Human Identification on the basis of Dental Biometrics4

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Declaration

I certify that this research work titled "*Human Identification on the basis of Dental Biometrics"* is my own work. The work has not been presented elsewhere for assessment. The material that has been used from other sources it has been properly acknowledged / referred.

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Language Correctness Certificate

This thesis has been read by an English expert and is free of typing, syntax, semantic, grammatical and spelling mistakes. Thesis is also according to the format given by the university.

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Copyright Statement

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Abstract

Human identification is becoming one of the major worldwide issue now a days. Dental biometrics is the leading biometric technique to identify individuals on the basis of their dental characteristics. Dental Features of persons are naturally unique. They can be used to authenticate humans exactly or almost to the maximum possible similarity. Here in this work, we present an efficient workable method to authenticate humans correctly and identify them properly, which is based on the dental information, which has been extracted out from the dental data. The method which we have proposed here, comprises of five main processing stages; the initial stage is pre-processing, i.e. initial work on dental data then the Segmentation step, i.e. getting the relevant part of dental data and other processing steps in segmentation. Then Features extraction is performed on segmented images and finally biometric analysis is done which is the most important step for matching. The method is tested on two databases i.e. dental radiographs and colored teeth images and the results are highly encouraging. The data set comprises dental radiographs of 14 persons and colored teeth images of 45 persons. An Equal Error Rate (EER) of 85.7% dental radiographs and 88.8% for colored teeth images found on matching the performance of our dental biometric analysis, which shows highly accuracy using our proposed methodology on the data set.

Table of Contents

CHAPTER 1: INTRODUCTION

The current research deals with human identification on the basis of dental information. The method we have proposed here comprises five main processing stages; the initial stage is pre-processing, i.e. initial work on dental data then the Segmentation step, i.e. getting the relevant part of dental data and other processing steps in segmentation. Then Features extraction on desired segmented form of dental data and after extracted the desired features the next step is dental biometric analysis which is the most leading step for matching.

The field of biometrics has getting more and more attention from the last few years because it has been an interesting and a different way to identify Humans than that of old authentication systems previously developed like signatures, passwords and entering pass to some place where complex record maintenance required and also these were weak ways of authentication. Under various circumstances, e.g. disasters, conventional biometric characteristics like fingerprints etc, may not be able to work because of their incompatibility in such a situation. Secondly these biometric methods are already in these cases, dental features are considered a useful tool for of human identification. In order to achieve our desired mentioned goal, dental biometrics automatically analyzes dental radiographs, stored in a database through some described processing.

Human identification comprises into three main divisions, which are “what do you have”, “what do you know” & “what you exactly" are. The very first point, which is “what do you have” includes personal identification cards or documents etc. Next point is “What do you know” indicates all kinds of password type’s things and like confidential information.

“What you exactly” are includes the anatomical features, also called biometrics, such as your face, DNA, iris, fingerprints and others. With the growing need for reliable and robust human identification in a variety of applications (e.g., international border crossing), biometric-based recognition has become an important topic for research in computer vision and pattern recognition.

Biometric features can be categorized into two types: physical and behavioral. Physical biometric features represent the anatomical makeup of the human body, like we have fingerprint features, face features, iris features, retina scan features, ear shape features, hand geometry features, hand vein, etc. Behavioral biometric features reflect the behavioral traits of an individual, such as voice, gait, signature, key stroke dynamics, etc.

Figure 1.1: Biometric Classification

In our work, we have developed an efficient dental biometric identification method based on five main processing stages; the initial stage is pre-processing, i.e. initial work on dental data then the Segmentation step, i.e. getting the relevant part of dental data and other processing steps in segmentation. Then Features extraction on desired segmented form of dental data and after extracted the desired features the next step is dental biometric analysis which is the most leading step for matching.

Figure 1.1: Block diagram below clearly explains our newly proposed dental biometric identification method based on information of dental data. Each of the steps are implemented and fully explained in the upcoming chapters.

