution of the picture. The IHS domain primarily includes spectral details in teeth and saturations. The main aim of IHS transformation is to ensure that the fused images represent all the spatial and spectral details in the sources. The block diagram for the IHS image fusion is shown in Figure 3.6.

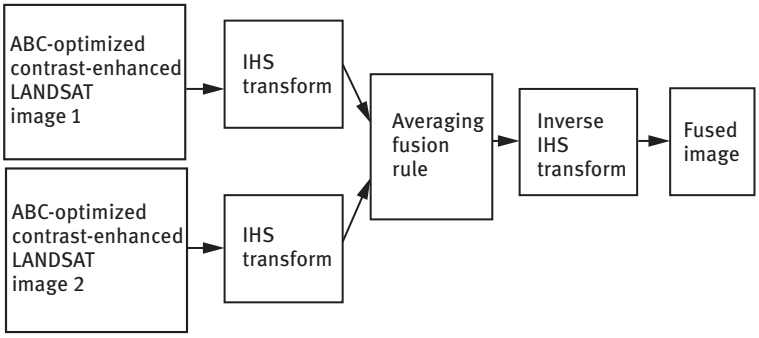

Figure 3.6: Based on IHS transform image fusion.

In intensity, color and saturation, the RGB in source images are divided. The components of the images such as the hue, saturation and intensity of each image obtained from the sources are mixed with the average fusion principle for achieving the corresponding modified components.

3.3 Experimental evaluation

Quantitative results were collected from 10 photographs to show the efficiency of the proposed procedure. For the fusing of images, three approaches were compared, namely, IHS, PCA and DWT. For each technique, FSIM, entropy, MSE and PSNR were calculated. The image fusion effects from the current PSNR approaches are shown in Table 3.2.

Every image has a certain degree of vulnerability in it. Uncertain image details result in uncertain image fusion. In contrast to traditional approaches, the current fusion approach eliminates ambiguities in the initial images that are collected from the source, resulting in a fused picture. The intensity variable displays the brightness of the picture during the IHS transformation. The average of individual components ensures that when the transformed images are fused using the HIS approach, the result is an improvement in the contrast of the images. In the fused image, the

Table 3.2: Comparison of PSNR were contrast-enhanced images using the current fusion techniques.

Dataset	IHS	DWT	PCA
Data 1	40.9292	35.9819	30.7882
Data 2	39.9225	36.2719	31.2877
Data 3	38.8945	36.1885	33.1356
Data 4	38.5789	37.3111	32.3726
Data 5	38.2933	36.4421	33.8192
Data 6	40.1686	35.4768	32.1335
Data 7	40.4694	37.1728	30.1919
Data 8	39.8115	36.2599	33.7935
Data 9	38.5196	36.7976	32.6925
Data 10	37.1624	34.1497	30.9743

overall brightness and contrast of the images obtained from the sources are retained. Table 3.2 shows data from the discussion scenario. Note that from the fusing of images using the IHS transformation, the PSNR values obtained are higher than the PCA and DWT approaches.

The PSNR levels, on average, improved by 36,1052 dB for PCA-based fusion. DWT- and IHS-based fusion show 31.9980 dB and 39,1750 dB, respectively. We may, therefore, assume that an increase by approximately 22.42% occurs. Table 3.3 compares the findings of the current MSE-related approaches for contrast-enhanced image fusion.

The higher the PSNR value, the lower the MSE value. The values for MSE are in comparison with the existing methods, and the methods suggested are smaller.

A structural similarity measure is SSIM. It determines the relationship between the source images by comparing luminance differences, the actual form of images form and their contrast. It has a range from –1 to 1. If the SSIM values are close, the output images are structurally identical to the source images. This is measured by eq. (3.13).

Where μx and μy are, respectively, the sample means of x and y; study varies between x and y. The model correlation is $\ddot{\sigma}xy$. Local windows of the two source images are the differences between x and y. Table 3.4 contrasts the current effects of the enhanced contrast image fusion SSIM-related methods. The SSIM levels, on average, have risen from 0.9240 in the case of DWT, 0.8775 in the case of PCA and 0.9575 for the IHS-based technical fusion. We may also assume that there is an improvement by

Table 3.3: Comparison of MSE of the contrast-enhanced images using the current fusion techniques.

Dataset	IHS	DWT	PCA
Data 1	15.872	20.541	24.223
Data 2	16.661	22.188	25.352
Data 3	17.174	25.558	26.324
Data 4	18.727	23.627	27.729
Data 5	14.833	20.915	25.992
Data 6	16.523	19.167	26.793
Data 7	16.191	20.574	28.967
Data 8	16.923	22.430	27.954
Data 9	18.429	25.929	28.179
Data 10	20.244	26.315	29.178

Table 3.4: Comparison of SSIM of the contrast-enhanced images using the current fusion techniques.

Dataset	IHS	DWT	PCA
Data 1	0.9771	0.9726	0.9771
Data 2	0.9637	0.9403	0.9637
Data 3	0.9759	0.9390	0.9759
Data 4	0.9577	0.9053	0.9577
Data 5	0.9639	0.9285	0.9639
Data 6	0.9616	0.9373	0.9616
Data 7	0.9740	0.9286	0.9740
Data 8	0.9598	0.9336	0.9598
Data 9	0.9779	0.9258	0.9779
Data 10	0.9736	0.9105	0.9736

9.11% in the other techniques. FSIM tests the conceptual similarity between the original and the target image analyzed. The estimate is based on the following equation:

$$\mathrm{FSIM} = \frac{\sum_{x \in X} S_{\mathrm{L}}(x)\mathrm{PC}_{\mathrm{m}}(x)}{\sum_{x \in X} \mathrm{PC}_{\mathrm{m}}(x)} \tag{3.12}$$

If X reflects the whole image, the similitude in the two images is $S_{\mathrm{L}}(x)$ and the congruency map of the phase is PC_{m}. Table 3.5 contrasts the enhanced comparison of the effects of the image fusion from the current FSIM methods.

Table 3.5: Comparison of FSIM for contrast-enhanced images using the current fusion techniques.

Dataset	IHS	DWT	PCA
Data 1	0.9963	0.9014	0.9963
Data 2	0.9914	0.9925	0.9914
Data 3	0.9043	0.9157	0.9043
Data 4	0.9843	0.9263	0.9843
Data 5	0.9976	0.9248	0.9974
Data 6	0.9865	0.9177	0.9865
Data 7	0.9782	0.9004	0.9782
Data 8	0.9568	0.9924	0.9568
Data 9	0.9655	0.9018	0.9655
Data 10	0.9723	0.9883	0.9723

In general, the FSIM estimate has increased to 0.9172 in the case of DWT, to 0.9833 in the case of PCA-based methodological image fusion and to 0.9438 in the case of IHS-based methodological image fusion. Thus, we are in a position to guarantee that there might be an increase of about 6.93 across the different techniques.

The image's contrast was enhanced using the existing image fusion process. The entropy values are shown in Table 3.6. It can be noticed that the entropy estimates are a lot higher when compared with the conventional techniques. Lower values suggest that the extraction and preservation of every information of the image from the source are not so efficient, whereas higher values suggest the extraction and preservation of every information of the image from the source are efficient.

On a normal, the entropy estimates have risen from 5.8636 in the DWT-based methodology and 5.0241 in specific PCA-based methodology to 6.4786 in the IHS

Table 3.6: Comparison of entropy for contrast-enhanced images using the current fusion techniques.

Dataset	IHS	DWT	PCA
Data 1	6.1377	6.0660	5.3805
Data 2	6.3150	5.0167	5.1620
Data 3	7.3660	6.4120	5.3066
Data 4	6.2677	5.2869	4.7723
Data 5	6.4369	5.5144	4.4574
Data 6	5.6952	5.3132	4.7359
Data 7	6.4294	5.3926	4.6675
Data 8	7.2500	6.6219	4.9800
Data 9	6.5401	6.1723	5.6029
Data 10	6.3315	5.8380	4.9541

transformation methodology of fusing of images. Thus, one can confirm an increase of approximately 29.60% over the other methodologies.

From the overall assessment of the discussed methodologies such as PCA-, DWT-, IHS-based image fusion, one can understand that the IHS-based image fusion methodology provides enhanced results for measures such as PSNR, SSIM, FSIM, MSE and entropy and that the enhancement of image's contrast is of acceptable levels in comparison to the other methodologies. The PCA-based methodology of image fusion impacts the image quality by adding unnecessary artifacts. The DWT-based methodology of fusion makes decomposition in multiple stages to be highly complex. The IHS-based fusion is better and quicker to execute and when compared to the other two approaches, it can retain the color information present in the origin images.

Figure 3.7 demonstrates the various levels of enhancement of an image's contrast for various gamma values, with or without the consideration of the ant bee colony optimization methodology. Choosing the acceptable gamma value is extremely important as the image's contrast rapidly changes with the gamma component. An optimum range of the gamma component is required to boost the contrast and retain the image's actual information. Else, the source image's poor contrast will have an impact on the fused image's quality. This restricts the use of these images for subsequent analysis. Due to this, the information in the original image can be identified by using the enhanced image. Without considering the ant bee colony optimization, the

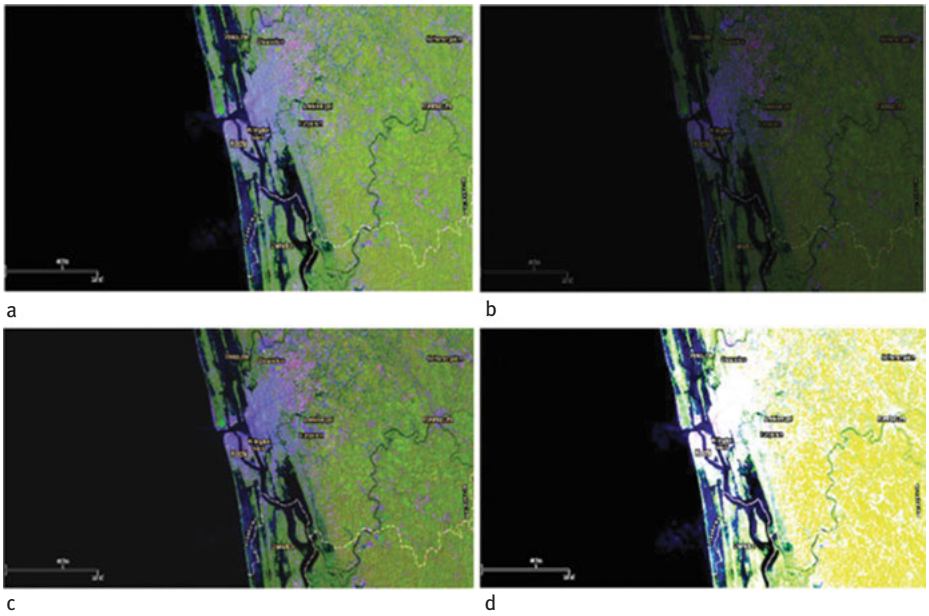

Figure 3.7: (**a**) Source image 1; (**b**) enhancement where $y = 0.8$, $\alpha = 0.1$ without ABC; (**c**) ABC enhancement where $y = 1.8$, $\alpha = 0.3$; (**d**) enhancement where $y = 4.2$, $\alpha = 0.2$ without ABC.

technique might result in poor enhancement of the images due to the selection of the parameters such as y and α that affect the later stages of image fusion.

If the enhancement of the image's contrast is not optimized further, it might provide darker images or overly illuminated images. These images are used as input for the subsequent stages of the fusion process to obtain the fused images. As they are darker or overly illuminated, such images do not provide any useful information. Therefore, the optimization of parameters such as y and α is necessary in the gamma correction methodology as part of the transformation. Without manual tuning, it is a highly difficult and laborious process to enhance the contrast of huge images obtained from satellites.

For a set of images, the gamma estimates will not be distinctive. These estimates change for various sets of images. Usually, the manual tuning of the gamma estimates will be laborious, particularly while dealing with darker and brighter contrast images. Therefore, the solution to this problem is to optimize the control parameters. This methodology is simpler and quicker to apply when related to other traditional methodologies.

A modified contrast enhancement methodology that combines methodologies such as histogram equalization and gamma correction may be used. This combination

enhances the contrast as well as the brightness of the image by enhancing the image's quality. The gamma correction approach will handle the drawback of the equalization approach by using a histogram of the images that improve the appearance overly and that, which uses an optimization approach to choose the gamma's values to enhance contrast at the level of acceptance without losing any information. The ABC optimization methodology also makes sure that the solution's fitness function converges rapidly. Figure 3.8 demonstrates the outcomes of the image fusion of the contrast-enhanced images.

We can observe clearly that the IHS-based methodology for image fusion outperforms the DWT-based methodology and the PCA-based methodology for image fusion, as the components of the image such as IHS are treated separately and then fused. Subsequently, quantitative improvement is also demonstrated by enhancing statistics such as entropy, SSIM, FSIM and PSNR for the IHS methodology over various methodologies for image fusion.

3.4 Conclusion

In this research, ABC improvisation is built on the implementation of satellite image fusion. The primary objective of this methodology is to preprocess images photographed in poor lighting to extract as much of an information as possible to store and to also protect the maximum information in the further phases of fusion. In the discussed methodology, the contrast enhancement process comprises two stages. The first stage is histogram equalization, and the later stage is gamma correction. In the later stage, the control parameters are optimized by using ABC optimization. Within this technique, the distinction sweetening includes two levels: bar graph equalization during gamma correction, within which the management parameters improved utilizing ABC optimization. Thus, the obtained images are enhanced and are taken for image fusion. For the image fusion process, there exist three different conventional methods such as DWT-based fusion, IHS-based fusion and PCA-based fusion. These methods improved the performance of the image fusion process. The advantages of the intensity–hue transformation built on fusing of images are simple, and faster to execute when compared with all the other conventional image fusion methodologies. Subsequently, this method can be extended to various focused images obtained from various sensors for the process of image fusion.

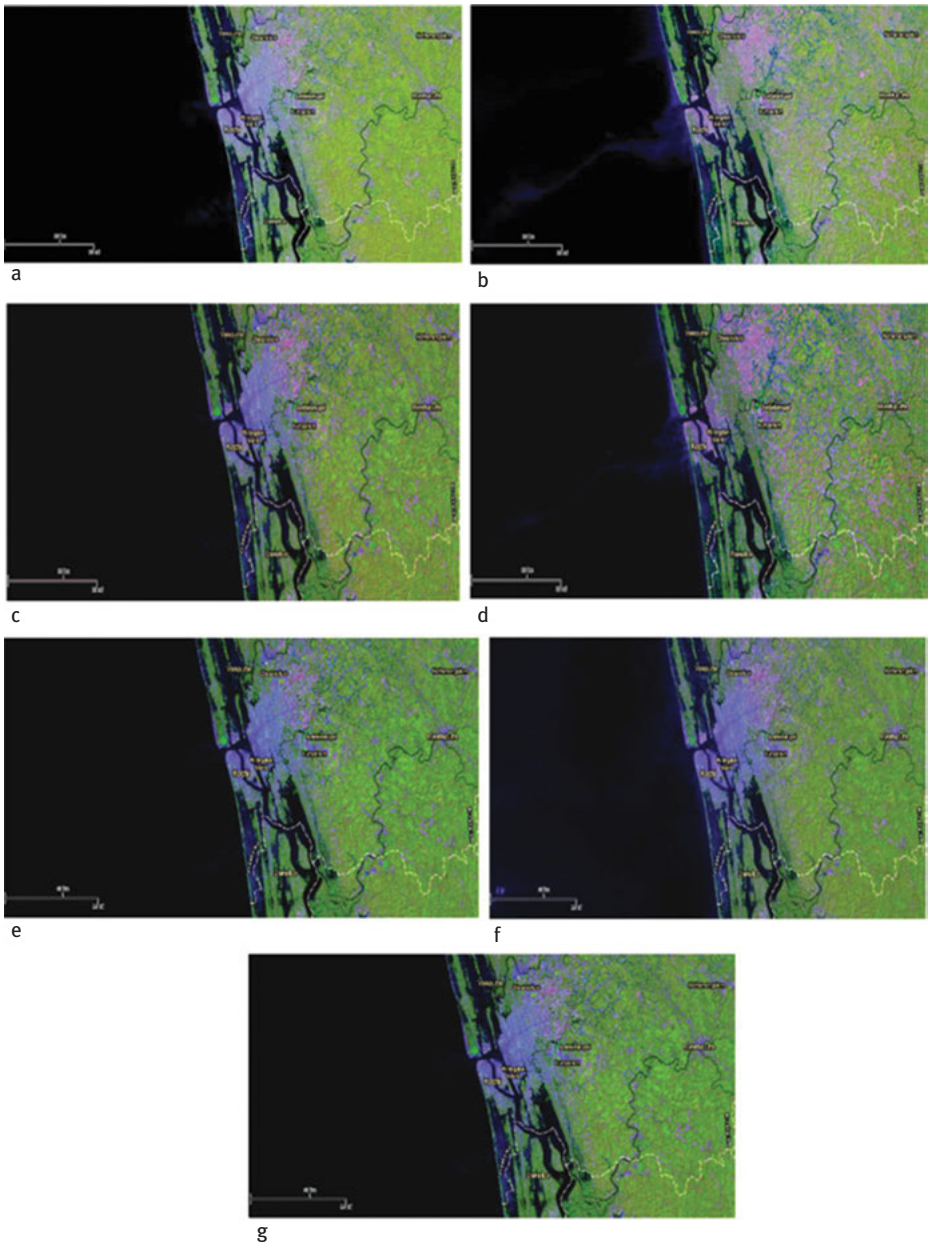

Figure 3.8: (**a**) Input image 1; (**b**) input image 2; (**c**) input image 1 enhanced using ABC; (**d**) input image 2 enhanced using ABC; (**e**) PCA fused; (**f**) IHS fused; (**g**) DWT fused.

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4 Role of intelligent IoT applications in fog computing

Abstract: With the growth in the demand for many intelligent IoT applications, there are different approaches and analyses in fog computing. This chapter includes fog computing and extends the paradigm of issues, challenges and future opportunities. In addition to this, we discuss the various analyses and techniques that would enable researchers solve real-time problems using fog computing that would serve as an inspiration and a source of ideas. Due to the need, various smart computing models are also being explored for new prospects.

Keywords: fog computing, IoT, intelligent systems

4.1 Introduction

The Internet of things (IoT), a high-level application, is evolving to suit several smart devices. Many applications such as smart technology devices require less delay and the potential to migrate data from a cloud to the devices where it may affect device performance. To resolve this issue, fog computing has been developed.

Fog computing is a novel concept and is an extended version of cloud computing that overcomes the above issues. It is one of the highly centralized platforms that offer computation, storage and services networked devices and cloud servers [1]. Using fog computing, IoT devices present edge technology to understand the practical and theoretical facts of networking and transmit data and communication. This concept develops typical operations and services that enable new applications. Here, the primary aim is to combine the available data from different data servers and send the intelligence to the end or output device. As we have said, it is very similar to cloud computing and may differ based on end devices and their mobility.

Emerging technology in digital computers leads to the automation of many actions done by human beings. In earlier days, some of the tasks were processed based on direct communication with input and end devices with specific programming and instructions. This technique resulted in lack of information; later on, the scientists came up with artificial intelligence. Here, the main aim is to replace human tasks with a machine that works on automated patterns to explore data and lead to discoveries in different emerging fields.

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The role of intelligent IoT applications is to create a framework that involves all technologies and is a solution for research issues. In today's digitalized world, the demand is to achieve the goals of latency and efficiency using many real-time applications and their services. This chapter justifies the concepts, technologies, issues and applications of fog computing. In adopting the basic to the advanced domain of IoT applications and their models, it provides a summary of its features by using present scenarios as a path for future research.

4.1.1 Why fog computing?

Many of the smart technologies have become commonplace; fog computing is a prominent high-level smart technology. The data transported from sensors to the cloud is used to process and store the fogging. This is done for efficiency improvement and latency reduction. Smart technology devices, computer networks, smart quotes, and others are the most popular fog computing applications.

We have a fog computing reference architecture that does the analytics as shown in Figure 4.1. Several models were provided for fog computing, but they originally come from the three-layer basic protocol, that is, terminal layer or end layer, fog layer and cloud layer [2]. With the fog layer between them, the cloud server continues to the edge devices. The reference model is shown in Figure 4.1.

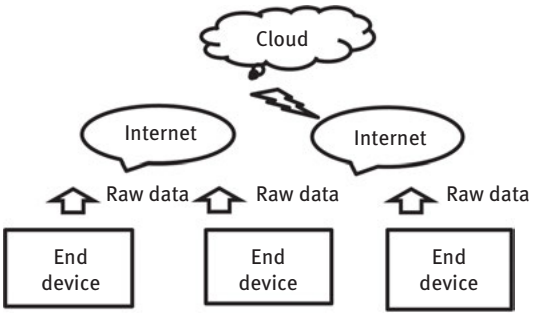

Figure 4.1: Reference model of fog computing.

Terminal or end layer: This layer is the basic layer for the fog condition surrounding end devices. It includes the various ends of IoT systems such as sensors, smart grids, and cell phones. This layer senses the data from the sensor and sends it to the upper layer for analyzing and storing purposes.

Fog layer: This is a sort of layer located at the edge of the network and is composed of a large number of fog nodes. It mainly incorporates firewalls, routers and gateways

as the intermediate devices in this layer. These devices are static or dynamic in a location, based on the surrounding atmosphere. The end devices that perform services connect with the fog nodes, and they can transmit and store. Nodes are also linked to the cloud server that is responsible for computing purposes.

Cloud layer: This is the high-level interface layer, which has a specialized server or computer type to perform the analysis. Smart towns, smart mobility and smart computing are some of the high-level technologies involved in this interface layer. It is highly useful in numerical research and for storing enormous quantities of data.

This architecture provides the IoT applications with scientific support in providing high-level data analysis and further storage capabilities. It helps to deploy location-based fog nodes that enable the managers to monitor users and devices to access the information. Sensors are devices which process the data for results measurement. Though the servers are available and have the computing power, they carry out remote synchronization. This process is performed in smart devices to reduce the amount of data needed to enter the cloud in fog computing. It includes sending input data to the cloud over the Internet by end devices that require privacy and security.