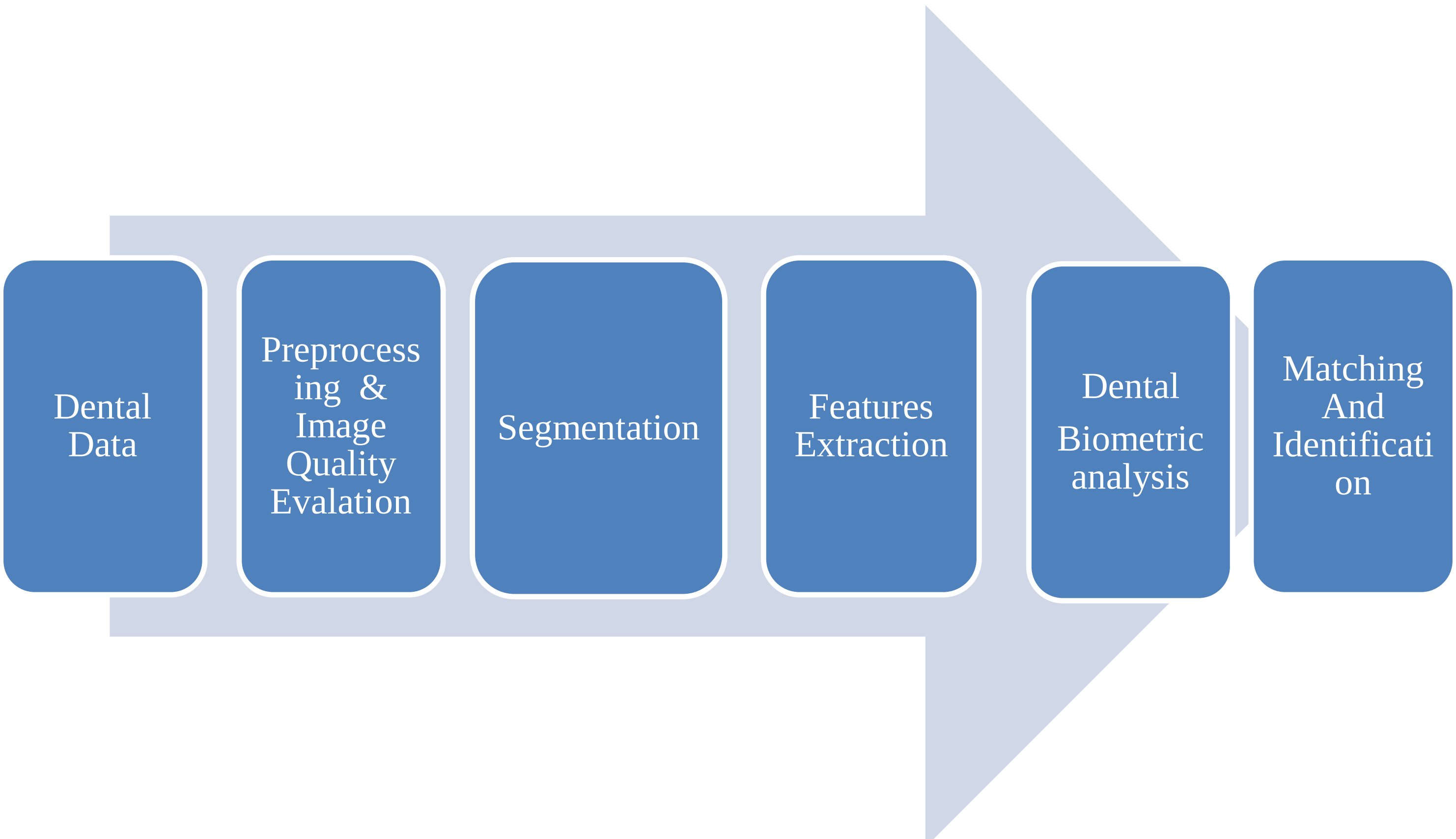


Figure 1.2: System Block Diagram

1.1 Motivation

On the Basis of data acquired from the experts of the "Criminal Justice Information Services" abbreviated as "CJIS", an organization under "FBI", there are more than 100,000 un-solved cases of un-identified persons in the "National Crime Information Center", Every time. Personal Identification issue has becoming more and more important in the world now a days.

With the advancement of technology, this issue is very much solved and defines various new ways of Human identification. Human identification has been used in maintaining data records of employees, in secured sites where un-authorized trespassing is not allowed, computer login, e- facilities, internet access, ATM, PDA, cellular phones, medical data records, credit cards, attendance management systems, NCIC, license, passports, terrorist identification, criminal records and etc. Before the advent of such systems it was very difficult to record the whole databases and perform identification so thoroughly. The first indexed fingerprints robust system was develop by Aziz-ul-Haque for IGP of Bengal, India. First biometric method was developed in late 1800 named as Bertillon’s method that used indexed fingerprints. But true biometric systems are developed in the next half of 20^{th} century emerging with the computers.

To increase the security and decrease the crime rates and holding large amount of data records sites are equipped with these tools. It is noticed that it is easy to handle a number of large records, crimes are decreased and security has been improved. The systems are made so much intelligent that they provide very precise classification and give negligible error. Misclassification is not tolerable especially when this is system is working at a highly protocol sites.

The main objective of our proposed methodology is to solve security, data management and data searching issues.

1.2 Thesis Structure

This thesis comprises the following five chapters. Chapter 1 is basic introduction; Chapter 2 gives a brief introduction about biometrics. Chapter 3 gives information about literature review and the image processing techniques and algorithms that we have developed that were used in the presented work. Chapter four describes our main approach, on the basis of extracted features matching part and in chapter five the results are discussed. Our conclusions & Future Work are presented separately.

CHAPTER 2: BIOMETRICS: AN INTRODUCTION TO DENTAL BIOMETRY

This chapter provides an overview of the field biometrics. Basic biometric terminologies and the biometric systems are described and introduction to common biometric techniques are precisely given. Finally, we introduce teeth the biometric character, which is our concerned biometric character.

2.1 Introduction to Biometrics

The field of biometrics has received much attention in the last years because it is an interesting alternative to traditional authentication systems such as signatures, passwords (personal identification numbers (PINs)) which are not dependent on the related person, anyone can take this information and can access through. Biometrics are totally dependent on one and only the person as these characteristics are unique for different persons.

The origin of the term biometrics is Greek. The words ‘bio’ means “life” and the word ‘metron’ means “to measure”, and is used to describe a characteristic or a process. In terms of biometrics characteristic it means a measurable characteristic which is concerned to the specific person only. In terms of biometrics process it means an automatic method for recognizing individuals on the basis of their biometric characteristics.