The aim is to reduce the cloud computing load. Fog computing is only data processed, analyzed and stored in the devices and is a current trend and prominent technology for IoT device operation. Here is a summary of how smart IoT devices deal with many obstacles, problems and implementations for potential benefits.

4.2 Related work

The researchers' literature survey outlines the vision of new services and the applications that are needed for more effective use of big data and analytics. Here, they considered the smart grid that helps illustrate the data generated by the sensors and devices by taking fog into paper1 as an evasion platform [3], submitting that fog computing would underpin rapid development in the field of IoT, edge devices, radio techniques and SVD in the direction of potential future. As the use of fog computing increases, there are inherent problems such as unreliable latency and location awareness by providing the end user with elastic resources and services, among others.

Dastjerdi et al. [4] encourage the use of fog computing with its key features and characteristics as a reference architecture for ongoing efforts and vision, along with recent developments and applications.

Yi et al. [5] provide a detailed description of fog computing using platforms and various applications. Many of the more important issues such as latency, lack of availability and the way cloud computing is used becomes more active when the services are in use. As a result, a framework for fog computing is developed to solve

the problems in smart home applications. Therefore, the work requires the most favorable results and executions.

Omoniwa et al. [6] presented an IoT literature survey (2008–2018) and adopted an fog/edge computing-based IoT (FECIoT) system covering science, technology and previous research issues. As previous studies have published, fog-based networks have a critical role in coping with the many resources at the edge of the network. Centered on advanced principles and using intelligent systems and smart technology, FECIoT is applied in real-life examples.

Al-Doghman et al. [7] defined that fog computing is a wide field of research and industry in hardware and software systems. This paper comes with fog-computing concepts, methods and observations. By implementing the services in the digital environment, it brings out the characteristics of the product that result in its end-use. In many ways, it includes the methodologies and fog computing scenarios within the IoT era. It also increases the capacity of the different resources in each dimension, helping to introduce fog computing.

Saranu and Jaganathan [8] explain how the planet is getting closer to the Internet age. Most people are addicted to using the Internet, and the need for storage has risen. To this end, cloud storage is one of the new technologies that helps performance of user services and storage of a large amount of data. Here, they provide details on big data with the cloud survey and discuss how big data in fog computing is beneficial.

4.3 Concept of intelligent IoT applications in the smart computing era

Development of machinery is helping people learn more efficiently in the modern century. People are beginning to leverage smart devices to access digital world services through wireless technology. Any computer with an intelligent system can be explored with matching progress in the scientific world; hence, several intelligent IoT applications are being implemented in the technological age. Among these applications, smart education has been widely explored and gained significance in recent times. In the field of education, some of the government programs engaged extensively (e.g., IBM in 2012, Hua in 2012 and Makela in 2014). Their projects include all the schools and envisage a multidisciplinary education system that improves the infrastructure for education. In the education sector, smart learning has entered a new age.

In this chapter, the smart learning system has been taken into consideration and reviewed. The smart learning system includes the smart learning science architecture and the task of intelligent smart learning follows [9] it. The issues are closed, enabling challenges that explore the smart system for research that inspires future potential are provided.

In the era of smart learning, several educational researchers concentrate on the concept of smart learning, according to the literature survey. This is illustrated in Figure 4.2 in two ways, with a recent activity that the researchers, Hwang and Scott, proposed to establish a definition of smart learning:

- Centered first on smart learners.
- Smart learning is effective and intuitive, based on the infrastructure.

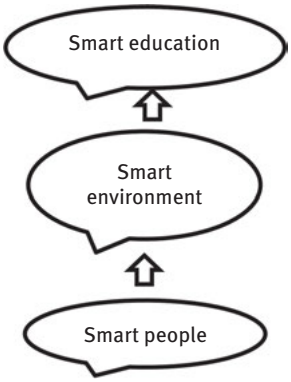

Figure 4.2: The process of smart learning.

Smart learning incorporates the opportunities of social learning and global learning. With this smart technology, in 2013, learners could participate and improve their communication, in general. Another function of smart learning is that it is motivated and self-directed and includes technology proposed by MEST, in 2014. One of the major parts of this smart learning environment is that it provides personal services, that is, learners can take their courses and present their classes in the right place. The smart environment is also the physical location that contains digital resources to create the right places for fast and better learning [10].

4.3.1 Smart learning environment

This intelligent atmosphere is typically one of the most important ingredients in smart learning. It also plays a critical role as the smart learner views it as the center of the program. Learning happens through the use of smart devices at any time; context-based learning plays a major role in successful learning. The main objective is to make it quick, efficient and promising [11].

Smart learning is listener focused and collaborated by analyzing the literature (noh et al. 2011). It also considered that smart learning requires effective planning and advanced user-friendly results, as stated in Spector (2014) [12].

4.3.2 Smart learning

This is one of the earlier technologies developed for the learning environments. This approach also involves hardware and the software in rendering services to explore effective learning in the modern world [13]. We have smart education apps that help you learn.

The apps support the intelligent services at each stage of implementing smart learning education as follows:

Alertness: In all respects, smart learning takes place with the respective technology. We use sensors or the network to transfer data to the smart learning education systems – for example, data mining, location-based or context-based learning, etc.

Replacements: Whenever the data were obtained by the sources or other intelligent systems using a method such as big data, they allow the learners to track the data and to store them for learning and services.

Activities: Different methods are used depending on the different situations, and the information is used to infer the result. Most smart systems will perform application activities. The learners are given correct data relating to the smart environment.

4.3.3 Challenges in enabling smart education

The main goal in developing smart education is to enhance the learning experience over a long period of time. With the assistance of intelligence techniques, it provides content-based and updated learning [14]. With the rise in scientific study, many leadership skills, ideas and systemic structures are an interesting part of smart education.

A smart learning environment performs a major role in the concept of smart education as it can reduce learners' focus on the techniques and methodologies. Trainees will undergo the best learning that will help them all around. They must have a simple and efficient environment in order to improve interpersonal skills and learning intelligence. This means that smart learners should be provided with a supportive and customized approach through intelligent exploration.

4.4 Components of fog-driven algorithms

Many kinds of algorithms have been proposed in the computing age. They are algorithms of two categories – those specific to applications and others that are application-unspecific. There are four groups of algorithms among them, and they have their respective tasks for analysis.

Here the first three application-specific groups include analysis, storage, distribution and energy consumption. The last is a part of the application-unspecific algorithm.

4.5 Working of fog-driven algorithm

4.5.1 Fog-driven algorithm for computing in the fog system

Classification of fog driven algorithm is described in figure 4.3. In this, we list three activities. They are:

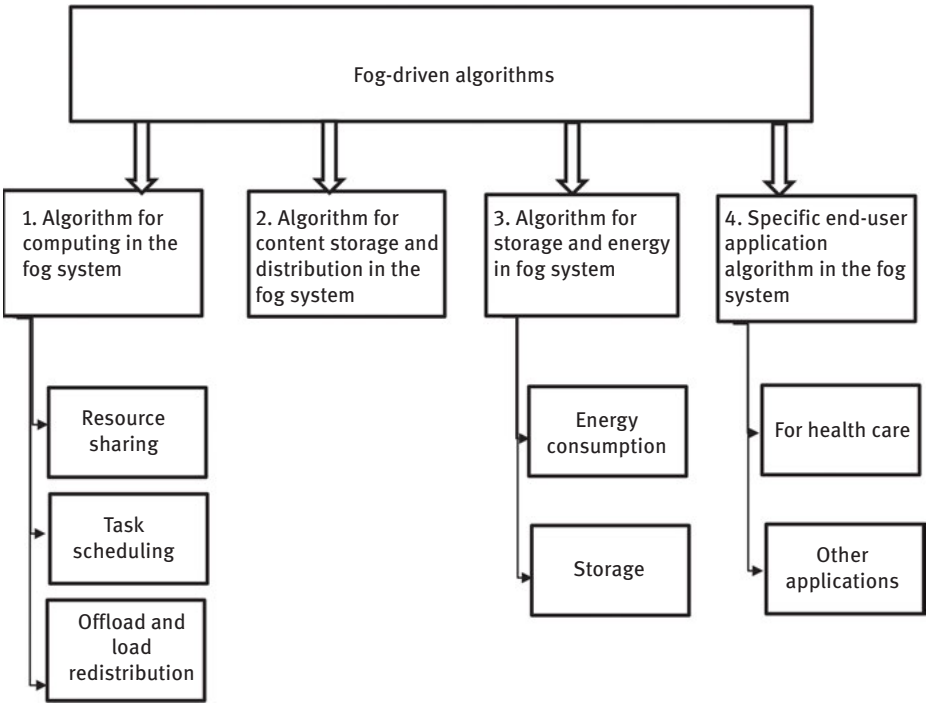

Figure 4.3: Classification of fog-driven algorithms.

Resource sharing: Abedin et al. introduced an algorithm that involves sharing the nodes of fog within the same domain of fog. In doing so, it follows users' demands. One-to-one pairing occurs depending on the pairing nodes and target nodes.

Task scheduling: Here comes the big question of how to make the tasks functional. It is studied by focusing on the task of the fog layer scheduling within a

network. Small cells are present in a cellular network to process the formation of fog nodes. Generally, it works in two ways:

Based on the organized user list, each person allocates resources for a specific purpose.

Clusters are created for computing; the requests are supported by following a specific objective in a certain order.

After selecting the fog nodes, there are three policies to perform tasks. Task scheduler algorithm is considered by taking different types of devices into account.

Offloading and load distribution: It includes the concept of reaching fog-based users with offload applications and mobile devices. It measures the data rate in the fog layer, too and includes the coding computations done in fog computing. It helps migrating operators with a strategy that focuses on reducing the migration costs. Figure 4.4 describe the function of computing in a fog system.

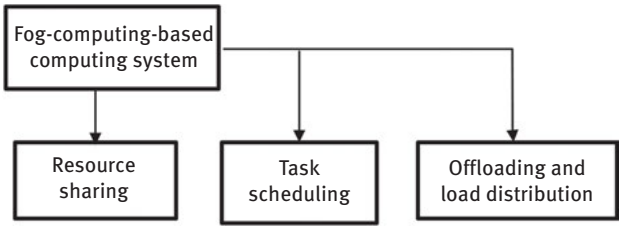

Figure 4.4: Functions of computing in a fog system.

4.5.2 Algorithm for content storage and distribution in the fog system

Apart from computation in the fog network, storage and distribution is another function that needs to be focused on. Fog-radio access networks (F-RAN) are present according to the survey studied. This is an extended version of cloud-RAN and allows for radio and application connectivity in a sensor network. The mobility factor is taken into account here, in a cellular network, which reduces device latency. These applications are very similar to the F-RAN applications and allow users to access servers with low latency.

Here, the focus is primarily on system-level problems. There is need to have a custom-made storage area to store the data. Results show mainly that throughput is high with local storage area use. The quality of service (QoS) is also one of the drawbacks of the services available.

Thus, the analysis shows that in fog systems, content-based knowledge has included F-RAN systems that improve scalability and mobility, but not QoS.

4.5.3 Algorithm for storage and energy consumption in the fog system

There are several research activities in the field of fog computing for energy use based on the surrounding atmosphere. In the earlier research, the study of the energy consumption in the fog computing systems was primarily absorbed by the IoT platform. A comparative analysis has also been performed, taking into account parameters such as latency and strength.

By analyzing the IoT-related applications in real time, several researchers have ended up with the conclusion that fog computing is better than cloud computing. In parameters such as latency, about 25% of services are flexible in fog computing with a 30% decrease in latency for intelligent applications, and less than 42.2% for power consumption.

Based on the cloud computing system, a given fog layer analyzes the energy usage with which the amount of data is transferred from the terminal layer. Results describe cloud data hubs as being more reliable than the small data hubs with reduced energy consumption. However, an increase in energy consumption is observed for the dynamic session in time for small data centers. The aim of the author is to satisfy the QoS by sending requests to achieve node scalability and mobility.

Several works had introduced algorithms related to fog computing that focused on the use of resources. A clustering approach had been implemented that supports the nodes to allow the services or resources to be used. By using this method, they support the high-value weights better, when compared with the other methods of clustering. There are several algorithms introduced to reduce energy usage, whereas small cluster nodes are considered using specific methods to display power consumption. Consequently, for F-RAN systems, the resource sharing problem is noted to allow optimization.

There are some key features and the contributions of the researchers for the algorithms are listed as follows:

Energy consumption:

- Implementing fog computing with intelligent IoT, taking many parameters into consideration.
- Examine energy consumption of the fog computing systems through cloud computing systems with each other.
- Develop a method of nano-clustering that is reliable while sending information on the power utilization path.
- Analyzed methods based on a sharing of resources using the best efficiency technique.
- Implemented an energy-reducing mode selection algorithm in F-RAN technologies that form users to servers.

- Proposed an algorithm for allocating the data in the cloud or fog computing.
- Proposed a fall detection method for energy purposes contributing to the existing technological trend.

Content storage and distribution in fog systems:
- Examine the limitations in parameters such as latency, mobility and energy efficiency in the F-RAN systems.
- Research review of F-RAN's hardware and software fog systems.
- Implementing a method to reduce the transfer of resources from users to protect the data.
- Evaluate the cache system in F-RAN systems.
- Developed an algorithm based on the source nodes to improve the video quality.
- Implemented a data-enabled framework for the fog-based nodes to keep data models.
- Developed a low-cost caching method for the data.

Based on the analysis, it is resolved that the fog computing systems decrease energy. It reaches the QoS rather than mobility and scalability by analyzing it.

4.5.4 Algorithm for specific end-user application in the fog system

This includes many high-end applications and algorithms to achieve specific resources. It addresses the algorithms relating to healthcare applications and other applications.

4.5.4.1 For healthcare applications

Many physical systems utilize fog computing in the medical sector to reduce the price of virtual machines. It helps develop a base station with user–user communication to QoS as a parameter, by adding fog nodes. Despite the complexity, they introduced a two-stage algorithm: (a) the first stage involves a reduction in uplink communication and (b) the second stage includes a reduction in the communication between base stations. This result shows methods consisting of a large number of base stations and time for the arrival of queries. About 100 users with 50 base stations are a small constraint for the highly advanced services.

According to the studies, the application for qualifying strokes is for fall detection analysis. In this section, the divide is between computing cloud and fog. Using the detection algorithm, the magnitude of the system is analyzed in the fog layer. In

the three stages, the threshold is measured followed by striking, drop and idleness. For example: if users drop to the ground, sensors are used to do the filtering which is analyzed in the layer of fog. The time is recorded by comparing the magnitudes, but incorrect actions are observed by performing the process on the cloud. This result shows less false positive rate, so QoS has achieved application-specific targets.

Key features of the researchers' studied work for fog computing systems are:

Developed a resource management algorithm within physical structures

Proposed an algorithm for verifying and analyzing the separate and specific dropdowns

4.5.5 Other applications

Other applications besides healthcare have also achieved the targets listed in the research works.

It has focused on services such as video streaming that are used to broadcast live telecast. In a livestream, the picture must be controlled in various ways. To minimize transcoding in the framework, a scheduling algorithm is introduced. The results show the algorithm efficiency and required data speed. Through this study, we can conclude that QoS is achieved through live streaming, and the other algorithms support scalability problems.

Key features of the work done by researchers on fog computing systems are:

- Fog computing introduced a systemic view of the scheduling scheme function.
- Developed peer to peer communication for livestream telecasting between the users.
- Developed the ultraviolet radiation algorithm.
- Reduced optimization on websites used by the fog nodes.
- In fog computing, algorithms are designed for gaming-orientated applications.
- Implemented the algorithms on any HTTP website to view the original standard of the images.

4.6 Issues of fog computing for intelligent IoT applications

Here, we discuss the issues that may be helpful for future research in the context of fog computing.

4.6.1 Fog networking

Fog network is one of the heterogeneous networks that allows all fog components to connect. The main task, especially in the field of IoT, is maintaining the network and providing tasks [15] and upgrading technologies such as virtualization and software-based networking for flexible maintenance. Through this, the deployment of these two technologies develops scalability and cost reduction.

4.6.2 Quality of service

For fog computation, this is one of the critical parameters. It can take different forms:

Connectivity: Since the sensor network can be aggregated in cluster form, this clustering can provide cost reduction and broad connectivity. We randomly select the nodes and make connectivity available to a single user for the minimal throughput.

Reliability: Reliability can be improved without any damage by synchronizing the periodic timings. More than latency, this failure will impact fog computing devices [16]. Therefore, it depends on the functioning of greater number of nodes as one.

Delay: Some of the applications we need for real-time services like video and audio streaming involve fog computing. Before implementing fog computing for data aggregation, the nodes to be used are considered after account prioritization.

4.6.3 Security and privacy

These issues affect the authentication of devices involved in fog computing [17]. Each device should have its own IP address. Any kind of malware may use a fake address to track information about the fog node. To overcome this, a prevention and detection system for intrusion should be applied and accessed in each layer [18].

4.6.4 Energy consumption

Less energy is consumed by distribution of the analytics that needs to be processed as platforms and heavy environments are present, and this is an important factor in fog computing.

4.7 Applications

Fog computing is of major importance in real-time applications. These applications can be a human-machine, or vice versa as different in both ways.

4.7.1 Mobile data analysis

In IoT, it is beneficial to use fog computing instead of cloud computing, since the data set is stored in the cloud. It reduces delay in computing time and processing of data. It also helps in eliminating data transmission and response time.

4.7.2 Smart utilization

The main aim is to save time, money and energy. The data that is analyzed should be up-to-date because it contains the end devices. Therefore, fog computing is an advantageous technique to run the utility service as per IoT, while sending the data from one point to another.

4.7.3 Health service

The data required for any basic health service or the data observed and noted are very confidential. A high level of security and data integrity is to be ensured. Since the data is exchanged between connected local areas, fog computing is necessary. Patients' health reports need not be carried manually because fog computing allows the doctors to access their data.

4.7.4 Fluid power in reservoirs or dams

Fog sensors are deployed in dams for data transmission from input devices to cloud servers, and he data is processed and analyzed by the higher authorities. The issue that arises here is time lapse in communication that may affect performance. To solve this issue, we use fog computing where the end devices are close to the cloud, so that the data can be transmitted and recognized flexibly.

4.8 Comparison of cloud computing and fog computing

Fog computing is primarily a reference model of varied device types that are controlled at each point by the smart devices. Cloud computing is a virtual solution for data processing and transmission with access to a cloud server. The facility provided by fog computing is located, and storage in fog computing is limited in the cloud, it is open globally.

The differences between fog and cloud computing parameters are illustrated in Figure 4.5. The nodes present in the fog computing are many and provide security in real-time scenarios.

Parameters	Fog computing	Cloud computing
Latency	Low	High
Security	More secure	Less secure
Mobility	Widely applicable	Limited applicable
Delay	Low	High
Nodes deployment	Very large	Limited nodes
Connectivity	Wireless	Wired/fiber cables
Node distance	Single/multiple	Multiple
Bandwidth	Low	High
Scalability	High	Low

Figure 4.5: Table of comparison of parameters of cloud and fog computing.

4.9 Conclusion and future scope

As we mentioned in the previous section about the applications, fog computing has the ability to receive data from a particular network's IoT devices, thus it can show rapid growth in IoT device management. We built the envisioned multi-issue system, problems with many applications. We consider fog computing as an evolving technology for IoT in real-time applications. It solves the issues of latency, energy, delay, etc. When considering IoT infrastructures, it is also very beneficial to integrate the data in a real-time environment. By improving on all the above lacunae, fog computing can offer a new array of opportunities and services. The new computing models and IoT services can also be promoted broadly.

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5 Energy-efficient routing employing neural networks along with vector-based pipeline in underwater wireless sensor networks

Abstract: Underwater wireless sensor networks (UWSNs) are outfitted by restricted battery power. Because of the unfavorable surroundings, battery substitution is costly in UWSNs. Energy consumption causes a significant network issue due to distant deployment and small size of the sensor nodes. Therefore, we propose energy-efficient routing employing neural networks using vector-based pipeline in UWSNs. The entire network in these UWSNs is separated into steady dimension clusters; in all clusters, cluster heads (CHs) are chosen under the source of power using a neural network approach. However, CHs transmit the packets to the base station using the vector-based routing. Simulation results depict that using neural network and vector based achieves maximum stability and increases network lifetime.

Keywords: UWSNs, cluster head, energy consumption, neural networks

5.1 Introduction

There has been an ever-growing interest in monitoring underwater mediums in which there are major technological advancements in related fields that have opened the horizon for various inventive systems administration plans. Sensor systems have changed each one of the territories of innovation that include science, industry and the administration [1]. Underwater networking is an enabling technology for ocean applications. It comprises several variable sensors in an underwater sensor network and also in vehicles that are deployed to perform community-oriented checking responsibilities in a given area. Underwater networks can be described by their spatial scope based on the thickness of their nodes [2]. Underwater sensors chiefly vary with the correspondence media utilized for data transmission. In light of the correlation, one can choose bearers for submerged sensor organizes that upgrade the correspondence productivity in the predetermined submerged condition. The underwater network acoustic considers the underwater networking needs and is sufficiently particular to permit simple coordination between businesses of various layers by various research groups [3]. The design is sufficiently adaptable to alter in itself diverse application necessities and a new opinion.

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To guarantee adaptability, the design additionally characterizes an increased structure so the design can be extended, and cross-layer advancement can be considered [4]. The network layer gives directing capability to the protocol stack. When the layer realizes that a packet couldn't be conveyed because of an absence of an accessible route, it might notify the client layer by the no-route warning [5]. The data link layer gives single-hop data transmission capacity. It might likewise give an error detection ability to us. If there should arise an occurrence of a mutual medium, the information interface layer must include the MAC sublayer. The physical layer gives balance [6], surrounding an error-correcting ability.

This chapter is categorized as follows: Related works are discussed in Section 5.2. In Section 5.3, EERVBP-NN is discussed in detail. The conclusion is discussed in Section 5.4 followed by references.