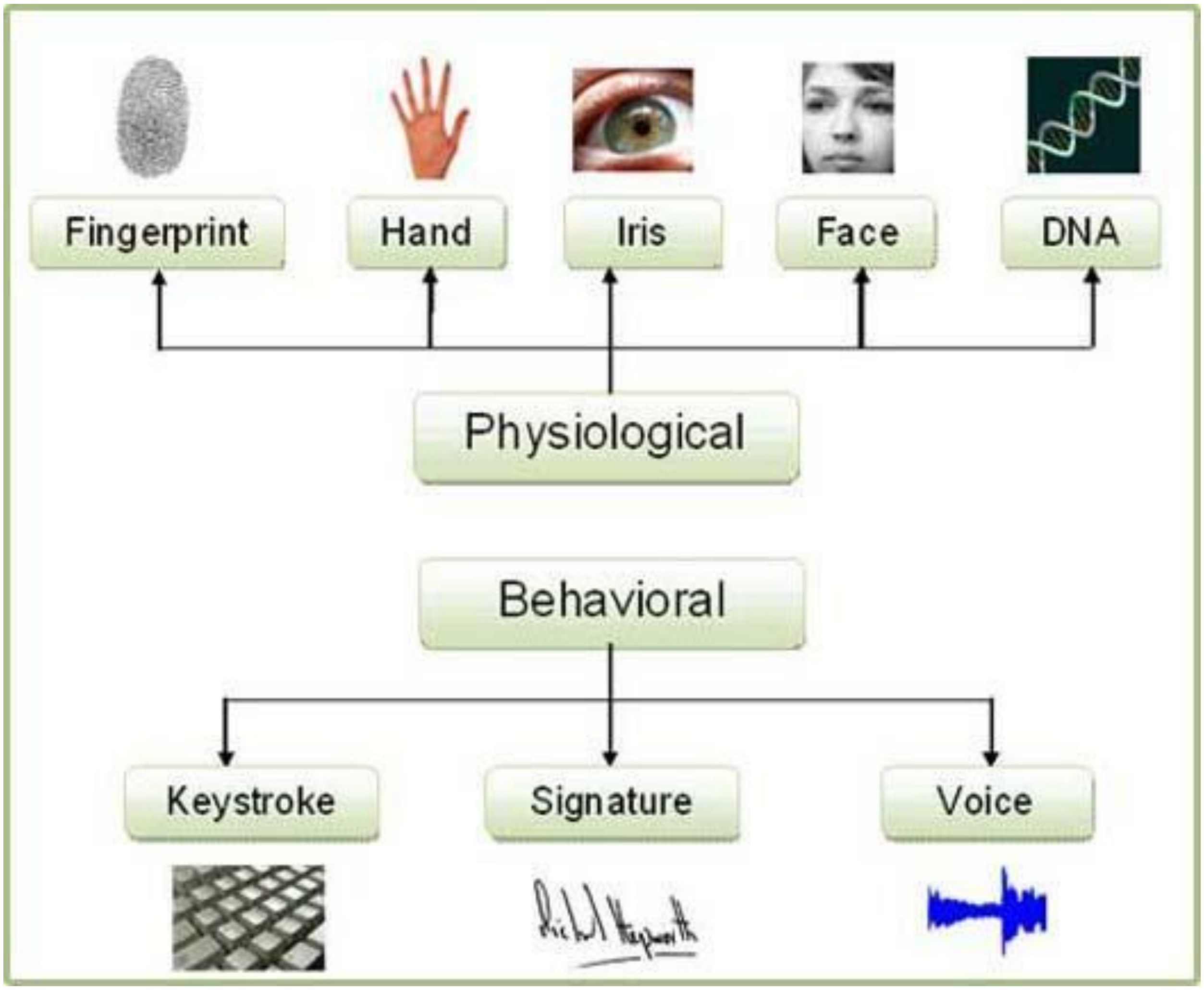


Figure 2.1: Biometric Categories

2.2 Classification of Biometric Characteristics

A biometric characteristic can be described with five qualities:

1. **Robustness**:

The biometric characters are stable, which means that they will not change over time.

2. **Distinctiveness:**

In order to clearly authenticate an individual, the biometric characteristics naturally show little or more variation person to person.

3. **Availability:**

The relevant persons should have recorded the data for measuring biometric characteristic.

4. **Accessibility:**

The concerned biometric characteristic should be easily available and properly acquired using updated electronic sensors or machinery.

5. **Acceptability:**

The method of acquiring biometric measurement data collection should be very easy and user friendly so that people do not have any objection of providing the data for this measurement.

2.3 The Biometric Process

The biometric process has been divided into five main stages,

1. **Data Collection:**

The first and foremost step is data collection. It includes Capturing or acquiring any concerned biometric sample, which is in raw data form of a biometric characteristic. If in case of unavailability of the reference in the database, the person should have to first register the biometric characteristic (e.g. a fingerprint) which will be included to database. This process of initial data adding into the database is called enrollment. If the person is already enrolled, or his or her data is present in to the database, the process is called authentication (verification or identification) which means the process of identification completion.

2. **Feature extraction:**

After pre-processing of the biometric data sample has been completed, an algorithm is defined which will extract the unique and desires features derived from the biometric sample and converts it into biometric data for measuring the properties for making a form of database so that it can be matched to a reference template in the database.