5.2 Related works

In a paper by Sharma et al. [7], presenting a directing protocol for underwater wireless sensor networks (UWSN) was a noteworthy research issue, which was useful to illuminating systems administration intrudes on, which by along with large comes into submerged sensor arrange and gives a stage to finding reasonable routing protocol for a particular reason. Total correlations of different routing protocols along with all favorable circumstances just as inconveniences have additionally appeared in the paper. Vector-based forwarding (VBF) protocols for UWSNs have been proposed earlier [8]. It is also known as the novel-based routing protocols. An epic-based routing protocol is expected for UWSN toward concentrating on the directing problem in UWSNs. It is a zone-based directing methodology. In this tradition, no status information is a need in the sensor nodes. Nodes close to the directing vector are capable of transmitting information from the sender to the receiver. Upgrading the power of area-based directing for UWSNs has been proposed by Maggiorini et al. [9], with a particular ultimate objective to move quickly the quality as well as to overcome these problems. An improved execution of VBF called "jump" by bounce VBF (HH-VBF) routing protocol has been proposed. They use indistinguishable coordinating divert form utilized in VBF from sender to receiver, however, not using the single directing channel. It will use bounce by jump vector directing channel. Reinstitution move toward about reveals that HH-VBF makes enhance result for packet conveyance amount, particularly in the lacking area hole along with VBF. The protocol proposed by Yu et al. [10] relies upon HH-VBF, anyway employing attractive control stage, the division to the objective node along with the transmission stretch out into the record, the execution of adaptable hop-by-bob vector-based sending (AHH-VBF) is significantly enhanced than that of HH-VBF to the extent of data movement, vitality usage, along with start to finish idleness. Daeyoup et al. [11] proposed a directional

flooding-based (DFR) protocol for UWSNs. Versatility along with bundle misfortune corrupts dependability. This protocol enhances the fixed-quality package flooding technique. The assumption is that every node sees about its territory, the zone of one ricochet neighbors along with that of the last objective. This protocol redesigns faithful quality by bundle flooding framework. EERU-CA was proposed by Ali et al. [12], with energy productive routing count for UWSN – a clustering approach. UWSN portrays two segments, for example, territory-based protocols along with region-free routing protocols. Nonetheless, region-based conventions are not appropriate for UWSNs. Obstruction in UWSNs is the most essential issue. This chapter proposed essentialness capable of directing in UWSNs-A grouping approach (EERU-CA). EERU-CA is utilizing the possibility of an exceptional center point. One kind of hub is having unlimited vitality along with tremendous transmission control. In any case, essentialness along with partition are the major parameters in which data trading should have the best vitality and least detachment at the tolerating unit.

5.3 EERVBP-NN: proposed scheme

Energy efficient as well as balanced energy consumption cluster-based protocol (EBECRP) proposed by numerous creators to implement cluster situated between the base-station adaptability as well as maintain a strategic distance from the depth base. In-depth base and short-depth nodes die in denial time for the reason that the unbalanced load on the nodes nearby toward the base station. As such, to manage this problem, in EBECRP employ versatile sinks, the nodes taking place to maintain the load. Clustering is utilized employing a particular ultimate objective to diminish the amount of spreading to alter the vitality usage as well as system lifetime. In any case, the result delineates that EBECRP achieves the most dumbfounding constancy period along with framework lifetime.

5.3.1 Network initialization and cluster head selection

The idea is in the direction of executing reconstruction of the network for UWSN systems utilizing the neural system approach. By applying some algorithms in neural networks in which weights can be regulated without difficulty, this idea becomes the main point in our work also. In each cluster, the node that has a high transfer power becomes a cluster head (CH). However, there is only one cluster that exists in a cluster but in the network, many CHs. The reclustering and regrouping are dynamic procedures that are balanced by the circumstance. The regrouping of the system can enhance the execution of the hubs if one bunch of head flops; by rebunching new bunch head can be picked and the execution of the framework can

be expanded along these lines. In our proposed work, reclustering of the system employing neural systems is the principal worry. In the current method, the grouping of the system is static yet in our proposed work, the network is dynamic during the clustering. The circumstances emerging can alter them as need be. Hence, the counts finished on the wellspring of battery utilization the nodes information sent is effectively customizable. The real worry here is to get away from the battery wastage. The group head choice is likewise done based on the least battery utilization through a neural system calculation.

As shown in Figure 5.1, the system model is used to represent in which the X(p) is the node id, W(p) is the battery corresponding to the node id that is given and the output is the best node which is selected as a CH.

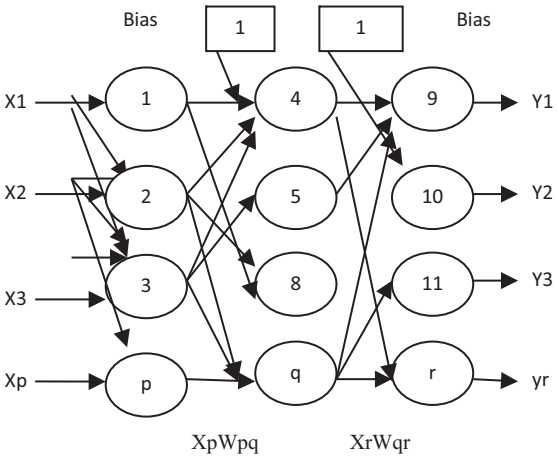


Figure 5.1: System model.

Algorithm for cluster head selection

1 **Procedure**
2 W- weight in the network
3 B $\leftarrow \theta$ – bias in the network
4 a←area/region in the network
5 X-input
6 Y- output
7 D- target
8 Deploy sensor network with fixed number of sensor nodes
9 Check network density ()
10 If network== inferior
11 Sparse region <– {a|a $\in$ A^a < A/2}
12 Network type =sparse
13 Else if network ==dense

14 Dense region <– {a|a ∈ A^a > = A/2}
15 Network type=dense
16 Apply location-based clustering to cluster sensor nodes
17 Cluster head selection
1 Initialize weight and bias in network
2 W=0,B=0, I=0
3 While ending situation is not fulfilled {
4 For each preparation tuple x in data set{
// broadcast the input forward
5 For each input layer d unit q{
6 $Yr = X_q$ // output of an input unit is its actual input value
7 For each hidden layer unit q
8 $X_q = \sum p\ wpq\ Yp + \theta q$; // process the net contribution of unit q as for the past layer p
9 $Y_q = \frac{1}{1+e-1}\}$ // calculate the yield part q
10 // Back-propagate the fault
11 For each unit j in the output layer
12 $Fault = Y_q(1 - Y_q)\ (D_q - Y_q)$; //calculate the fault
13 For each part q in the hidden layers, while the end of the initial hidden layer
14 $Fault = Y_q(1 - Y_q) \sum r\, Fault_r W_{qr}$ //calculate the fault by means to the next superior layer, r
15 For each load W_{pq} in network {
16 $\Delta W_{pq} = Fault_q Y_q$; // weight rise
17 $W_{pq} = W_{pq} + \Delta W_{pq};\}$ //weight update
18 For each bias θq in network{
19 $\Delta\theta_q = Fault_q$; // bias increase
20 $\theta_q` = \theta_q + \Delta\theta_q\}$ //bias update
21 }}
22 Recover path through sensor nodes which have a higher rating
23 Select as cluster head (CH)
24 Start communication from cluster head to sink with vector-based routing
25 End if
26 End else if
27 End

In this proposed algorithm, the system is conveyed with a limited number of sensor nodes. The entire system is partitioned into locals and based on nodes in the region the sparse or dense region is defined in the network. The CH is selected in each region based on neural networks. In the neural networks model, the node identification and their battery are given as input and based on these two inputs the actual output is calculated with the formula given in algorithm. The error is calculated

based on the desired and actual output. The blunder is utilized to change the loads so that the mistake will get reduced. The procedure is rehashed until the point that the mistake is negligible. The node which has the least error is selected as the best node for the CH. The aggregation energy is calculated with the given formula in the algorithm. The new CHs get selected in the network after each round based on the given procedure unless the whole network gets dead.

The neural network input layer has $(x_1, x_2, x_3, \ldots, x_p)$ nodes, where the hidden layer has $(m, n \ldots r)$ and one output layer Y. The weight of the first input node is 0.3 and 0.2, whereas the weight of the next node is 0.6 and 0.4 and the hidden first node is 0.2 and the next node is 0.5. The learning rate (γ) value is 0.25, whereas the momentum (δ) value is 0.5.

Step 1: Feed forward

$$\begin{aligned} &\text{Node } m = f(m) = f\ (1^*0.3 + 1^*0.6) = 0.7109 \\ &\text{Node } n = f(n) = f\ (1^*0.2 + 1^*0.4) = 0.6456 \\ &\text{Node } Y = f\ (Y) = f\ (0.2^*0.7109 + 0.5^*0.6456) = 0.4649 \end{aligned} \tag{5.1}$$

Step 2: Reverse pass (destination = 1)

Fault computation from (5.1):

$$Y_{\text{Fault}} = Y_q(1 - Y_q)\ (D_q - Y_q)$$

$$Y_{\text{Fault}} = 0.4696^*(1 - 0.4696)\ ^*(1 - 0.4696) = 0.1334$$

$$\begin{aligned} &\Delta W_{mY} = \gamma^* Y_{\text{fault}}{}^*\ f(m) \\ &0.25^*0.1334^*0.7109 = 0.0236 \end{aligned} \tag{5.2}$$

$$\begin{aligned} &\Delta W_{nY} = \gamma^* Y_{\text{fault}}\ ^*\ f(n) \\ &0.25^*0.1334^*0.6456 = 0.0215 \end{aligned} \tag{5.3}$$

New weights from hidden node will be computed from values (5.2) and (5.3):

$$\begin{aligned} &W_{mY}, \text{new} = W_{mY} + W\Delta_{mY} + \delta^*\ \Delta(d-1) \\ &0.2 + 0.0236 + 0.5\ ^*0 = 0.2236 \end{aligned} \tag{5.4}$$

$$\begin{aligned} &W_{nY}, \text{new} = W_{nY} + \Delta W_{nY} + \delta^*(\Delta(d-1) \\ &0.5 + 0.0215 + 0.5^*0 = 0.5215 \end{aligned} \tag{5.5}$$

In the value of $\Delta(d-1)$, $(d-1)$ is preceding delta to modify the weight. While there is no delta alter so it is zero.

From eqs. (5.4) and (5.5) calculate the error for input node:

$$\begin{aligned} M_{\text{fault}} &= Y_{\text{Fault}} * W_{my}, \text{new} \\ 0.1331 * 0.2236 &= 0.0297 \end{aligned} \tag{5.6}$$

$$N_{\text{fault}} = Y_{\text{Fault}} * W_{\text{ny}}, \text{new } 0.1331 * 0.5215 = 0.0694 \tag{5.7}$$

$$\begin{aligned} \Delta W_{X1m} &= \gamma * m_{\text{fault}} * X \\ 0.25 * 0.0297 * 1 &= 0.007425 = \Delta WX2m \end{aligned} \tag{5.8}$$

$$\begin{aligned} \Delta W_{X1n} &= \gamma * n_{\text{fault}} * X \\ 0.25 * 0.0694 * 1 &= 0.01735 = \Delta WX2n \end{aligned} \tag{5.9}$$

From eqs. (5.8) and (5.9) new weights from the input node is calculated:

$$\left.\begin{aligned} W_{X1m}, \text{new} &= W_{X1m} + \Delta W_{X1m} + \delta * (\Delta(d-1) \\ 0.3 + 0.007425 + 0 &= 0.307425 \\ W_{X2m}, \text{new} &= W_{X2m} + \Delta W_{X2m} + \delta * (\Delta(d-1) \\ 0.6 + 0.007425 + 0 &= 0.67425' \end{aligned}\right\} \tag{5.10}$$

$$\left.\begin{aligned} \textit{Similarly}, \; W_{X1n,} \text{new} &= W_{X1n} + \Delta W_{X1n} + \Delta(d-1) \\ 0.2 + 0.01735 + 0 &= 0.21735 \\ W_{X2n}, \text{new} &= \mathrm{W}_{X2n} + \Delta W_{X2n} + \Delta(d-1) \\ 0.5 + 0.01735 + 0 &= 0.5173 \end{aligned}\right\} \tag{5.11}$$

Step 3: Weight updates in the second pass using the values from eqs. (5.10) and (5.11):

$$\begin{aligned} &\text{Node } m: f(m) = f\ (0.307425 + 0.67425) = 0.9148 \\ &\text{Node } Y: f\ (Y) = f\ (0.2236 * 0.9148 + 0.5215 * 0.7347) = 0.587 \\ &\text{Node } n: f\ (n) = f\ (0.21735 + 0.51735) = 0.7347 \end{aligned} \tag{5.12}$$

Fault is computed by using the value from eq. (5.12):

$$Y_{\text{fault}} = 0.587 * (1 - 0.587) * (1 - 0.587) = 0.0228$$

Therefore, following the primary situation, the calculated error was 0.1333 and in the second pass the error has reduced to 0.0228. Hence, the algorithm has improved. This provides a pale initiative of effective BP algorithm for the selection of the CH.

5.3.2 Data transmission

When the CH is selected, then the node sends the data packet with the help of vector-based routing. In which node transmits the packets and each data packet takes

the location of the source (S), the destination (D) and sender (R). By the routing vector, the forwarding path is specified from the sender to target. A node calculates its comparative location when it gets the data packet sent to the sender by computing its separation to the sender and the angle of appearance of the signal. When the entire node gets the packets, it computes their location. In the sensor network every data packet sender appearance a "routing pipe." Instead of using a single "routing pipe," each node has its routing pipe through which they can send the data from CH to base station. The node sends the data packets only through the routing pipe; otherwise, nodes have to discard their value and recognize its residual energy. If the node is there in the routing pipe, first, check the least energy from the packet through it, then recognize the residual energy and estimate δ as follows:

$$\sigma = \frac{E_{\text{recent}} - E_{\text{least}}}{E_{\text{primary}}} \ldots\ldots\ldots\ldots\ldots \tag{5.13}$$

where E_{recent} signifies the residual energy of recent node, E_{least} is the least energy that is mined from the data packet, E_{primary} energy of the node use up. However, σ is the residual energy of the node that is inferior to the least energy of all nodes that take part in sending.

Algorithm for data transmission

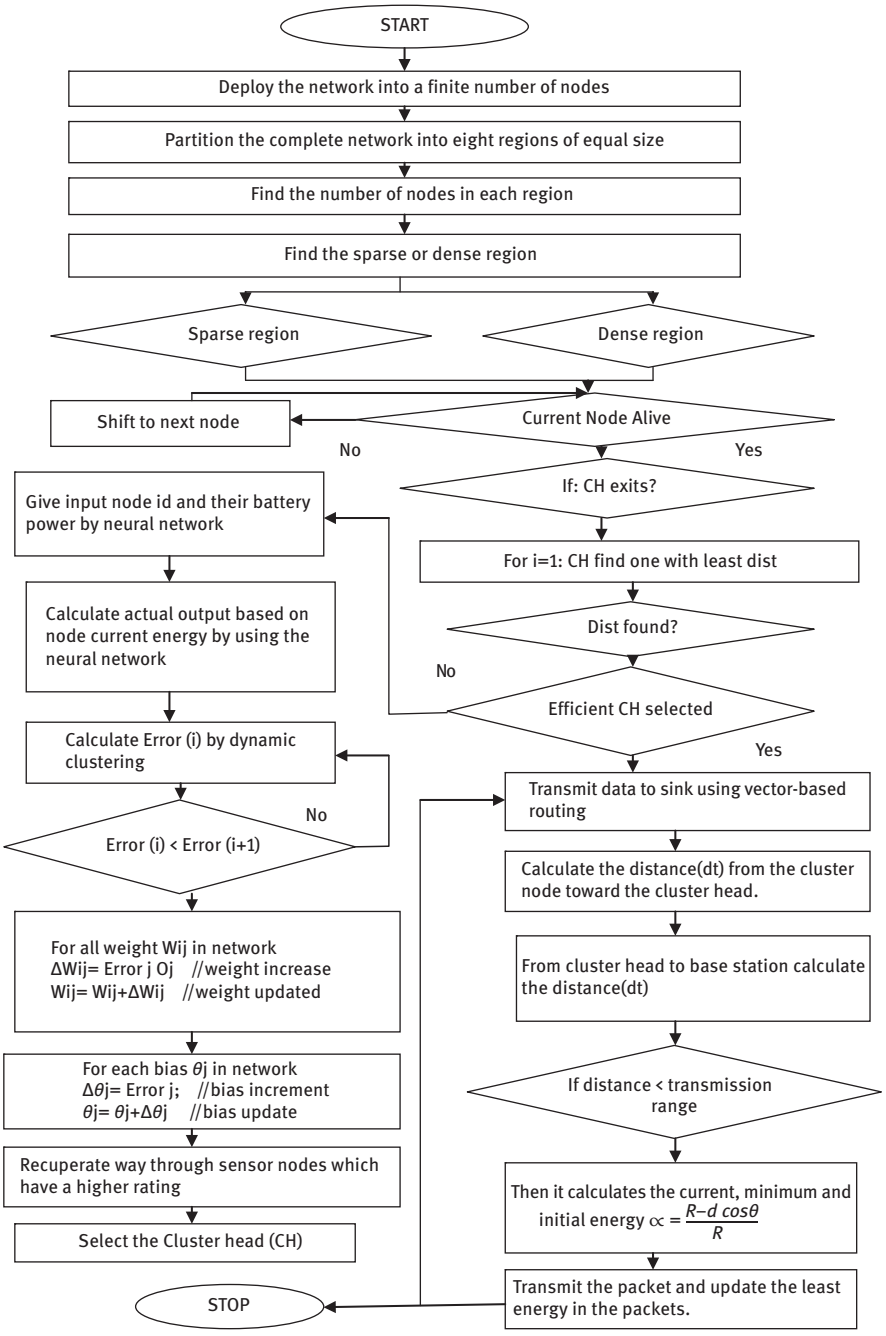
1. When cluster head selected
2. Discover the packet information (S,D,R,E_{least}) from packets(m);
3. Calculate the distance(dt) from the cluster node en route for cluster head;
4. From cluster head towards base station calculate the distance(dt)
5. If dt<R then
6. Calculate $\sigma = \frac{\text{E recent} - \text{E least}}{\text{Eprimary}}$

$$\propto = \frac{R - d^{*}cos\theta}{R}$$

Transmit the packet and renew least energy in the packet (m);

7. Else
8. dispose of the packet(m);
9. End
10. end

Flowchart


START
Deploy the network into a finite number of nodes
Partition the complete network into eight regions of equal size
Find the number of nodes in each region
Find the sparse or dense region
Sparse region
Dense region
Shift to next node
Current Node Alive
No
Yes
If: CH exits?
Give input node id and their battery power by neural network
For i=1: CH find one with least dist
Calculate actual output based on node current energy by using the neural network
Dist found?
No
Efficient CH selected
Yes
Calculate Error (i) by dynamic clustering
Transmit data to sink using vector-based routing
No
Error (i) < Error (i+1)
Calculate the distance(dt) from the cluster node toward the cluster head.
For all weight Wij in network
ΔWij= Error j Oj //weight increase
Wij= Wij+ΔWij //weight updated
From cluster head to base station calculate the distance(dt)
For each bias θj in network
Δθj= Error j; //bias increment
θj= θj+Δθj //bias update
If distance < transmission range
Recuperate way through sensor nodes which have a higher rating
Then it calculates the current, minimum and initial energy ∝ = R–d cosθ / R
Select the Cluster head (CH)
Transmit the packet and update the least energy in the packets.
STOP

5.4 Simulation and results

The proposed algorithm is based on the neural network algorithm in the direction of decrease of the energy utilization of the network. The 100 sensor nodes are deployed in an 800 m × 800 m region. All the sensor nodes outfitted with the first energy of 0.1 J. The broadcasting range of all the sensor nodes is 18 m (in all directions). The size of the data packets is 1,000 bytes. The proposed algorithm is implemented in NS2 and results are analyzed in terms of various parameters by considering the parameters given in Table 5.1.

Table 5.1: Simulation parameters.

Parameters	Values
Network size	800 m × 800 m
Number of nodes	100
Initial energy node	0.1 J
Data packets size	1,000 bytes
Transmission range of the sensor nodes	18 m
Number of sinks	2

5.4.1 Performance parameters

We utilize the accompanying parameters on behalf of the execution assessment.

Throughput: It depicts the number of effective packets achieved at the mobile sinks. Figure 5.2 reveals that the throughput of the proposed, as well as existing count, are taken a gander at, and it has been analyzed that framework throughput is extended because of the decrease of odds of blame in the system.

Packet drop: It demonstrates the number of packets that are not observed by the side of the mobile sinks. Figure 5.3 depicts that the packet drop in the EBECRP and EERVBP-NN algorithm has been evaluated as well as examined in the proposed procedure as diminished because of the right determination of the CH.

Residual energy: The total amount possessed by all the sensor nodes will become a CH. Figure 5.4 depicts that the energy consumption is compared, and it has been analyzed that energy consumption of EERVBP-NN is less when compared with the existing algorithm. We utilize mobile sinks and clustering to adjust the heap on every one of the nodes in the system which brings about the adjusted energy consumption.

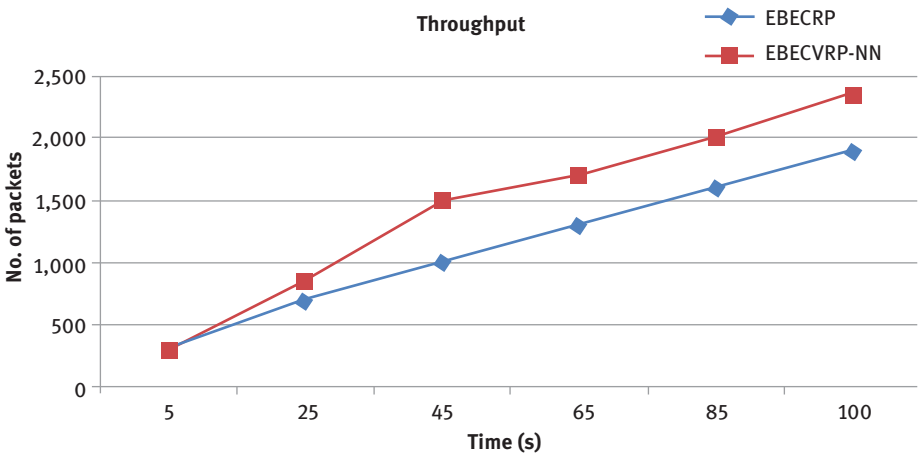


Figure 5.2: Throughput comparison.