3. **Template database:**

In the case of acquiring biometric data, it will be stored in a template database. In the case when authentication process is performed, biometric data will be matched against a reference template from the template database.

4. **Matching:**

In performing the matching stage, the biometric data are compared with the template data present in the database as a reference giving a level of matching similarity.

5. Deciding:

The identification of humans on the basis of biometric data is depends on the scored level of similarity resulted in the matching stage. In matching stage, on the basis of biometric properties calculations the matching performed and then decision making is performed to identify humans.

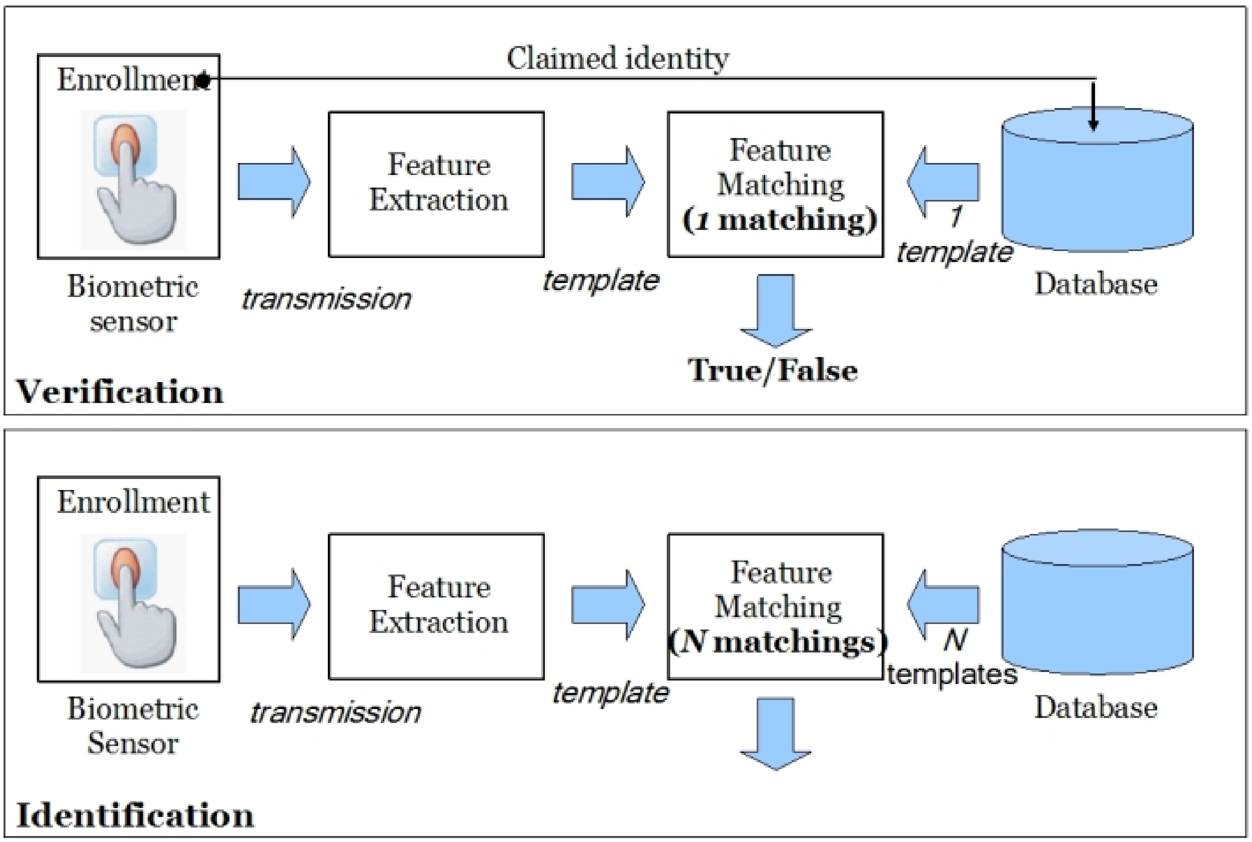


Figure 2.2: Biometric Process

2.4 Biometric Modalities

2.4.1 Face Recognition:

Face recognition is a biometric technique that analyzes the natural characteristics of a person's face. It is one of the widely used technique overall in the world. Facial recognition is used in passports, identity cards, driving