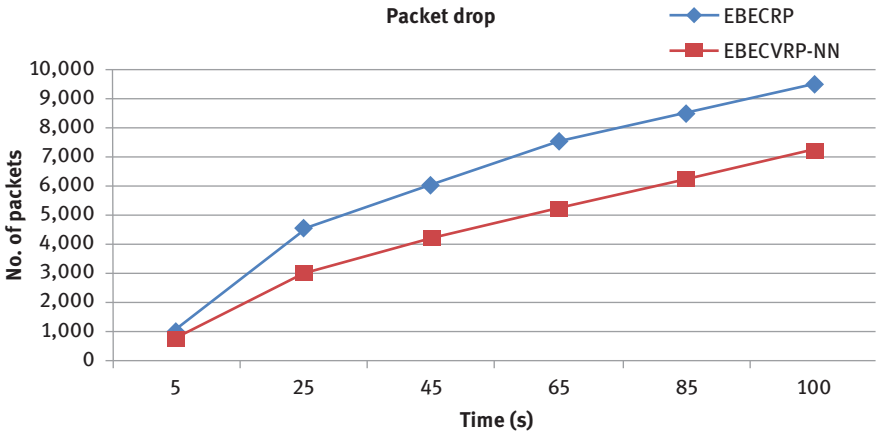


Figure 5.3: Packet drop comparison.

Network lifetime: The length till every one of the nodes in a system comes up short on energy. Figure 5.5 reveals that the network lifetime of EERVBP-NN and EBECRP algorithm is evaluated and due to the least chances of a link failure in the network, network lifetime is increased at a balanced rate

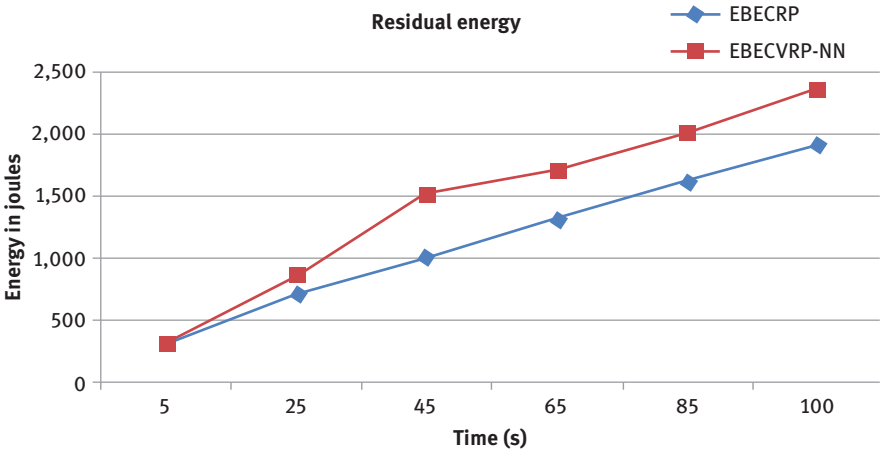


Figure 5.4: Residual energy comparison.

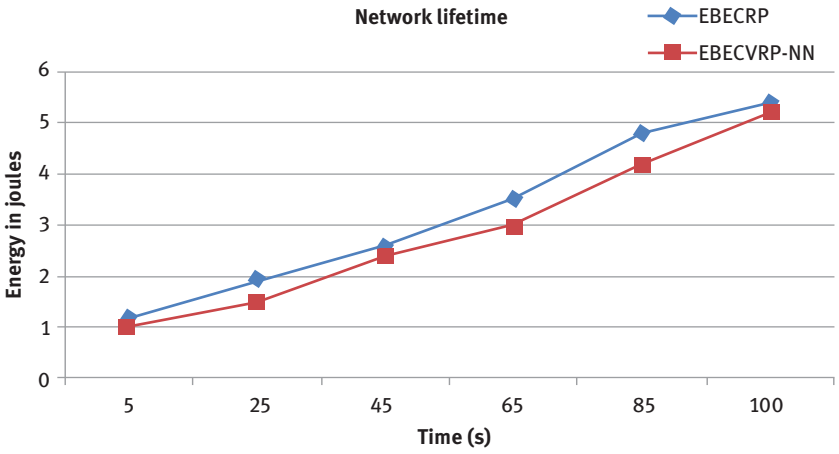


Figure 5.5: Network lifetime comparison.

Node power: The node that has the high power in a cluster will become a CH. Figure 5.6 depicts that the node power of EERVBP-NN and EBECRP algorithm is evaluated and it has been examined that due to the least chances of fault in the network, where the node power is more in the proposed technique when compared with the existing technologies.

Stability: The duration to link fail in the network. Figure 5.7 reveals that the node stability of EERVBP-NN and EBECRP algorithm is estimated and it has been examined that due to the proposed improvement the nodes are more stable which increases the node stability value.

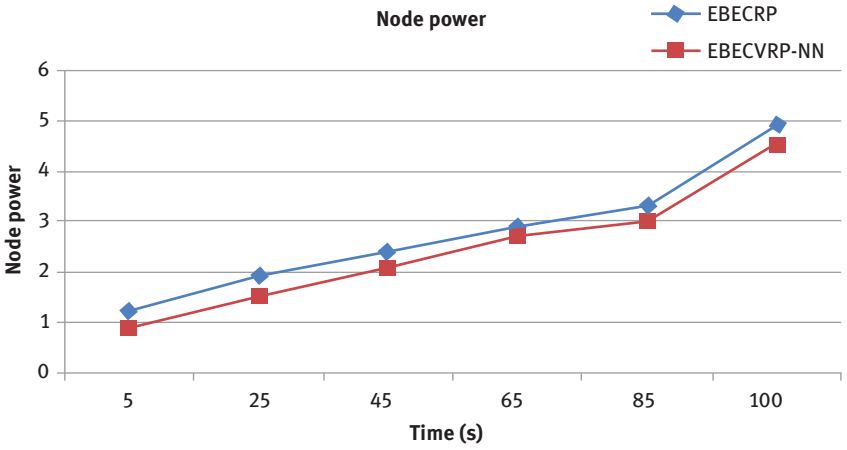


Figure 5.6: Node power comparison.

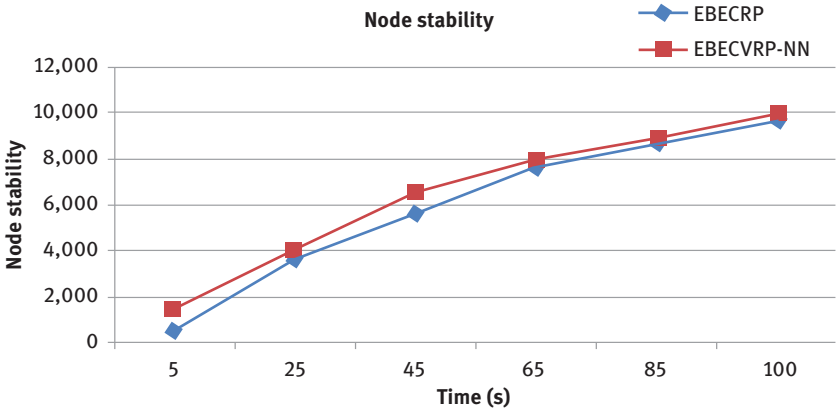


Figure 5.7: Node stability between the nodes.

Node mobility: Node mobility is taken into thought too well for energy consumption as well as propagation delay performance. As shown in Figure 5.8, the node mobility is that in which it counts the mobility of each node in the network. While there is extra fault-tolerant in the network, then the node mobility is increased at a steady rate.

Packet acceptance ratio: It is the proportions of progress full bundles got at the movable sink on the way to the number of packets sent to the moveable sinks at a typical time between times. As shown in Figure 5.9, the bundle acknowledgment proportion of the proposed calculation is contrasted and the current calculation. It has been analyzed that when a large number of packets are delivered at the destination it also increases the PAR value.

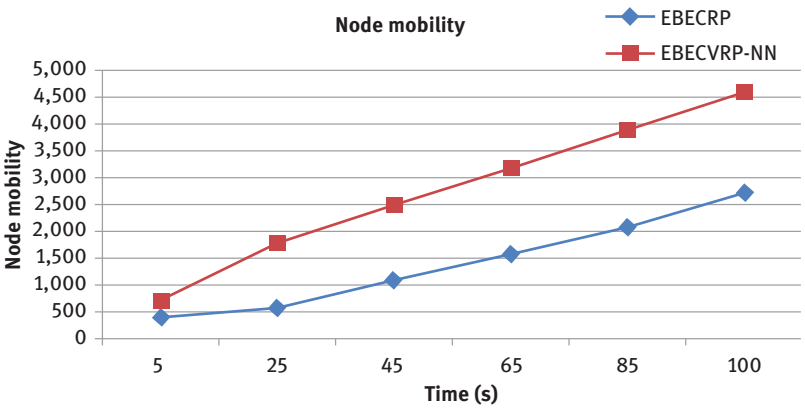


Figure 5.8: Node mobility between the nodes.

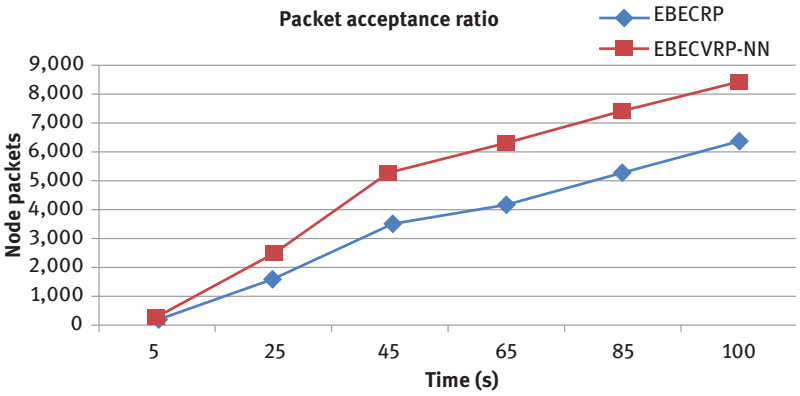


Figure 5.9: Packet acceptance ratio.

5.5 Conclusion

In this chapter, it has been concluded that UWSNs are the type of sensor networks that are deployed in the deep to detect underwater situations. The entire system is isolated into lasting size clusters, and CHs are picked from all clusters scheduled on the basis of energy as well as distance. This chapter chooses clusters to head utilizing neural systems, which directs to a reduction in energy consumption and increases network lifetime. However, in the future, the proposed algorithm able to overcome existing other energy efficient methods of UWSNs. The proposed system can be additionally enhanced to expand the security of the system utilizing shared validation procedures.

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6 A review of global optimization problems using meta-heuristic algorithm

Abstract: Accurate (traditional) optimization algorithms are unable to provide an appropriate result for the optimization problems with a large dimension explore space. In such problems, the explore space raises exponentially with the size of the problem. The classical (traditional) probabilistic optimization algorithm is a heuristic algorithm, but the validity of the algorithms is a difficult task for each problem. So, meta-heuristic algorithms solve such problems and explore the large spaces of population-based or candidate solutions, which are capaciously deployed to obtain the result of the optimization problem nowadays. Due to local exploitation and global exploration capability, population-based meta-heuristic algorithms are particularly used for global researches. The objective of this chapter is to analyze the performance of meta-heuristic algorithms and to examine the exploitation and exploration of discrete and continuous space.

Keywords: optimization, meta-heuristic algorithms

6.1 Introduction

In the past few decades, several optimization algorithms have been used to derive solutions using traditional as well as probabilistic algorithms in nature. In inaccurate (traditional) optimization algorithms, the construction and execution of algorithms generally depend on multistage programming. The optimization algorithms provide local and global solutions to real-world problems. Global optimization gives a better opportunity to obtain global or near-global optima compared with local optima. In global optimization, there is no assurance of getting exact results but there may be an approximate solution. Such an optimal solution may be obtained by a deterministic or probabilistic approach. So, meta-heuristic methods are more effective and popular methods compared to traditional methods in solving optimization problems and are executed in various fields including transportations, engineering business and social sciences. A review of meta-heuristic algorithms is pursued by population-based meta-heuristics. Some meta-heuristic algorithms with population-based structure have been depicted to deal with optimization problems

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with large dimensions. Genetic algorithm (GA), ant colony optimization (ACO), particle swarm optimization (PSO), differential evaluation (DE), multiverse optimizer (MVO), biogeography-based optimization (BBO), flower pollination algorithm (FPA) and harmony search (HS) algorithm fall in the category of such algorithms. These algorithms and their developed systems have depicted a better advancement in several problems such as data mining, optimization of function, and neural network.

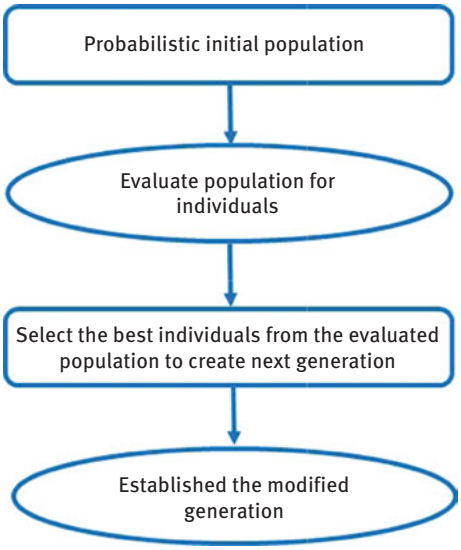

Figure 6.1: Evolution process of meta-heuristic algorithms.

This chapter is a classified review of the population-based meta-heuristic algorithm. The framework of this chapter is summarized as a literature review of meta-heuristic algorithms, as discussed in Section 6.2. Issues of optimization techniques and their application are provided in Section 6.3. An overview of concerned work being described in many population-based, meta-heuristic algorithms in search spaces is defined in Sections 6.4, and Section 6.5 concludes.

6.2 Literature review

This section provides contrasting knowledge about the past three decades of surveys on traditional meta-heuristic algorithms. So, we have adopted surveys that have an extraordinary effect on contemporary studies reflected, which refer exhaustive references for researchers who are curious in exploring meta-heuristic algorithms. Many

researchers have executed and analyzed meta-heuristic algorithms within different frameworks. Askarzadeh [1] established the crow search algorithm (CSA), which describes concealed surfeit food and regaining of it when required. Beheshti et al.'s [2] population-based meta-heuristic algorithms have a more effective ability to provide global solutions for global and local exploitations. Various meta-heuristic algorithms have been examined for continuous and discrete search space. Bianchi et al. [3, 4] proposed ACO, evolutionary computation, Simulation Anneling (SA), tabu search (TS) and stochastic partitioning approach and has focused on their research categorization. Binitha et al. [5] discussed bioinspired algorithm surveys. Boussai et al. [6] focused on a detailed survey of meta-heuristic algorithms. Camacho-Villalon [7] discussed the water-level amount required in soil in the intelligent water drop algorithm. Dasgupta and Michalewicz [8] discussed the engineering application aspect of evolutionary algorithms based on industry problems. Dokeroglu et al. [9] very extensively prepared a detailed study of meta-heuristic algorithms, specifically focused on 14 outstanding meta-heuristic algorithms rather than classical algorithms. These 14 meta-heuristic algorithms are selected based on their effective and efficient performance and high citations. Erol and Eksin [10] developed an algorithm on the basis of the theories of evolution inspired by the universe. Espejo et al. [11] depicted the classification of study in genetic programming. Fister et al. [12] gave a broad spectrum of reviews about the firefly algorithm. Guo et al. [13] explained the effect of migration rates on BBO, which are useful for designing of migration model. Khademi et al. [14] proposed significant and expanding research of BBO and its application in different fields. Goldberg [15] extensively elaborated on the optimized solution by GA and machine learning. Gong et al. [16] studied hybrid algorithms of DE and BBO for searching numerical to optimize. Hussain et al. [17] reported extensive literature of meta-heuristic algorithms, which rigorously explain algorithms, applications, comparisons and analysis. Hordri et al. [18] evaluated the performance of BBO, GA and PSO for convergence. IIhem et al. [19] obtained the result for the given objective function for the constraint-based optimization (inequality and equality) problems using BBO. Jafari and Nikolaidis [20] proposed a challenging meta-heuristic algorithm to obtain the global optimal solution for gas turbine aeroengine. Karaboga [21] gave a detail of the idea of honeybee optimization borrowed by the artificial bee colony (ABC) optimization algorithm. Kennedy and Eberhart [22] developed a new algorithm to analyze species activity. Kennedy et al. [23] proposed a new approach of swarm intelligence that explores the idea of emigration and immigration. Kotinis [24] analyzed multiobjective constraint-based problems using a PSO algorithm. Koziel and Yang [25] elaborated optimization methods with computational algorithms and coding. Mahdavi [26] stated the art of meta-heuristic algorithm and its recent application in large-scale global optimization problems. These algorithms are more effective and efficient to provide better outcomes in the field of engineering, science, business and economics. Mallipeddi and Suganthan [27] discussed the DE algorithm with an ensemble of parallel populations wherein the number of functions evaluated by taking successive

iteration for obtaining global numerical optimization. Mirjalili et al. [28] developed the MVO algorithm. This algorithm is based on physical phenomena (big bang and cosmology) wherein the concept of the black hole, white hole and wormhole is applied for exploration, exploitation and search space locally. Ma and Simon [29] studied the BBO algorithm to analyze the performance of constrained and unconstrained benchmark functions. Ma [30] explained the migration models in BBO and explores the execution through different benchmark functions. Ma and Simon [31] investigated BBO evolutionary algorithm papers since the past decade wherein they summarized and organized the literature. Qu and Suganthan [32] obtained the adaptive weighting coefficients for each point for solving a linear programming problem which updated the design variables and converted the single-objective problem after linear approximation. Rao et al. [33] explore the teacher learning based optimization (TLBO) algorithm, which is a population-based meta-heuristic algorithm wherein a group of learners, that is, population (classroom) and trainer, is considered. Rashedi et al. [34, 35] proposed a new algorithm based on the law of gravity agents attract each other by gravitational force. Ray and Liew [36] discussed the multiobjective optimization problem with a swarm metaphor. Shabani et al. [37] have given the new idea of refining the HS optimization algorithm. Simon [38] established a new vision toward the study of the biographical optimization algorithm. Sorensen [39] discussed meta-heuristic algorithms based on the metaphor of some man-made process or natural process. Sorensen et al. [40] studied and accumulated in one frame and spread out the vast knowledge of the meta-heuristic algorithm. Storn and Price [41] proposed a new approach to obtain global optimum solutions for different population sizes. Trelea [42] studied the convergence analysis of PSO algorithms by varying the various parameter. Talbi [43] prepared a detailed sketch from design to implementation for the meta-heuristic algorithm. Uymaz proposed a [44] biometa-heuristic optimization algorithm, known as artificial algae algorithm, inspired by the living behavior of microalgae and photosynthetic species. Wang [45] established a moth search algorithm which provides the information on levy flights of the moths inspired by phototaxis and levy flight.

Viveros et al. [46] discussed an effective heuristic algorithm that is applied to find the optimization solution globally by adopting the nearby evolution. Wang et al. [47] proposed a hybrid HS algorithm with the cuckoo search for global numerical optimization. Wang and Guo [48] developed a hybrid bat algorithm with a HS for global numerical optimization. Wei and Qiqiang [49] highlighted a detailed survey of PSO algorithm. Weian et al. [50] introduced migration models for multi-objective problems (MOPs) using BBO. Zavala et al. [51] used meta-heuristic algorithms for analyzing the multiobjective functions. We have elaborated on the detailed study of meta-heuristic algorithms in the literature survey and on that basis the categorization of algorithms has been developed and depicted by the pie chart in Figure 6.2.

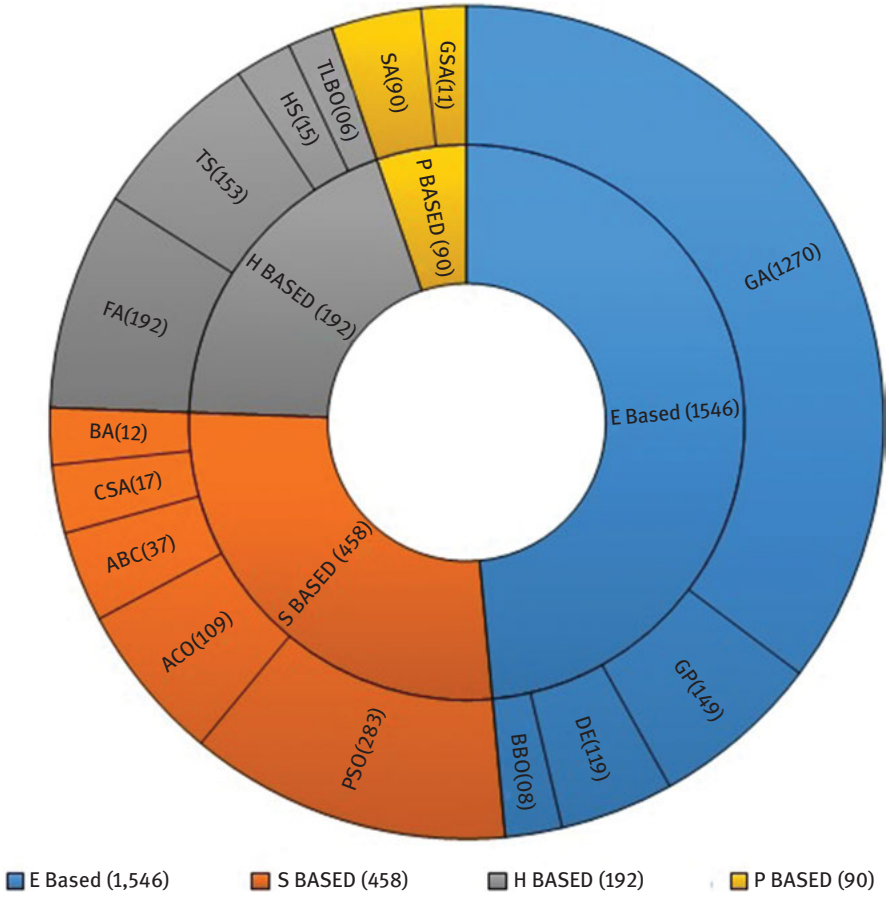

Figure 6.2: Classification of meta-heuristic algorithms.

6.3 Issues of optimization

Optimization algorithms have been studied by many authors. The implementation of the optimization algorithm is a very challenging task for researches depending on the nature of the problem, desire solutions, available resources of computing, computing time, availability of the algorithm implementation, complexity of the problem and final decision of the maker. Thus, many factors are involved in it. However, we emphasize broadly on the following four major issues:

- Simulation-driven optimization
- Effectiveness of algorithm
- Accuracy and efficiency of numerical result
- Implementation of the most efficient algorithm

The selection of the algorithm based on the problem that provides appropriate results is a difficult task, which depends on many empirical observations. Researchers do not have any universal guidelines on which kinds of algorithms provide better outcomes for any particular problem. Conventionally, the researchers use the following methods such as Newton, Hill–Climbing, Nelder–Mead downhill simplex, trust region, and interior point to work out the solutions of the real word problems. After the implementation of these methods, there is no guarantee to determine the desired solutions. The nature of such nonlinear problems is NP-hard and it can be addressed by global optimization algorithms. Global optimization algorithms are capable to give good solutions, desirably also the global best solution. Generally, optimization algorithms are mostly classified into two categories: stochastic and deterministic. Several methods like probabilistic and deterministic are enhanced by applying hybridization. Figure 6.3 depicts the various branches of optimization algorithms.

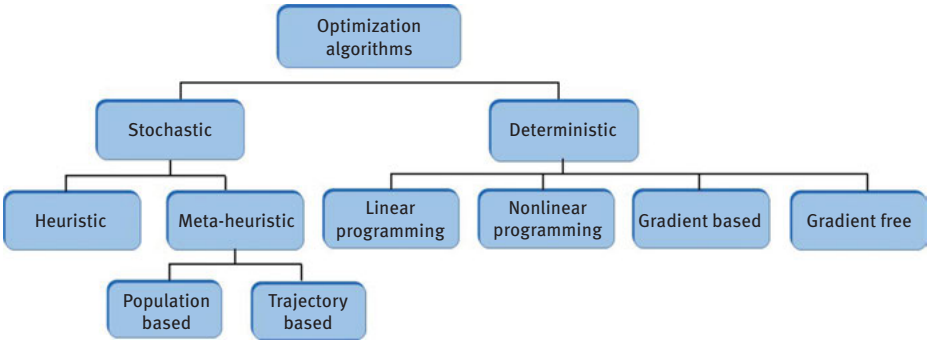

Figure 6.3: Classification of optimization algorithms.

It is to secure the computational time by fewer iterations or by increasing the simulation in the optimization algorithm. The aim is to reduce the number of iterations as well as to apply effective algorithms.

6.4 Meta-heuristic algorithms

Meta-heuristic algorithms are iterative and nature-based algorithms. Meta-heuristic word is made of two individual words "meta" and "heuristic." Meta means higher dimension and heuristic means to obtain or to explore. These are used to construct the formation in sequence to obtain an effectively optimal solution. There are several books that emphasize meta-heuristic algorithms such as Yang [52–55] and Talbi [43]. There are many meta-heuristic algorithms such as GA, DE, PSO, BBO,

FPA and MVO. A successive iteration process that demonstrates several views for exploiting and exploring the search space which is discussed and learning strategies are applied to construct the information in sequence to obtain effectively approximately optimal results. Nature-based meta-heuristic algorithms are divided into four categories, as shown in Figure 6.4.

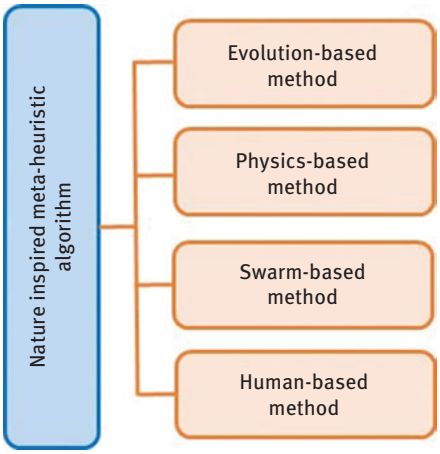

Figure 6.4: Types of nature-inspired meta-heuristic algorithms.

Evolution-based meta-heuristic algorithms: Algorithms are developed by the rules of evolutionary nature. The group of the population is developed randomly. The optimal solution is formed step by step to next-generation population method which goes on till it reaches the best solution.

6.4.1 Genetic algorithm

GA is a popular evolution-based method, which was introduced by Holland (1975). Furthermore, this algorithm was upgraded by researchers. Many researches have been carried on based on the theory of Darwin. GA basically depends on the selection, crossover and mutation to terminate the not best solution and searching next to next generation to obtain best solution, a group of all elements is called 'genes' which indicate a set of solutions for the optimization variables. GAs are totally based on chromosomes (strings) and are a subsequent class of evolutionary algorithms. In this algorithm, the elements of the explore search space are arrays or binary string types. In the reproduction operation, genotypes are applied when the results of the objective function (fitness functions) are calculated on the phenotypes in the problem space by the genotype–phenotype image we have obtained in the problem space.

Let us consider the following maximization problem:
Maximize $f(y)$;

$$y_j^{\mathrm{l}} \le y_j \le y_j^{\mathrm{u}} \quad i = 1, 2, 3, \ldots, N$$

where y_j^{l} and y_j^{u} are the lower and upper bounds of the variable y_j. A maximization problem can also be solved using GA.

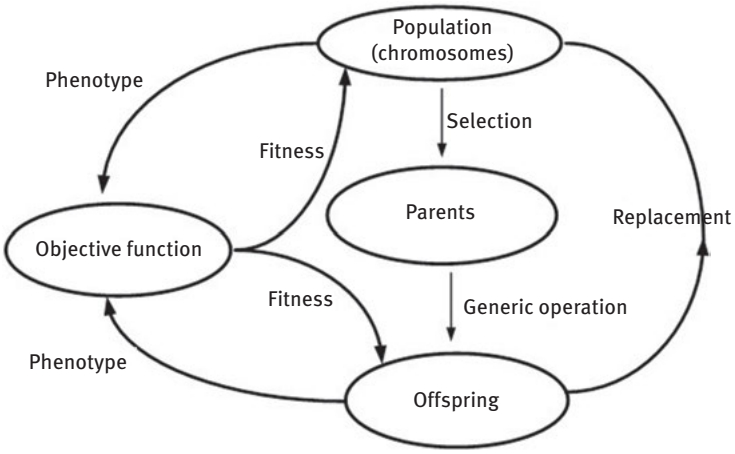

Figure 6.5: Genetic algorithm cycle.

The fitness function was calculated to near the individual's desirable result. A fitness function may be complex or simple. It is based on the optimization problem.

Individuals were chosen according to a process based on fitness. Selection's operator fabricated the selection procedure and selected the ranking. More individuals were fitted in the optimization problem for better results to be provided in the upcoming generation.

Parent 1:	**1100**	**10110**	**1011**
Parent 2:	0110	11001	0100
Offspring 1:	1100	11001	1011
Offspring 2:	0110	10110	0100
		A Crossover operation	
Parent:	1100	1	0011011
	11001	0	00110011
		B Mutation operation	

In this operation, the bit values of each string were (randomly) discretely reserved in accordance with a special property. A mutation process may support the GA to ignore the local optimum and obtain the best result globally.

6.4.2 Biogeographic-based optimization

BBO is a new seeming population-based algorithm. BBO algorithm is proposed by Simon [38]. BBO is based on the immigration and emigration of the biological organism. The immigration rate finds the solution of biological organisms and changes its decision variables. It has depicted more improved performance of many constrained and unconstrained benchmark functions. Mathematical modeling is based on BBO. In BBO, we examine how to move the biological breeds from one part to another part. In BBO, how new breeds generate and damage the breeds. Emigration and immigration are effected by some components like that habitat suitably index (HSI). These components promote the tacit of breeds in an area. HSI hinges on several factors atmosphere, vegetation, rainfall, and so on. These factors help the tacit of breeds. Allocation of breeds and high HSI is steadier to low HSI.

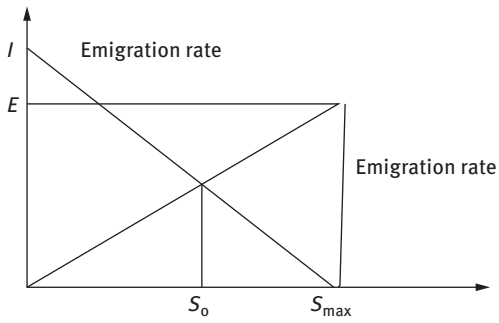

Figure 6.6: Migration.

Migration and mutation are the main operators of BBO.

Migration: To study for enhancing the candidate solution G_i for every merit of a provided candidate solution g_i. The immigration rate of candidate solution p_k is applied to decide randomly which is immigrate or not. If it is possible, then the candidate solution of emigration g_i is randomly selected, based on the rate of emigration r_k. It is shown as

$$g_i(q) \leftarrow g_j(q) \tag{6.1}$$

where q is a candidate solution, g_i has personnel immigration rate p_k and emigration rate r_k. The validity of the result depends on high r and low h and for the weak candidates, the vice versa is true.

We can find the immigration rate p_k and emigration rate r_k of the candidate solution by eq. (6.1):

$$p_k = 1 - \text{fitness}(g_i)$$

$$r_k = \text{fitness}(g_i)$$

where the range of fitness value is [0, 1] and we obtained the probabilities of immigration to g_i and emigration from g_i

$$P_r\ (\text{immigration to } g_i) = p_k$$

$$P_r(\text{emigration from } g_i) = \frac{r_k}{\sum_{j=1}^{N} r_j}$$

where N is population size.

6.4.3 Physics-based meta-heuristic algorithms

These algorithms are based on physical phenomena in the cosmos which provide better results in optimization. MVO, black hole algorithm (BHA), artificial chemical reaction optimization algorithm (ACRO), big bang big crunch (BBBC), ray optimization algorithm (ROA), curved space optimization (CSO) are the most recognized algorithms. Such few algorithms are mentioned as follows:

- MVO
- BBBC
- BHA
- ROA
- CSO
- Artificial chemical reaction optimization (ACRO)
- Central force optimization (CFO)

6.4.3.1 Multiverse optimizer

MVO algorithm is based on the theory of physics which is introduced by Mirjalili (2016) and considered as the source of everything happening in the world, and existence of this world depends on a big bang theory; now there is another way known as multiverse theory. According to multiverse theory, more than one universe exists in the world. These universes may follow the law of physics; there are collisions, interactions

and other phenomena. This algorithm are mostly based on the concepts of white holes, black holes and wormholes, which are accepted by the multiverse theory. In this theory the white holes are created by collisions of parallel universes. Black holes are generated by the attraction of every object including beams of light with high gravitational force and wormholes are generated by connecting or joining all other parts of the universe with each other. These holes connect other parts of the universe; it is used as a tunnel by the objects to move from one area to another area in the universe. Also, it gives the path to travel from one universe to another for the object. All three main components are depicted in Figure 6.7 (white holes, black holes, wormholes). Every universe has its exact inflation rate which is accountable for the expansion of the universe in terms of space.

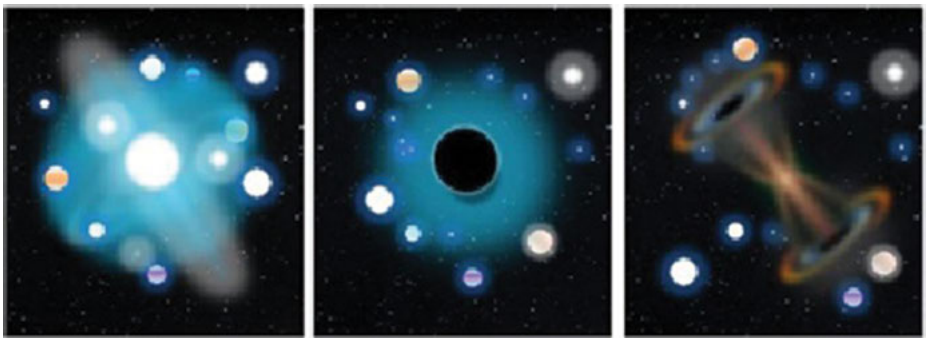

Figure 6.7: White hole, black hole, wormhole.

The inflation rate is a very important part of every universe. The generation of asteroids, stars, planets, physical laws, suitalbility for life due to White, Black and Wormholes, they depend on the inflation rate. White, black and wormholes depend on the inflation rate. All three holes are a technique for all universes to attract with each other to acquire stable stars; this theory provides the basic knowledge of the MVO algorithm.

Some rules are framed to obtain optimization solution by applying the MVO algorithm with the consideration of phenomena of the universe which are

- Inflation rate $\propto$ existence probability of white holes
- $\text{Inflation rate} \propto \dfrac{1}{\text{Existence probable of black holes}}$
- The universe with a greater inflation rate tries to send objects via white holes.
- The universe with smaller inflation rate try to received obtain objects via black holes.
- Objects of all universes move randomly toward the best universe through wormholes without considering the inflation rate.

6.4.4 Swarm-based meta-heuristic algorithms

This algorithm is based on the social behavior of chemicals or herd. The PSO algorithm is more popular and is originated by Kennedy and Eberhart (1995) in order to find the best result to provide search space. In PSO, exploitation and exploration are awareness and social parameters join to search space. Several optimization algorithms are demonstrated in swarm intelligence. These are

- PSO
- FPA
- ACO
- CSA
- ABC
- Bat algorithm
- Whole optimization algorithm
- Dragon files
- Bacterial foraging optimization algorithm

6.4.4.1 Particle swarm optimization

PSO is one of the population-based stochastic optimizations which is inspired by flocking and schooling deportment of birds and fish. PSO algorithm offer the best solution by upgrading the current solution. It provides better results in a faster manner and cheaper way. PSO algorithms are capable to deal with many such as multiobjective optimization, security, electronics, and neural network. In PSO, the potential resolution referred to particles fly through the matter area by following the present optimization particles. Eventually, particles keep track of its coordinates within the downside area that square measure related to the fitness function achieved thus so far. This Wroth is termed as best and another best Worth that's half-track by the PSO is that the best wroth, obtained thus so far by any particle within the neighbors of the particles. This word is best. Once a particle takes all the population as its topological neighbors, the simplest worth maybe a world best and is named g-best. The PSO idea consists of several and different steps by changing the acceleration of every particle towards its p-best and I-best versions. Acceleration is weight by the random term, with separate random numbers being generated for acceleration towards g-best and I-best location when finding the simplest values:

$$Z[ip] = z[ip] + Q1^{*} r(ip)^{*} (p^{\text{best}}[ip]) + Q2^{*} r^{*} (ip)(g^{\text{best}}[ip] - X[ip])$$

$$X[ip] \ = X[ip] \ + z[ip]$$

where $Z[ip]$ is particle rate, $X[ip]$ is the current particle, $r[ip]$ is random range between [0,1]

$Q1$ and $Q2$ are learning factors typically $Q1 = Q2 = 2$

6.4.4.2 Flower pollination algorithm

FPO was introduced by Yang [52]. Most real-world optimization problems are highly nonlinear, very complex and involve many different variables under certain constraints. Many researchers are taking inspiration by nature-inspired meta-heuristic algorithms, which are capable of obtaining the optimal solution improved step by step to the next search. But there is no surety that the desired optimality is more reliable for such problems. Flower pollination is a method of translocation of flower pollens. The birds, bats, insects and other animals perform such translocation. Some flowers and insects are specialized as flower pollinator partnerships. The process of pollination is described in the figure and it is expedited by an agent. The result of fertilization is pollination which must be used to grow fruits and seeds. Pollination is classified into two ways:

- Self-pollination
- Cross-pollination

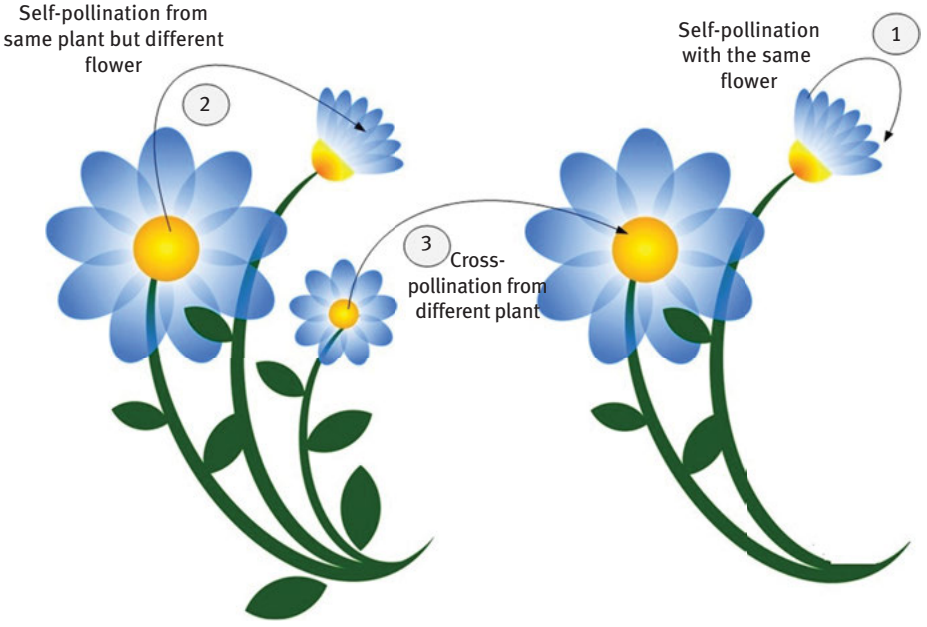

Figure 6.8: Process of pollination.

A. Self-pollination: The pollination of the same flower of the same plant is called self-pollination. In this phenomenon, pollination occurs between male and female gametes.
B. Cross-pollination: It occurs with the help of biotic agents and other animals. They are called pollinators. When the pollination has occurred without the entanglement of peripheral agents as well as external agents, it is known as biotic pollination. Biotic pollination may occur at a long distance which is performed by insects, bees and bats that can fly a long distance. When some birds or insects visit certain types of flowers at the same time, these insects sidestep other species of flowers and such happening is known as flower consistency. Such flower consistency can be advantageous for pollinators that are capable of providing the guarantee of maximum reproduction. Moreover, flower consistency can be used as an incremental step using the similarities or differences of two flowers. Such a method gives global pollination. In global pollination, the pollinators, insects, pollens and birds can go up to a very long path. Let $p^{\star}$ indicate the fitness flower congruity and first mathematical expression as

$$Y_i^{g+1} = Y_i^g + L\left(Y_i^g - p^*\right)$$

where Y_i^g is a solution vector Y_i at step g and p^*, p^* is a running (current) best solution obtained out of all solutions at the running iteration. L is the capacity of pollination. The birds go the very long distances; it can be caricatured applying Levy flight. By Levy distribution $L > 0$

$$L - \frac{\mu\mu\ \sin(\mu\pi/2)}{\pi}\frac{1}{1+\mu} \quad d >> d_0 > 0$$

where μμ represents the gamma function and very large steps $d > 0$.

6.4.5 Human-based meta-heuristic algorithms

It is introduced by the betterment in the stage of exploring techniques. Some human-based meta-heuristics are:

- TLBO
- HS
- TS
- Firework algorithm
- Exchange market algorithm
- Social-based algorithm

In such a manner, meta-heuristic algorithms are classified to obtain the improved result of the objective function for a particular task.

6.4.5.1 Harmony search

The HS algorithm is a music-based algorithm. It was introduced by Geem et al. (2001). It can be discussed by the enhancement of musician's thoughts. In HS algorithm musician has three main cases: (1) Play any popular part of music definitely from his/her harmony; (2) play some famous part which is similar (slightly change the pitch) and (3) play random notes or new composition. If we arrange the cases for optimization then we have three-part composition using HS, pitch settlement and stochastic process (randomization). A significant lap is the pitch settlement, which can be deemed a local search path. If Y_{old} is the present solution (or pitch) then the new solution (or pitch) Y_{new} is developed by

$$Y_{\text{new}} = Y_{\text{old}} + c_{\text{p}}(2\varphi - 1)$$

where φ is the stochastic number between [0, 1] and c_{p} is the bandwidth which handles the low range of pitch settlement.

It observes that the pitch settlement by the above equation in a stochastic path. The application of randomization is to obtain global optimization.

6.4.6 Differential evolution algorithm

DE is a meta-heuristic algorithm as well as a population-based algorithm. DE is based on the main components mutation, crossover and selection. DE is introduced by Storn and Price [41], which is used in many technical and social problems in several fields. In the DE algorithm, mainly three basic benefits have to find fast convergence rate, control parameters and true global parameter values. We use the conventional denotation which are $y_i = (y_i, y_{2i}, y_{3i}, \ldots, y_{ni})$ a population of n solution vectors. For each solution y_i at any generation.

(i) **Mutation**: A mutant vector is generated by

$$u_{i,}\, G+1 = y_{i,}\, G + R(y_{t1,}\, G - y_{i,}\, G) + Q(y_{t2,}\, G - y_{t3,}\, G)$$

where $t_1, t_2, t_3 \in \{1, 2, 3, \ldots, NP\}$, Q is the scaling factor and R is the combination factor.

(ii) **Crossover**: A trial vector $V_{ij,}\ G+1$ is generated by mixed parent vector with mutation

$$V_{ji}, G+1 = \begin{cases} u_{ji,}\ G+1 \text{ if } (tnd_j \le \text{CR}) \text{or} \quad j = tn_i \\ w_{ji,}\ G \text{ if } (tnd_j > \text{CR})\ d \quad j \neq tn_i \end{cases}$$

where $j = 1, 2, 3, \ldots, D$; $t_j \in [0,1]$ is the random number, CR is crossover constant $\in [0,1]$ and $t_{ni} \in (1, 2, 3, \ldots, D)$ is the arbitrarily chosen index.

(iii) **Selection**: In the population, all solution has chosen as parents for fitness value is independent. After evaluation of mutation and crossover, the child is selected and comparison of the performance of the child and parent better one is chosen. If the parent is a little better, then it is maintained in the population.

6.4.7 Other meta-heuristic algorithms

We summarize the information about some more meta-heuristics algorithms. Most of the meta-heuristics have been introduced for the past two decades. There are nature-inspired and population-based algorithms. Animal herds can accept very critical behavior. We observed that such type of behavior has acquired many studies. Askarzadeh [1] introduced the CSA. This type of algorithm is inhabitant based and connects to the crows; they conceal their extra food for further need. Yazdani and Jolai [56] forwarded the lion's algorithm which is nature-inspired and explains the behavior of lion herd and search the optimal solutions from global search space. Wang et al. [57] explained the elephant herding optimization algorithm which is connected to the elephant's behavior. They live in a group and the group is left by the male elephants when they become mature or adults. The nature of the elephants can be applied to detaching operators and updating or improving the dynasty or family. Neshat et al. [58] proposed a report on artificial fish swarm algorithm. Mirjalili et al. [59] developed a salp swarm algorithm of single and multiobjective optimization problems, which is based on the behavior of salp freely swimming throughout their steering and food exploration in sea or ocean. Ofradch et al. [60] introduced a hunting search algorithm which is inspired by carnivorous animals such as lions, wolves and dolphins. Such types of animals explore and traps prey by applying the rand and siege operations. Each animal connects to other animals with respect to their locations. Jain et al. [61] provided a squirrel search algorithm. This algorithm pretends the rummaging behavior of airborne squirrels, and their path of movement is called slithering. Lam and Lin [62] pretended the attraction of atoms/molecules and got the (low energy) stability of low energy in chemical reaction optimization algorithms.

6.5 Conclusion

The review indicates the typical issues about meta-heuristics and recent opinions for research approaches and open issues in nature-inspired population-based optimization. In this manner, to observe the challenging issues, we compare the new- and old-generation meta-heuristics algorithm and the main features are exploitation and exploration of the meta-heuristics algorithms. These features can balance the

optimization process. The study of new-generation meta-heuristics algorithms shows the huge amount of parameters which is the drawback of meta-heuristics algorithms, but to acquire the high-quality results inadmissible amount of time is needed for optimization. These parameters are used by meta-heuristics to obtain the solution of large problems in tenable time while the traditional algorithms take more time. The previous research reveals that several difficulties are affecting the enactment of meta-heuristics. Giving better durability between diversification and intensification is off the field. Diversification is used for the solution of global searches whereas intensification is used for local searches. It has been observed that in many cases, the performance of the optimization problems depends on the tuning of parameter and significant effect of execution of meta-heuristics algorithms.

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7 Secure indexing and storage of big data

Abstract: Health-care sector generates a large volume of data as and when patients visit the hospital in different forms, such as medical reports, computed tomography scans and other magnetic resonance imaging reports. There are structured, unstructured and semistructured data which are to be taken care of by different tools and entities. Integration of stored medical data is required to generate a better health-care system that will be capable of handling several aspects easily. As the data is in a separate and different pattern, personal health record system comes into the picture which handles large data with improved indexing and helps in secured transmission. As data are involved in various size and length, data compression, minimization, encrypting and decrypting become a challenge. The algorithm in use takes huge time to fetch and store data due to involvement of MD5 hashing technique. This chapter deals with the storage of huge volume of data in the cloud and efficient way to extract the required data from the cloud in less time. Hence, to improve compression, storage time and retrieval time, an updated algorithm is presented in this chapter. Security and storage improvement are attained by hyperelliptic curve cryptography with asymmetric encryption technique and SHA2 for hash algorithm carried out by discrete wavelet transform compression reduce cloud occupancy. This approach over the simulation parameter and environment outperforms its best while comparing it with the Electronic Health Record (EHR) technique.

Keywords: health-care storage, redundancy, virtual machine, de-duplication, data security, SHA2, HECC

7.1 Introduction

The cloud storage is a space or location available to store data or file, and retrieve or access data on remote servers that can be accessed from the cloud over the Internet [1]. The data are managed, maintained, stored and backed up remotely in the cloud, for which the users generally pay charges monthly or per consumption rate of space in the cloud. Cloud storage uses data centers with massive or big computer servers that can physically store data and make it available online to users via the web over the Internet. Users can upload their content over the Internet, store them and retrieve

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the data as and when required remotely. One of the various available options for data management is cloud storage. Many storage service providers are available to store data in the cloud. To opt for a cloud service, it becomes very important and crucial to select the required parameter and understand the working of cloud storage.

The cloud storage uses a long chain of servers which includes both master control server and storage servers [2]. The servers are all interlinked with one another and can be utilized depending upon our specific uses and requirements, which can be charged based on data size. Cloud storage saves lots of money, which otherwise would require amount on more strong servers as business needs increase. In cloud storage, we only pay for the space used by the data in the cloud [3]. Figure 7.1 shows the cloud computing environment.

Figure 7.1: Cloud computing environment [4].

7.1.1 Redundancy in cloud computing

Cloud processing could be portrayed as maintaining copies of different types of data and tools to be used as a piece of an event, in which a bit of one's cloud registering structure crashes and burns. This abundance is made open by having replicated data. A couple of conditions on various PCs or units required in comparable server on

cloud computing in distributed modes provides customers with the reason along with beneficial compensation as we use. Cloud customers pay only for the exact usage of pointing resources, accumulating, transmission limit, as demonstrated by their requirement, utilizing the cloud's resources and computational capacities. Cost of cloud use is a basic problem when attempting to reduce the price. Also, there may be redundant data existing on the cloud, which may increase the server cost, computational cost, bandwidth and access time. There are various redundancy elimination techniques used in the cloud to eliminate duplicate data [5].

7.2 Preliminaries

The literature review describes the survey about the previous author's work, their approach and their problem analysis which come out after discussion. This discussion gives an evaluation of the proposed algorithm which can be expected and can be derived using given drawbacks.

7.2.1 WANAX: wide area network acceleration for the developing world

Ihm et al. [6] proposed a strategy for wide area network (WAN) quickening. Here most of the network traffic occurs between the sender and receiver during transmission of similar data over and again, that data may contain records, reports, video's and so forth. Lately, different traffic redundancy and elimination (TRE) strategies have been created for taking out repetitive information. WANAX is a WAN accretion quickening agent that dispenses with repetitive system traffic from point-to-point correspondences, empowering higher successful data transmission. Here sender center box holds correspondence convention stream and sends a mark to recipient center box, at that point beneficiary looks at the information found in reserve the information which isn't found in the store is recovered from sender center box or firmly related collector center box this causes 3-way handshake [6].

7.2.2 PACK: prediction-based cloud bandwidth and reduced cost system

Zohar et al. [7] proposed a system called PACK in 2014. The creator delineates the present methodology which is PACK algorithm for traffic reiteration disposal structure. PACK utilizes sender-based methodology and the beneficiary-based methodology for

excess disposal. Here information is partitioned into little pieces. The recipient registers the separate mark for individual pieces and searches for a similar identification in its lump store nearby. If lump's mark matches then the collector decides if it is a part of a recently gotten chain, making use of the part in the metadata. On the other hand the recipient transmits a message to the sender for the next expected lumps chain. The sender reacts with a prediction acknowledgment message as a beneficial expectation [7].

7.2.3 TRE: survey on traffic redundancy and elimination approach for reducing cloud bandwidth and costs

Ihm et al. [6] proposed a technique known as TRE. In the request of evacuating repetition, we are utilizing the TRE approach. An enormous measure 6 of prevalent content is moved over and over crosswise over the system that connects on the web. To move the data between the sender and collector, information is isolated into lumps. Piecing component improves the proficiency by parallel transfer/download of various lumps and each piece creates a mark to move information in a secure way [8].

7.2.4 CORE: cooperative end-to-end TRE technique

Lei Yu et al. proposed a technique called as CORE in 2007. Agreeable end-to-end TRE strategy is a productive TRE answer for administrations that are on cloud CORE and have an idea of expelling present moment and long-haul repetition with the goal that excess can be disposed off effectively.

It has two layers: in the primary layer, TRE performs forecast-based coordination of information to discover long-haul traffic excess. The second layer TRE inspects maximal copy substrings with an active piece and contrast and recently transmitted information in a nearby lump at the sender call as IN-lump Max-Match. If the repetition assurance comes up short from the outset layer, CORE checks it on the second layer to discover momentary excess inside lumps. The calculation cost of deciding transient repetition is more than the long haul. The center joins different structure advancement to decrease calculation cost. Here information is isolated into little pieces and examination of lumps mark is discovered.

7.2.5 Authorized data deduplication using hybrid cloud technique

Mane Vidya Maruti et al. proposed a procedure data deduplication utilizing crossover cloud. Distributed computing is crucial in the data-sharing application. Step-

by-step usage of cloud is growing. In this method, the client needs to be present the record and verification of responsibility for then no one but the client can send the solicitation to check copy information on a cloud when there is both document and benefits of the client just that time it affirmed copy check demand. In this chapter, content, level deduplication and file-level deduplication of record data are taken a gander at over the cloud. Here, check on content at various levels is done, then based on hash match record content is executed. In this method, content level deduplication and file level deduplication of records are taken care. Here, check on content at various levels is done. Based on hash match record content is validated and repetition is resolved. This method proposed a new duplication check strategy that produces the token for the private record which checks content level duplication [9].

7.2.6 A lightweight process for eradicating superfluous resources on cloud

A. Bhavani et al. proposed this strategy in which clearing the duplicate resources stored on the cloud by checking small part of benefits by varying and then starting at current downloaded part, with the ultimate objective that spending on the client end would get reduced like cost, manual effort and computational time. The major objective is to reduce the burden on the server in checking duplicates to an effective level that the client on own can check for redundant resources by using perceptive assertion. This method moreover updates the plan of mentioning cloud client server migration, repeated resource saving. It is a new objective that would depend on the course of action like planning, differentiating past packs and just the created packages. The past plan relies on transmission control protocol, and enlargement was made to tackle all server platforms and server protocols. A lightweight strategy gives more endeavors on the customer side by contrasting previously obtained information signature and recently obtained information. This method finds the copy of information before downloading and settles issues like traffic advancement where spares time cost can be decreased. Here the essential thought is to download just a part of the record at that point registers its signatures at that point discover hash code contrast and existing code that is now put away if match discovered, at that point message copy generally transfer it [10, 11].

7.3 Problem definition

There are different cloud computing techniques with the data stored in the data center, where access is performed by different users. Multiple file upload and its

usage make duplication of data over the server. After verifying the diverse situation on the accessible system and comparing various results with the existing calculation over record-based deduplication are taken as a base for our exploration work. The following are the focuses that are distinguished as issues and further investigated to perform further upgrades.

- Existing techniques such as EHR, TRE, PACK and deduplication have no concept of security on data that are transmitted between the sender and receiver.
- There is no concept of similarity measure scope in survey techniques.
- The existing techniques deal only with textual data.
- The existing algorithm takes advantage of previous traditional techniques but still more refinements are required as per today's standard. Thus, for better security, hashing mechanism can make it more reliable and executable to tackle current security and cloud scenarios in the world.

7.4 Proposed methodology

As per the analysis done in problem identification and their limitation found in various terms and scenarios, our work presents a methodology that is profoundly secured and expends low computational time and low computational expense over the enormous number of organized accessible information collection. Our work includes algorithm, a calculation with more security using hyper elliptic curve cryptography (HECC) along with asymmetrical is performed with SHA2 function [12].

7.4.1 HECC algorithm for security intermediate level

Hyperelliptic curve cryptosystem security depends on the discrete logarithm issue. This issue maintains a strategic distance from the spy on breaking of a key of both P and S esteems known freely. Various kinds of bend need to be concentrated to comprehend about the open key as P, bunch point as (S) and hyperelliptic curve discrete logarithmic issue [13–15].

Hyperelliptic bend C of class gen >=1 over limited recorded E is the arrangement of (z, r) ϵ E*E for the following condition:

$$C{:}y2 + h(r)z = f(z) \tag{7.1}$$

where h(z) is a polynomial equation of degree gen and h(z) ϵ E(z), f(z) is a monic polynomial equation of degree 2gen + 1 and h(p) ϵ E(z). The bend C is a nonparticular

bend if sets are empty (z, r) ϵ E*E. Equations of polynomial f(z) and h(z) are picked in a way that they should fulfil the accompanying conditions:

$$2r + h(z) = 0$$

$$h'(z)r - f'(z) = 0$$

7.4.2 Kinds of variety bend

Family bend chooses the processing time of the HECC, for example, key, encryption and unscrambling steps. Estimation of gen chooses the equation polynomial of bend E like gen = 3, 4, 5. Polynomial equation picked on different 3, 4, 5, 6 and 7 over prime field Ep is mentioned beneath

Class gen = 2:

$$R2 = z5 + a4z4 + a3z3 + a2z2 + a1z + a0$$

Class gen = 3:

$$R2 = z7 + a6z6 + a5z5 + a4z4 + a3z3 + a2z2 + a1z + a0$$

Class gen = 4:

$$R2 = z9 + a8z8 + a7z7 + a6z6 + a5z5 + a4z4 + a3z3 + a2z2 + a1z + a0$$

Class gen = 5:

$$R2 = z11 + a9z9 + a8z8 + a7z7 + a6z6 + a5z5 + a4z4 + a3z3 + a2z2 + a1z + a0$$

Class gen = 6:

$$R2 = z11 + a9z9 + a8z8 + a7z7 + a6z6 + a5z5 + a4z4 + a3z3 + a2z2 + a1z + a0$$

7.4.3 Jacobian of hyperelliptic curve

The Jacobin bend C given over limited field E is meant by JC (E) [8]:

$$JC(E) = Dj0/z$$

$$Dj = \sum mipi$$

where Dj is a diminished divisor, mi is the focused number, Pi represents figures toward curve C. The decreased Dj as a divisor as said to utilize Mumford portrayal [16] frames the gathering law in Jacobian of a HECC [9, 17].

HECC comprise three procedures such as a key generate, data encryption and data decryption [18, 19].

7.4.4 Key generate

Information: The open parameters are hyperelliptic bend is C, Pi is prime and Dj is the divisor.
Output: P is the Public key and S is the Private or Secret key.
Procedure:
Private Key: Ki∈ RNi; Random Prime no (Ki) is chosen from Ni.
Public key: Pu□ Ki* Dj;
Do is the pair of polynomials which is [(u(z), v(z))] and Dj is the Divisor
Pair of key: [(Ki, Pu)]

7.4.5 Data encryption calculation

The plaintext(m) is converted to ASCII code format and qualities are in the Sequence (uz, vr). The encoded message alludes as Emes, which means it is pursued with the goal of encoding message. Emes is scrambled data of client P that is transmitted to client Q:

Secrete Key: Ki∈ RNi;
Ki(Irregular prime no) is picked from Ni.
Public key: Pu□ Ki. Di;
D0 is combination [(t(u), r(s))] where divisor is Dj.
Concurred key: Qa□ Ki. Pb; Pb is the collector's Public key.
Figure content: Cm□ {Qa, Emes + Pu}; Cm is said to be [(t(u), r(s))]

7.4.6 Data decryption calculation

To decode the figure content Cm, client Q removes the principal facilitate “Qa” from the figure message, then duplicate with it the secrete key (Ab) and then subtract the output from the subsequent organize. It can be composed as follows:

$$= \text{Emes} + \text{kPb} - \text{Ab}(\text{Qa}) = \text{C}$$

$$= \text{Emes} + \text{kPb} - \text{k}(\text{Ab.Dj})$$

$$= \text{Emes} + \text{kPb} - \text{Ab}(\text{kDj})$$

$$= \text{Emes} + \text{kPb} - \text{kPb} = \text{Emes}_1$$

These equations and security algorithms make use of cryptography in between packet transmission (shown in figure 7.2) and perform the security over data exchange.

The proposed work consists of enhancing version of the elliptic curve cryptography (ECC) technique after compressive optimization, where the technique is further applied with the modified components, and then it is applied at the cloud server. Further work is compared with the existing MD5- and ECC-based solutions proposed by various authors while performing cloud security and integrity verification [20].

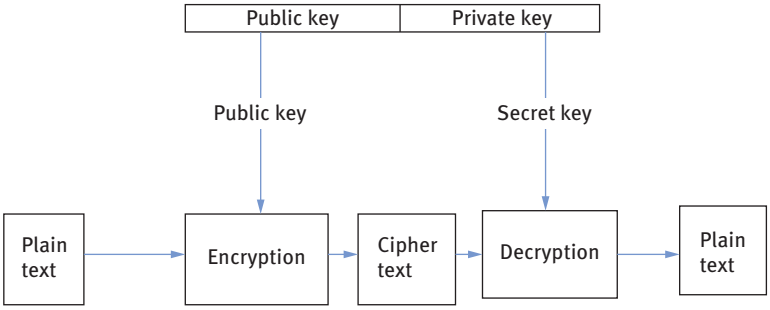

Figure 7.2: Elliptic curve cryptography.

7.4.7 Algorithm

The proposed algorithm is described as follows:

Step1: Hospital maintains patient's data in the file format using their software.

Step2: After completion of a complete day or week, the file from Hospital gets transferred to Cloud.

Step3: There is a possibility of data theft. To avoid theft, the data is stored in encrypted format using HECC along with Asymmetrical encryption and Hash value is generated using SHA2.

Step4: DWT compression is used to compress the file else it would accommodate large space in the cloud.

Step5: With DWT compression and HECC encrypted algorithm data is copied and stored in a cloud environment.

Step6: To retrieve the data, the Hash key, an encryption key is stored in a database table.

Step7: When the authorized user tries to search a record in the cloud, Hash kay would be generated for the search key.

Step8: Using hash generated value, the files are picked and downloaded to the local server.

Step9: Once the file is downloaded it is decrypted using the HECC algorithm and loaded in the database table.

Step10: Using the search Index, Data are retrieved from the file and gets displayed on the screen.

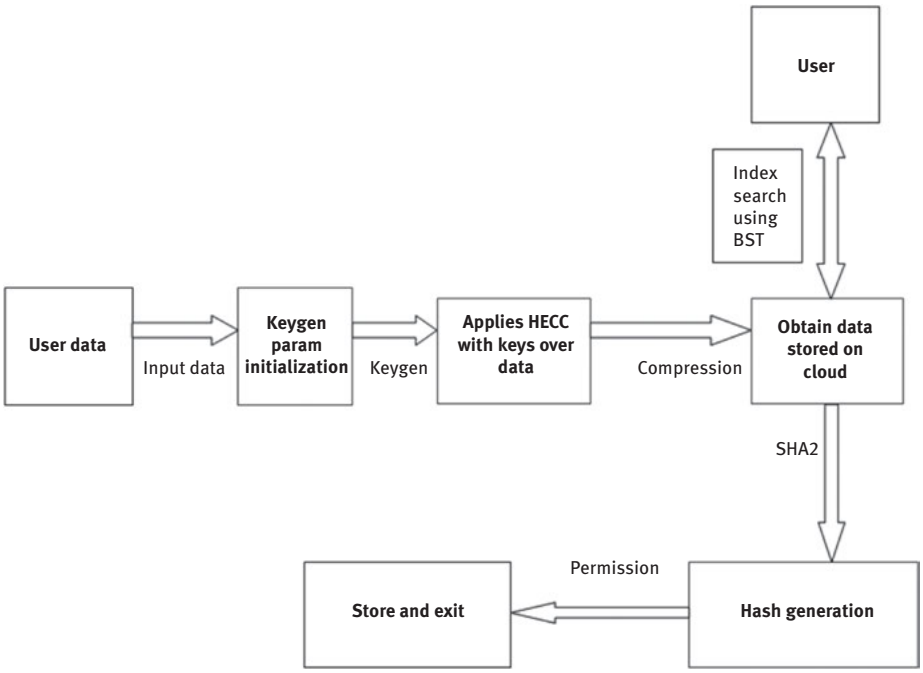

Figure 7.3: Block representation.

The block diagram (Figure 7.3) shows the step–by-step process of handling the data file. Here, at first, hospital data are stored in the file. The input stored file data are then transmitted using HECC encryption to the cloud environment and parallelly hash value is created using the SHA2 algorithm which is maintained in a table. As soon the user filters the record, the hash value is created for the filtered record, then

corresponding files are downloaded from the cloud and get loaded in the table of a database. Using the filtered index, data are retrieved and displayed as the search value from the table.

7.5 Simulation setup

Under this title, simulation setup, results and formulas used for computation are presented. NETBEANS IDE along with Java language system is utilized to run the code and generate the actual results. The following is the description of the data used and the time taken to process the records [21, 22].

7.5.1 Performance measures

7.5.1.1 Computation time

The start time of the run is taken as start time, and completion time of the running process is noted as end time. The difference between the actual start run time and actual completion time is known as computational time. The computational time is expressed in milliseconds:

$$Tc = \text{End time of the process} - \text{start time of the process}$$

7.5.1.2 Bandwidth

A bandwidth in the cloud and network server is the total consumption of data amount in its process. All the data consumption including coding part, client end graphics and many other components are related to calculate the usage. All the combination data usage by all resources get to the bandwidth computation:

$$Bw = \text{summation of (all data usage by resources)}$$

or

$$Bw = \text{total file size/computational time}$$

7.5.1.3 Traffic volume

Traffic volume is also one of the important parameters of monitoring the parameter for comparison. It can be computed as the total work performed by the available resources. It is the product multiplication of traffic intensity with time:

$$\text{Tv} = \text{traffic intensity} \times \text{time}$$

7.5.1.4 Traffic cost

Traffic cost is calculated using the formula product of total file size and basic unit cost value of data processing divided by the total time:

$$\text{Total traffic cost} = (\text{total file size}/\text{total time}) \times \text{basic unit cost value}$$

or

$$\text{Tc} = (\text{total size} \times \text{bandwidth})/\text{time}$$

7.6 Result analysis

In this section, the comparison is done on various parameters like computational time and traffic cost using the same file size but on a different approach. Here the comparison is done on the previous algorithm and proposed solution. Tables and graphs (Figure 7.4 and Figure 7.5) are listed in the following pages.

Table 7.1: Comparison of EPACK and EHR based on the computational time (ms).

	EHR	EPACK
Computation time	784	770

Table 7.2: Comparison of EPACK and EHR based on the traffic cost.

	EHR	EPACK
Computational cost	21	19

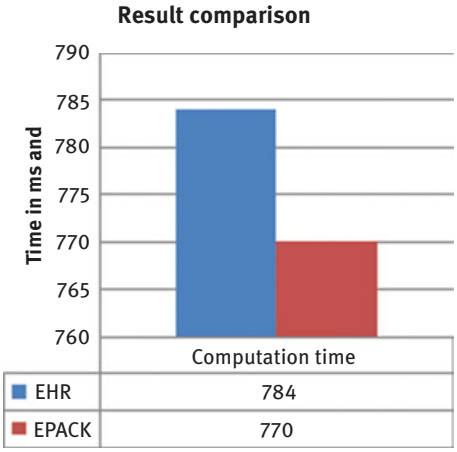

Figure 7.4: Comparison of computational time for previous and proposed works.

Taking a shot at content-based graphical calculation, for example, our proposed procedure confirmation will be proficient and simple to envision and to make it all the simpler for clients to utilize, and such exception system will be effective to utilize.

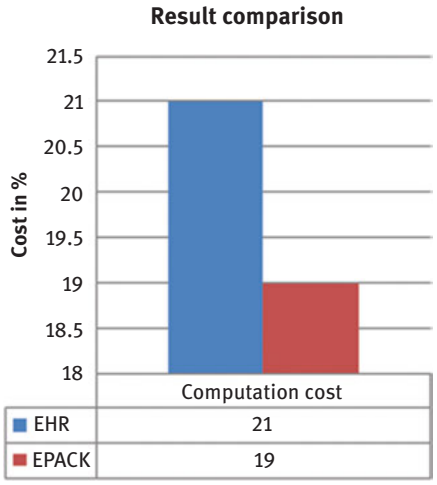

Figure 7.5: Comparison of traffic costs for EHR and EPACK works.

7.7 Conclusion

The distributed computing system of the cloud is a developing research sector, where foundations are shifting their administration and conveyance progressively productive. Distributed computing makes it increasingly adaptable, progressively solid, secure and open with a lot of alternatives to play out its best. The chapter discussed on the file-level distribution and redundancy detection using file-level chunking. We have also used MD5 for hashing computation. Computational time for security along with the implementation of the hash algorithm takes a long time to process the large volume of data. The existing EHR algorithm is also not much effective with the large data file. Thus, to avoid these issues related to the traditional paper approach, our optimization algorithm EPACK algorithm with a more secure algorithm HECC is performed along with SHA-2 as a more stable hashing approach. The proposed algorithm validates proper redundancy in more secured and using reliable conditions. The proposed work makes use of various parameters such as computational time and computational cost to perform the comparison analysis. Using Java language, the algorithm is developed with Java IDE net-beans platform setup having 3 GB RAM, intel i5 processor, 160 GB hard disk. The comparison done on various parameters, analysis and execution results proved that the proposed approach EPACK has shown better results while comparing it with the existing algorithm.

7.8 Future work

The proposed EPACK calculation gives a significant level of security close to the deduplication approach. Further analysis has to be carried out to demonstrate this work for industrial use. Following accompanying works are left for future work:

- Proposed execution to be implemented and carry at various cloud framework businesses to note that it is secured, consistent, faster than the other interchange accessible methods over the web.
- More study on hashing technique has to be done, which can make all the available process quicker. A study of the system can be derived and performed with different operating systems with other file format values.
- More study over the unstructured data like image and graph has to be carried out.

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8 Genetic algorithm and normalized text feature based document classification

Abstract: With the increase in the digital network, the more text content is available on various platforms. Therefore, the arrangement of such a set of documents depends on human understanding. This chapter proposes a document classification technique where instead of using any prior information a training classification was done. Here teacher-based learning optimization genetic algorithm was used where a novel fitness function has increased the classification rate with the lower computational cost. In this work, probable solutions were updated twice in one iteration step. We experimented with a real dataset of research documents obtained from various journals and compared this result with the previously existing method and found that the proposed work has improved precision, recall and accuracy parameters.

Keywords: spam detection, content filtering, online social networks, fake profile

8.1 Introduction

Unformatted information remains a challenge in about every information application field such as business, trade, universities, analysis establishments, technology-intensive firms and government funding agencies. Eighty percent of the total information concerning an entity (like person or place or thing) are out there solely in disorganized form. They are in the type of email, reports, news, views, and so on. Text mining analyzes the up now hidden relationships between entities in a dataset to significant patterns that replicate the data present within the dataset. This information is used in decision making [1]. Text analytics first converts the text into a numeric value, and this value successively brings structure to the information and facilitate to spot patterns. The structured information with higher analysis and eventually, the higher choices would be. Now it is conjointly tough to process the information manually and categorize them. So this leads to the appearance of intelligent tools in text processing within the field of the linguistic communication process to investigate lexical and linguistic patterns. Clustering, categorization and labeling are extreme techniques to pursue in-text analytics [2]. For example, it is a

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method of distribution as a document to a selected category label among different category labels such as education, medicine and biology. Thus, text categorization could be necessary to introduce data discovery [3]. The purpose of this chapter is to investigate various types of text classification techniques utilized in monitoring, their clarification in multiple application domains, and weaknesses, strengths and current analysis trends to supply improved awareness relating to data extraction potentialities.

The chapter is organized as follows: in the second section, the necessity of text features is also examined. The third section lists various techniques adopted by the researcher to increase classification accuracy. The fourth section provides related works of the current approaches applied by different researchers to correct the class of document. The research problem is pointed out, and then the proposed problem is formalized in detail. The conclusion of the chapter is given in the last section.

8.2 Related work

Gourav and Jindal [4] described the given approach utilizing the nearest neighboring algorithm with the cosine analogy to categorize analysis papers along with patents revealed in many areas and keep in several journals and conference information. Conduct experiment results show that user reclaims result by traversing analysis paper in a very specific set. The first benefit of the given approach is that the search space would be compact. And the waiting time for query resolution has reduced. So they need to calculate the edge relying upon similarity in terms of the question, analysis paper and patent. The estimation of the threshold value was not strictly based on numerical importance. Thus, this given technique is categorized more accurately than the active one.

Yudha and Sarrno [5] inspected that electronic media posts will analyze confidential intelligence. The key base of living human performance is nature. Nature tests detailed the individual persona that influences the main concern and relations. Users share opinions on electronic media. The text categorization was demoralized to forecast the nature on the idea. West Germanic and Indonesian language were used for this categorization. *k*-Nearest neighbor, naïve Bayes and Support Vector Machine (SVM) have performed the method for arrangement. The analysis works use personality datasets.

Santoso et al. [6] navigate the web for vast information to collect data. It comprises big unstructured information like images, videos and text. Tricky issues are the organization of massive information and gather helpful data that would be utilized in the bright computer system. Now ontology is covering the massive space of topics. To build the associate degree ontology with the specific domain, massive datasets on the net were used and arranged with a specific domain. Naïve Bayes classifier was enforced with the map-reduce model to arrange a massive dataset. Animal and plant domain articles from encyclopedia are available online for experiments. Planned

techniques yielded a robust system with higher accurateness to arrange information into domain specified ontology. During this analysis work, datasets use animal and plant domain article in Wikipedia or online encyclopedia as datasets.

Tang et al. [7] projected Bayesian categorization techniques for the text categorization utilizing class-specific characteristics. In contrast to the regular approach of the text classification planned methodology, a selected feature set in each category is chosen, applying the various class-dependent characteristic for classification. The theorem of Baggenstoss's projection was pursued to regenerate PDFs and create a rule of Bayes classification. The significance of the instructed approach is that it features choice criteria, estimating performance on much actual benchmark information set and differentiating with feature choice approaches. Now the experiments have tested approaches for texture categorization on binary instantaneous benchmark: 20 Newgroups and 20 Reuters.

Cao et al. [8] presented a bidirectional long short-term network to engrave the short text categorization with a pair of settings. The short text categorization is needed in applications for data mining, particularly the application of healthcare briefly text mean semantic ambiguity bound semantic expression because of that ancient approaches fail to capture actual linguistics of restricted words. In the health-care domain, the texts include rare words, during which because of lack of training information embedding learning is not simple. A deep neural network is the potential to spice up the performances. At first, typical attention mechanisms were adopted to lead network training with the domain data in the wordbook. And direct cases once the data wordbook is out of stock. They have given the multitask models to find out the domain data wordbook and performing art text categorization task. They have applied instructed techniques to the existing aid system and completely obtainable dataset of Airline Travel Information System (ATIS) to induce the highest results.

Vijayan et al. [9] reviewed the method of data categorization and active algorithm. The e-Document contains a great amount of information. Text mining could be a technique of taking out information from all these documents. Categorizing text documents in a specific manner of predefined categories is text categorization.

8.3 Proposed methodology

The proposed TLBO (teacher learning-based optimization) genetic document clustering algorithm steps were detailed in this section. For ease of understanding, the block diagram is as shown in Figure 8.1.

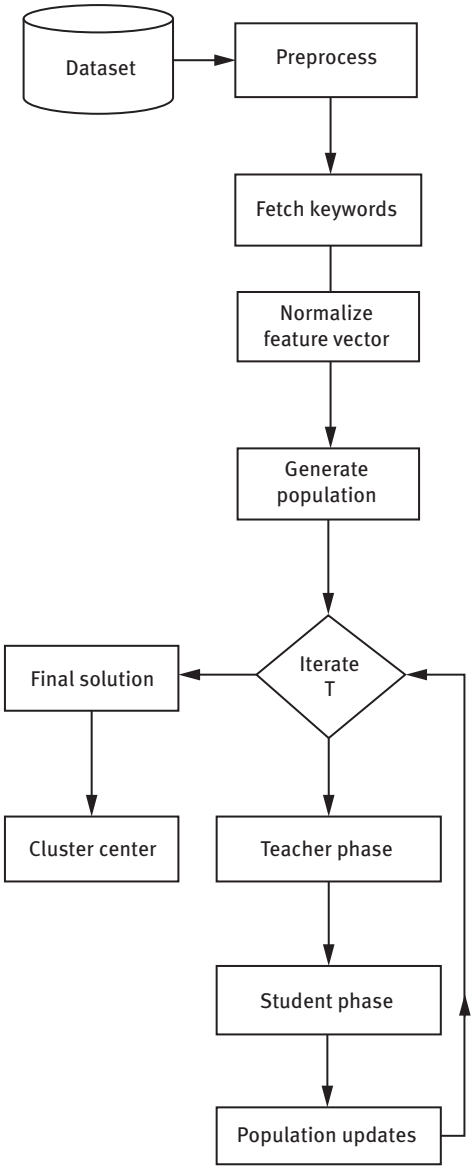

Figure 8.1: Proposed work block diagram.

8.3.1 Preprocessing

The text dataset is a collection of the document where each document has words that need to be preprocessed. In this work stop, a word removal technique was adopted for removing unwanted data from the document. The preprocessing step is to identify and

remove words like is, am, are, for, the, to. The asset of those words helps to frame the sentence instead of meaning.

8.3.2 Fetch keywords

The set of words obtained from the above step of preprocessing is a further process to get a representative keyword set. So, in this step, all repetitive words are count and check the frequency in a single document if any word crosses a threshold number of counts than the word that acts as a keyword for that particular document. Hence, each document has there a separate set of keywords:

```
Loop 1:b // b: number of words obtain after pre-processing
      If BOW[b] greater than Minimum Threshold
   UBOW ← BOW[b] // UBOW: Updated Bag of Word
EndIf
EndLoop
```

In this way, the feature vector is generated from the document.

8.3.3 Normalized feature vector

In a single UWV (Unique Word Vector) vector, the keywords obtained from each text are gathered. In UWV, all set of documents send their keyword list. The counter of similar keyword occurrence also maintained, which received from all documents.

In this step, once this list of UWV was prepared, then the final feature vector of each document was prepared, which was collectively represented in the form of a matrix where each row is a document and each column represents a word from UWV, while the presence of any keyword of a document is a nonzero value. To normalize this vector in the scale of 0–1, each row is divided by its corresponding summation. This helps the algorithm to identify the important words of a vector, or important words having high value play a decisive role.

8.3.4 Generate population

Let us assume that some cluster sets are a combination of various documents and are generated by the random function in mathematics, which selects the fixed number of document cluster for the centroid.

8.3.5 Fitness function

To identify the classification, accuracy of the work proposed has a fitness function in this algorithm. In this step, chromosome centroid document feature vector was compared with the noncentroid document feature vector. While comparison it was observed how many similar positions of feature vector have nonzero value. Those similar maximum nonzero values are a sum to obtain the final similarity score (SC). Now the fitness value of the chromosome is a sum of the maximum total score of each document in a dataset.

8.3.6 Teacher phase

The top conceivable chromosomes are arranged as per the fitness values in the decreasing order. Hence, the first chromosome in that list acts as a teacher and other sets of chromosome act as a student. So teachers in the current iteration modify other chromosome cluster sets as per its own cluster set.

Presently, teacher T will show understudy S by haphazardly supplanting one cluster center. This distinction changes the current chromosome as indicated by the accompanying equation:

$$\mathrm{Ch_N} = \mathrm{Crossver}(\mathrm{Ch_T}, \mathrm{Ch_S})$$

where ChN is a new set of solution, while ChT is a teacher chromosome cluster set and ChS is a student chromosome cluster set.

8.3.7 Student phase

In this stage, all conceivable chromosomes after the instructor stage are a bunch for self-gaining from one another. It can be assuming a set containing two chromosomes, then every chromosome that is best in contrast with others will perform crossover operation to improve the other chromosome fitness values. The fitness value of the new chromosome is compared with the older chromosome and the best of them survive in a population.

8.3.8 Population updates

Each iteration involves a teacher phase than a student phase, so after completion of each phase maximum iteration values, T was the check. So two conditions arise if maximum iteration values were reached, then iteration stops and final best chromosomes were identified; otherwise, again teacher and student phases were done.

8.3.9 Cluster document

Once the iteration of teacher and student phases was over, then the proposed work gets the final cluster center document set, which can be known as the best chromosome in the available population. Here, as per the obtained cluster center, each noncentroid document is clustered into a respective class of document by using steps in Table 4.2 where SC was used identifying the most relevant class of the document.

8.3.10 Proposed algorithm

Input: DS Document Dataset, Cn Cluster Number
Output: CD // Classified Document

1. DS ←Stop-Word-Removal(DS) // Here Stop words are removed from the Input text file
2. K←Fetch-Keywords(DS) // Here Keywords are retrieved from each text file.
3. FV←Normalize-Feature-Vector(DS)// FV: Document numeric feature vector
4. P←Generate-population(Cn, DS)
5. Loop T= 1:Itr // This is for Iterations
6. Loop Iterate T time // T: Maximum number of iteration
7. F←Fitness-Function(P, FV) // F: Fitness
   T←Max(F)
8. P←Teacher-Phase(T, P)
9. P←Student-Phase(P, FV)
10. EndLoop
11. F←Fitness-Function(P, FV) // F: Fitness
    T←Max(F)
12. CD←Cluster-Document(T,FV)

In this algorithm, DS document dataset was a collection of text files, and the number of cluster centers was passed as input. The output was a CD classified document, where each input DS text file was grouped in any of the Cn cluster.

8.4 Experiments and results analysis

Implementation of the proposed genetic algorithm-based document clustering approach model was done on MATLAB software because of collection of the number of inbuilt functions such as text scan to separate the string into words, reading the writing of text files, comparison of the word, and collection of words into a structure.

8.4.1 Dataset

In this chapter, an experiment is done on the actual collection of text file dataset content obtained from various resources of journals where three classes of documents were collected for clustering. Table 8.1 shows the explanation of each class of document.

Table 8.1: Experimental dataset explanation.

Class set	Documents
Image processing	12
Data mining	12
Solar energy	12

8.4.2 Evaluation parameter

$$\text{Precision} = \frac{\text{TruePositive}}{\text{TruePositive} + \text{FalsePositive}}$$

$$\text{Recall} = \frac{\text{TruePositive}}{\text{TruePositive} + \text{FalseNegative}}$$

$$F - \text{score} = \frac{2 \times \text{Precision} \times \text{Recall}}{\text{Precision} + \text{Recall}}$$

$$\text{Accuracy} = \frac{\text{Correct\_Classifications}}{\text{Incorrect\_Classification} + \text{Correct\_Classification}}$$

8.5 Result

Existing work done in [10] was used to compare the proposed document clustering genetic algorithm.

As shown in Figure 8.2 and Table 8.2, the proposed TLBO genetic-based clustering algorithm has enhanced the precision values when compared with the approach adopted in [10]. Hence, the use of a unique word vector with a normalization factor increases the precision of clustering the document in a specific group. The use of two-time updates in chromosomes as per the good set of cluster centers also increases the precision value.

As shown in Figure 8.3 and Table 8.3, the proposed TLBO genetic-based clustering algorithm has enhanced the recall values when compared with the approach

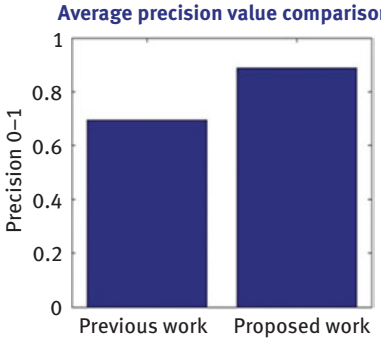

Figure 8.2: Comparison of average precision values of the proposed document clustering genetic algorithm and previous work.

Table 8.2: Comparison of precision values of the proposed document clustering genetic algorithm and previous work.

Emotion	Precision value comparison	
	Previous work	Proposed work
Set 1	0.6923	0.8333
Set 2	0.6667	1
Set 3	0.7273	0.8333

adopted in [10]. The use of two-time updates in chromosomes as per the good set of cluster centers also increases the recall value. Collection of the term into a set of unique word vector with the preprocessing step increases recall as well.

As shown in Figure 8.4 and Table 8.4, the proposed TLBO genetic-based clustering algorithm has enhanced the *F*-measure values when compared with the approach adopted in [10]. Hence, the use of a unique word vector with a normalization factor increases the *F*-measure of clustering the document in a specific group. The use of two-time updates in chromosomes as per the good set of cluster centers also increases the *F*-measure value.

As shown in Figure 8.5 and Table 8.5, the proposed TLBO genetic-based document clustering algorithm has enhanced the accuracy values when compared with the approach adopted in [10]. The use of two-time updates in chromosomes as per the good set of cluster centers also increases the accuracy value. Collection of the term into a set of unique word vector with preprocessing step increases accuracy as well.

As shown in Table 8.6, average evaluation parameter value of TLBO genetic-based document clustering algorithm precision, recall and accuracy values are higher than the existing method adopted in [10]. As shown, the accuracy of 91.67% was achieved.

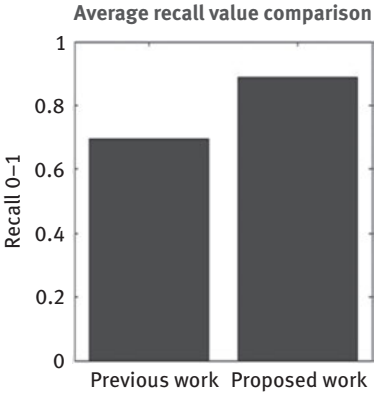

Figure 8.3: Comparison of average recall values of the proposed document clustering genetic algorithm and previous work.

Table 8.3: Comparison of recall values of the proposed document clustering genetic algorithm and previous work.

Emotion	Recall value comparison	
	Previous work	Proposed work
Set 1	0.7500	1
Set 2	0.6667	0.75
Set 3	0.6667	1

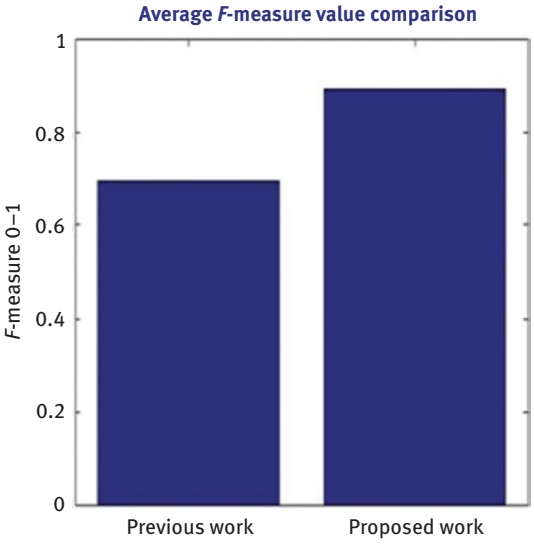

Figure 8.4: Comparison of average *F*-measure values of the proposed document clustering genetic algorithm and previous work.

Table 8.4: Comparison of *F*-measure values of the proposed document clustering genetic algorithm and previous work.

Emotion	*F*-Measure value comparison	
	Previous work	Proposed work
Set 1	0.7200	0.9091
Set 2	0.6667	0.8571
Set 3	0.6957	0.9091

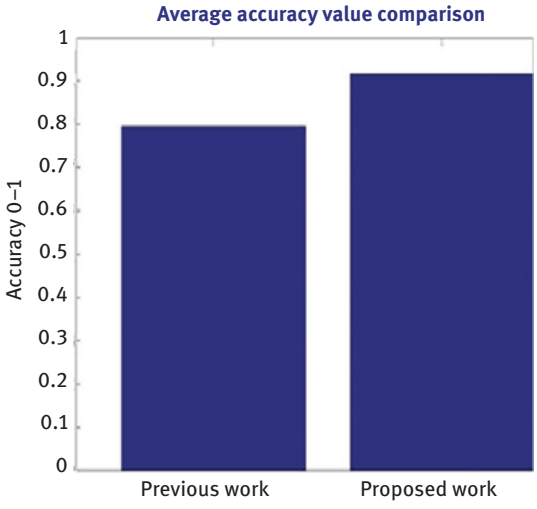

Figure 8.5: Comparison of average accuracy values of the proposed document clustering genetic algorithm and previous work.

Table 8.5: Comparison of accuracy values of the proposed document clustering genetic algorithm and previous work.

Emotion	Accuracy value comparison	
	Previous work	Proposed work
Set 1	0.8056	0.8333
Set 2	0.8056	0.8333
Set 3	0.7778	0.8

Table 8.6: Comparison of average evaluation parameters values of the proposed document clustering genetic algorithm and previous work.

Parameters	Previous work	Proposed
Precision	0.6954	0.8222
Recall	0.6944	0.8889
Accuracy	0.7963	0.9167

8.6 Conclusions

The process of classification and labeling is aimed at dividing the textual data into chunks of labeled blocks of data. This is very useful in organizing data and further helps in understanding data quickly and efficiently. This chapter proposed a method of dynamically adopting document classification where prior training was not required for the system in the form of author, content, history and so on. This work has developed a unique feature collection technique where computational cost gets reduced while efficiency was also improved. Here, the use of genetic two-step population updation increases the accuracy of the work as well. Results were compared on various evaluation parameters and it was obtained that the proposed work has improved the precision by 12.68%, recall by 19.45% while the accuracy of classification for all sets of classes was also improved by 12.04%.

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9 Nature-inspired optimization techniques

Abstract: The problem of optimization of target functions in machine learning plays a vital role in accelerating the learning process, so much so that mapping of knowledge on the system shows the minimum error rate. An optimization algorithm iteratively executes in a search space, to find among them, the proper solutions and compares them accordingly, until the best solution is found. We present some of the most popular optimization techniques widely used presently – ant colony optimization, particle swarm optimization, artificial bee colony and bat algorithm.

Keywords: optimization algorithm, optimal solution, ant colony optimization, particle swarm optimization, artificial bee colony, bat algorithm

9.1 Introduction

Swarm intelligence algorithms contain a set of similar species in which the individuals cooperate without any central form of control [1, 2]. The group of species is generally referred to as a swarm. Swarm intelligence algorithms thus relate to nature and are biologically inspired, which leads us to believe that any nature-inspired social convention can be encoded as an algorithm. Many swarm intelligence algorithms have been proposed owing to nature's wide range of living diaspora. We study here the following algorithms – ant colony optimization, particle swarm optimization (PSO), artificial bee colony (ABC) and bat algorithm (BA). PSO is used for optimizing nonlinear functions and is a swarm intelligence, metaheuristic optimization algorithm. It is the easiest optimization algorithm among all others. ABC optimization is based on the honeybee swarm's intelligent behavior. This algorithm can optimize multivariable functions easily. Ant colony optimization is based on the natural food search technique of least distance and time used by ants.. Bat-inspired algorithm is a new metaheuristic algorithm based on the echolocation of bats. This algorithm is superior to all other genetic and swarm intelligence algorithms. We present a detailed overview of these in the subsequent sections.

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9.2 Particle swarm optimization

PSO [3] is used in optimizing nonlinear functions. It is mainly related to two concepts: the first is the relation to artificial life, generally, and a flock of birds or school of fish, particularly and the second, to evolutionary computation, thus being tied to genetic algorithms [4, 5]. It is a simple algorithm that can be implemented easily and is computationally inexpensive in terms of speed and memory requirements [6, 7].

9.2.1 Algorithm

PSO uses particles as a bunch called a swarm (Figure 9.1). The particles are free to explore the search-space and guided by their inertia, distance from the individual particle's best-known position and distance from the swarm's best-known position. The particles communicate with each other to converge in a single space faster.

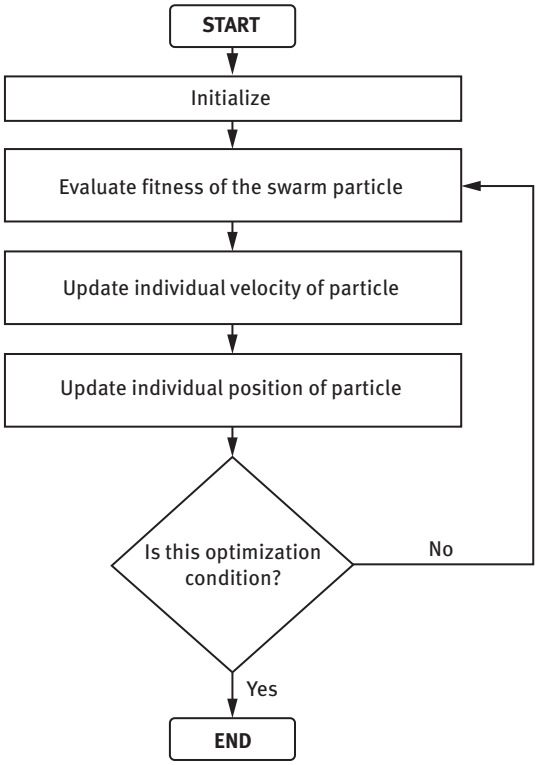

Figure 9.1: Particle swarm optimization algorithm flowchart.

Initialize the position of swarm particles randomly
while *optimization condition not met* ***do***

evaluateSolution
updateVelocity
updatePosition
end while

The pseudocode is explained as follows:

evaluateSolution
The solutions are evaluated or checked by cycling through the swarm particle's fitness. We check if the current position is the best position of an individual particle. It is necessary to cycle through all the values of the particles to find the global optimum value.

updateVelocity
The individual velocity of a particle is updated by the formula:

$$V_x = V_x + rand(0,1)^* rand(0,1)^* \left(v_{best\_x} - v_{present\_x}\right)$$

updatePosition
The individual position of the particle is updated by the formula:

$$P_x = P_x + rand(0,1)^* rand(0,1)^* \left(p_{best\_x} - p_{present\_x}\right)$$

9.2.2 Applications

PSO was first used to train neural networks [3]. Since then, many areas of application have been discovered such as telecommunications, data mining, combinatorial optimizationpower systems and signal processing. This algorithm has been used mainly to solve unconstrained, single-objective optimization problems, constrained problems, multiobjective optimization problems and problems with dynamically changing landscapes. Additionally, hybrids of PSO have been developed using several optimization algorithms, which further enhance the applicability of this algorithm [8–16].

9.3 Artificial bee colony optimization

ABC optimization [17] is based on the behavior of honeybees living in a colony while trying to search for food sources to sustain themselves. An artificial colony has bees

as agents, while the food is the solution that must be carefully extracted by them, to survive and save their resources as well.

9.3.1 Algorithm

ABC consists of three types of bees – employed bees, which are bees that are visiting a food source they have previously visited; onlookers, which make decisions on choosing a source of food; and scouts, which randomly search the area. The ABC algorithm is structured in two parts – the first is the half colony that has employed bees, and the second has the onlookers. Every food source has only one employed bee, which translates to the number of food sources near the hive being equal to the number of employed bees. An employed bee becomes a scout when its food source has been consumed by the employed and onlooker bees.

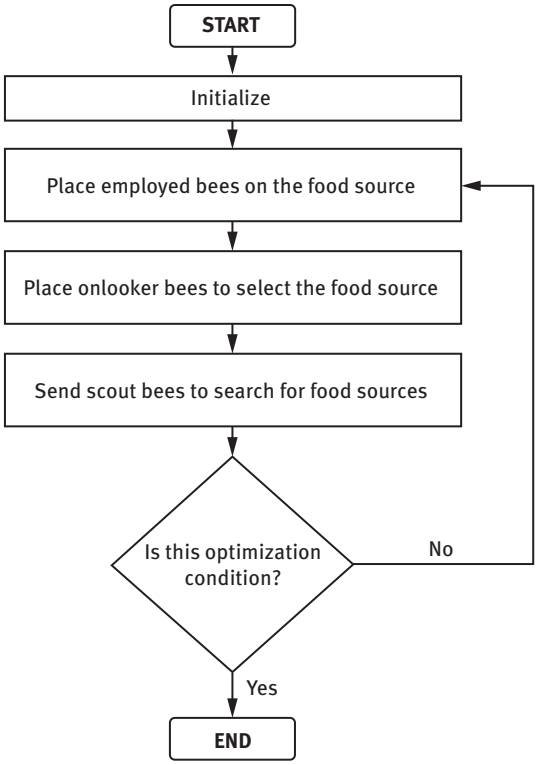

Figure 9.2: Artificial bee colony optimization flowchart.

Initialize
while *optimization condition not met* ***do***
    placeEmployedBees
    placeOnlookerBees
    sendScouts
end while

In each iteration, the employed bees are sent to the food sources and their nectar amounts measured, onlookers select the food source after seeking information from employed bees to determine the nectar amount in foods and the scout bees are sent to possible food sources.

Initialize
The food sources x_m are initialized $\forall m = 1, 2, \ldots, p$;p:population size, by scout bees through the following formula:

$$x_m^i = l^i + rand(0,1)^*\left(u^i - l^i\right)$$

where l^i and u^i are the lower and upper bounds of the parameter x_m^i, respectively.

placeEmployedBees
Employed bees search for new food sources, v_m, that have more nectar within an area of the food source in their memory. The fitness or probability of the new food source is calculated:

$$v_m^i = x_m^i + \varphi_m^i(x_m^i - x_k^i)$$

where x_k is a randomly selected food source, i is a random index for parameter and $\varphi_m^i \in rand(-a, a)$.

The fitness value of the solution $fit_m\left(\overrightarrow{x_m}\right)$ is calculated as follows:

$$fit_m\left(\overrightarrow{x_m}\right) = \begin{cases} \frac{1}{1+f_m\left(\overrightarrow{x_m}\right)} & if\ f_m\left(\overrightarrow{x_m}\right) \geq 0 \\ 1 + abs\left(f_m\left(\overrightarrow{x_m}\right)\right) & if\ f_m\left(\overrightarrow{x_m}\right) > 0 \end{cases}$$

placeOnlookerBees
The onlooker bees select a food source based on the probability values, using the fitness value provided by employed bees. The probability value,p_m, where x_m has been selected by an onlooker bee is calculated as

$$p_m = \frac{fit_m\left(\overrightarrow{x_m}\right)}{\sum_{m=1}^{SN} fit_m\left(\overrightarrow{x_m}\right)}$$

sendScouts
The scout bees scan the area randomly using the equation:

$$x_m^i = l^i + rand(0,1)^* \left(u^i - l^i\right)$$

9.3.2 Applications

ABC is used in neural network training in the XOR gate problem and in welded beam design in the real world. The traveling salesman problem is mostly optimized using ABC [18, 19]. Applications of this algorithm can be vast and thought upon. Much research has been conducted to find such applications. Hybrids of the ABC algorithm, which are used in many unique areas of electronics have also been proposed and developed [20–26].

9.4 Ant colony optimization

Some species of insects are capable of reacting to significant stimuli, which are signals that trigger reactions that are genetically encoded, a type of indirect communication based on their performance measure. A particular term for this phenomenon is "s*tigmergy*" [27, 28]. Many ant species exhibit stigmergy. During the course of food search, ants deposit pheromone on their path that is detected by other ants and influences their path. Thus, a stronger concentration of pheromones suggests a greater chance of discovery of food, which means ants will follow that path and forego their own, resulting in the old pheromone fading away. This process results in a pheromone trail, helping other ants reach the food source easily, as other ants have previously identified it. Ant colony optimization (ACO) is very closely associated with its biological inspiration.

9.4.1 Algorithm

Artificial ants are independent, asynchronous entities cooperating to find a good solution to the problem at hand. Their main goal is to find a good solution for a given optimization problem. They update the values of artificial pheromones by traversing the path, one state at a time.

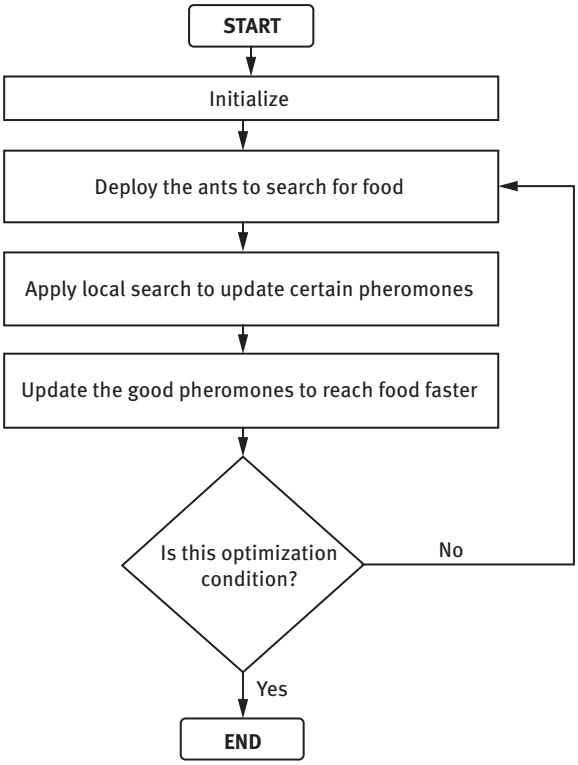

Figure 9.3: Ant colony optimization algorithm flowchart.

Initialize parameter and pheromone trails
while *optimized solution not found* ***do***
    developAntSolutions
    applyLocalSearch
    updatePheromones
end while

developAntSolutions

A set of m ants develop solutions from a set of paths available in $C = \{c_{ij}\} \ \forall \ i = 1, 2, \ldots, n; j = 1, 2, \ldots, |D_i|$ for domain D. The solution starts with an empty partial solution s^p. At each iteration, a feasible solution is added to this partial solution from a set of feasible neighbors $N(s^p) \subseteq C$. The process of developing solutions is given by the graph $G_c = (V, E)$. The values of the solution are calculated as a probability in each iteration. The best rule is

$$p(c_{ij}|s^p) = \frac{\tau_{ij}^{\alpha}.\eta(c_{ij})^{\beta}}{\sum_{c_{il}\in N(s^p)} \tau_{il}^{\alpha}.\eta(c_{il})^{\beta}} \forall c_{ij} \in N(s^p)$$

applyLocalSearch

When solutions have been constructed and pheromones updated, we apply local search to the developed solutions, so that we can decide which pheromones need to be updated.

updatePheromones

Updating pheromones means increasing pheromone value of good solutions and decreasing bad solutions, so that we find the right path. This is done through pheromone evaporation, where we decrease all pheromone values but increase pheromone value on a set of acceptable solutions S_{upd}.

$$\tau_i \leftarrow (1-p)\tau_{ij} + p \sum_{s\in S_{upd}|c_{ij}\in s} F(s)$$

where F is the fitness function and $\rho \in (0,1]$ is the evaporation rate.

9.4.2 Applications

Ant colony optimization is a powerful metaheuristic algorithm. It can be used to find the shortest path among a set of paths for a particular node. This property can be applied to the traveling salesman problem [29, 30] and job assignment problem [31]. Other new areas where ACO can be used include the problems of dynamic optimizations, multi-objective optimization [32–36] and hybrid techniques designed using various optimization techniques [37–39].

9.5 Bat-inspired algorithm

Bat-inspired algorithm (BA) [40, 41] is a new algorithm that is suitable for tough optimization problems. This algorithm is very powerful as it combines the major advantages of the other swarm intelligence algorithms. Bats are insectivores. This algorithm uses the concept of echolocation of bats, a type of sonar, which helps them find their prey and differentiate between different insects in complete darkness. Each pulse of echolocation lasts a few thousandths seconds, usually 8–10 ms, at a constant frequency, in the range of 25–150 kHz. During hunting, the rate of pulse emission increases up to 200 pulses per second. The emitted pulse is as loud as 110 dB in the ultrasonic spectrum. The sound is loudest when searching for prey and lowest when chasing them.

9.5.1 Algorithm

We assume the following rules before defining the algorithm:

1. All bats use echolocation to sense distance and know the difference between food and obstacles.
2. Bats fly randomly with velocity v_i at position x_i with a fixed frequency f_{min}, varying wavelength λ and loudness A_0 to search for prey. They automatically adjust the wavelength or frequency of the emitted pulses and adjust the rate of pulse emission $r \in [0, 1]$, depending on the closeness of their target.
3. The loudness varies from a large A_0 to a minimum constant value Amin.

Objective function $f(x) \forall x = (1, 2, \ldots, x_d)^T$
Initialize the bat population $x_i \forall i = (1, 2, \ldots, n)$ *and* v_i
Define pulse frequency f_i *at* x_i
Initialize pulse rates r_i *and the loudness* A_i
while t *<Max number of iterations*
    Develop new solutions by adjusting frequency and updating velocity
    if $rand > r_i$
    Select a solution among the best Generate a local solution around the selected best solution
    end if
    Generate a new solution by flying randomly
    if $rand < A_i$ *and* $f(x_i) < f(x_*)$
    Accept the new solutions
    Increase r_i *and reduce* A_i
    end if
Rank the bats and find the current best x
end while

The equations for virtual movement of bats is as follows:

$$v_i^t = v_i^{t-1} + \left(x_i^t - x^*\right) f_i$$

$$x_i^t = x_i^{t-1} + v_i^t$$

where x^* is the global best solution and $\beta \in rand(0,1)$.

Once a solution among the best solutions has been selected, the generation of the new solution is done through:

$$x_{new} = x_{old} + \alpha A^t$$

where $\alpha \in rand(-1,1)$ and A^t is the average loudness of all the bats.

To update the loudness and rate of pulse emission, we use the following formula:

$$A_i^{t+1} = \alpha A_i^t \;\&\; r_i^{t+1} = r_i^0[1 - exp(-\Upsilon t)]$$

where α and Υ are constants.

9.5.2 Applications

BA is a relatively newer optimization algorithm. It can be used to optimize neural networks, in image compression and tracking [42–46]. Recent advances are being made in in-depth study about the algorithm [47–49]. It has been widely used with adaptive neurofuzzy inference system in various areas such as software engineering, electronics, and hydropower generation, which highlights its compatibility with other existing techniques to optimize their parameters. This property allows the algorithm to develop its hybrid variations [50, 51].

9.6 Conclusion and future research

PSO is an extremely reliable algorithm for optimizing most functions. It is one of the simplest swarm intelligence algorithms, which is easy to implement, inexpensive to run and store locally and performs well for a wide range of application areas. More research work can be carried out to derive new areas of applications of the algorithm, explaining its elegancy and versatility in the various fields of sciences. ABC is a powerful algorithm that can be used to optimize the multivariable functions effectively. This algorithm searches solution faster as compared to other swarm intelligence algorithms. The future scope of research lies in searching for application areas for the algorithm, the effect of the parameters on the performance of ABC and the converging speed optimization of ABC. Ant colony optimization is an algorithm based on the natural behavior of ants. It is flexible and robust. Though we have presented a basic version of the algorithm, many variations of ACO such as ant colony system and max–min ant system have been developed and continue to be developed. The future scope of work lies in discovering new application areas of the algorithm, some of which have been mentioned and hence, increasing the productivity of the algorithm for computational comparisons that may increase criteria for research. Bat-inspired algorithm is a powerful optimization algorithm that outperforms other swarm intelligence algorithms. It is one of the robust ones available in a huge list of other optimization algorithms.

The inspired algorithm that uses the property of echolocation of bats is a recent advancement in the world of swarm intelligence algorithms. The future scope of work

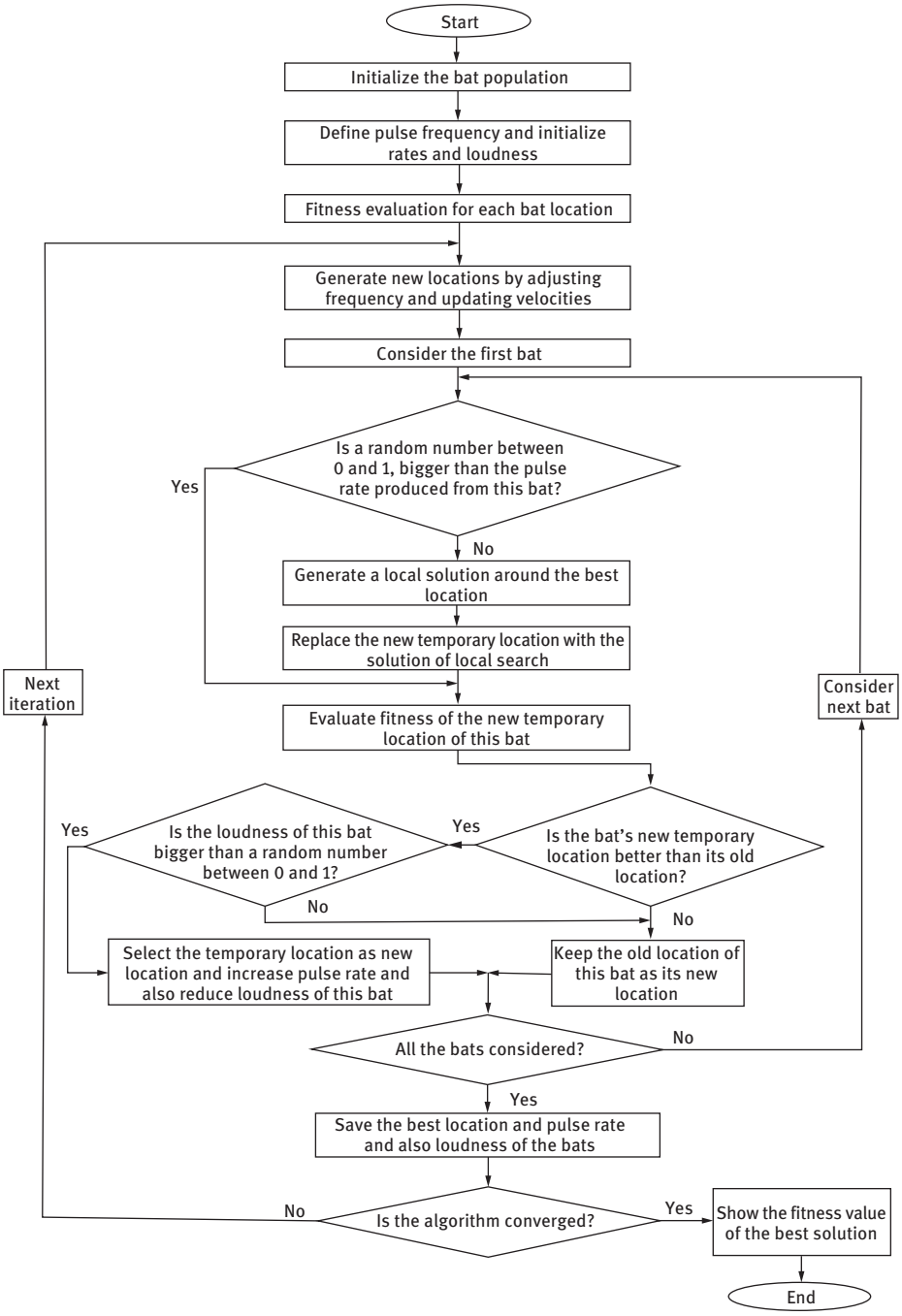

Figure 9.4: Bat-inspired optimization algorithm.

lies in developing a different version of the algorithms that can be more powerful, optimizing the parameters of the original BA and finding new applications of the algorithm. A future research direction for all the algorithms lies in hybrid variations that can be developed by a combination of several optimization techniques and different parameter sets in the algorithms.

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