licenses etc. Facial recognition method comprises static and dynamic facial recognition. This dynamic recognition is used to identify a person in a crowd area or while moving persons are identified and static while static is during static position identification. Face Recognition using biometrics uses not only the physical appearance of the features of face but also the location like nose, eyes, lips and others. The system can also be used for the identification of persons by global analysis. Figure 2.3 shows facial recognition.

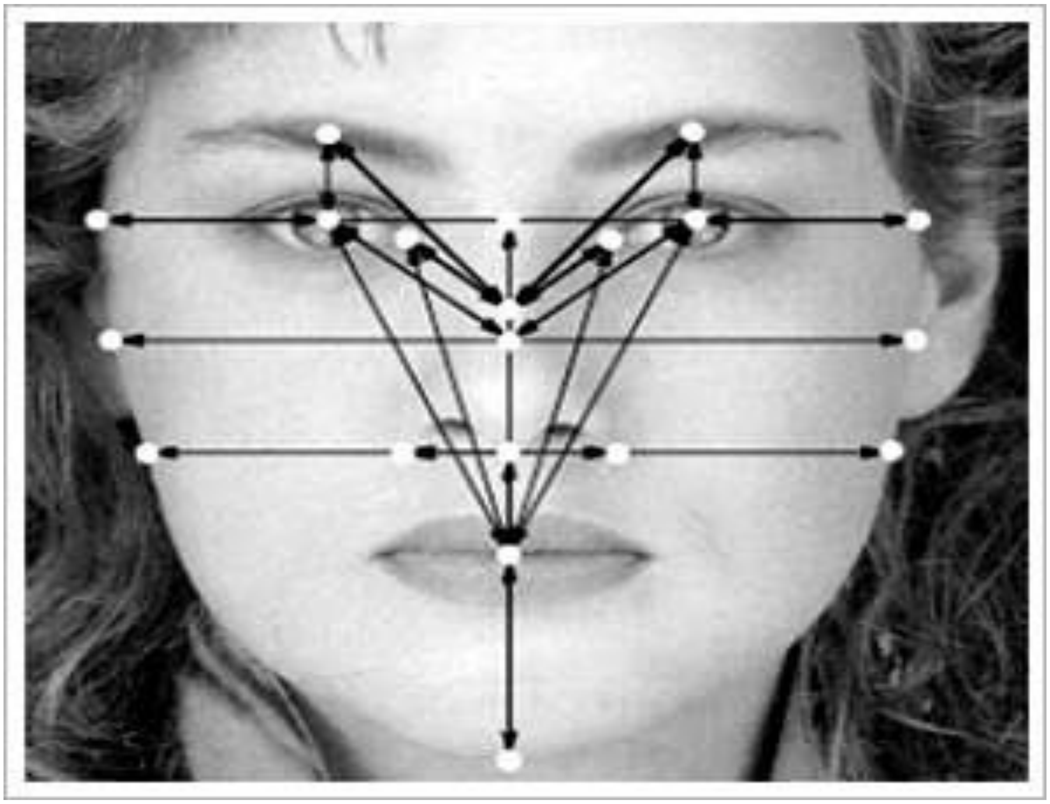


Figure2.3: Facial Recognition

2.4.2: Ear Recognition

Ears can also be used to distinguish and identify a person by using biometric techniques on ears. Ear has many characteristic properties like size, texture, color and distance from pinna by taking a reference point on ear can be selected as features for biometrics, on the basis of which person is identified. Ear recognition is a secure biometric technique than fingerprints technique as patterns in fingerprints making difficulty. Figure 2.4 shows ear recognition.

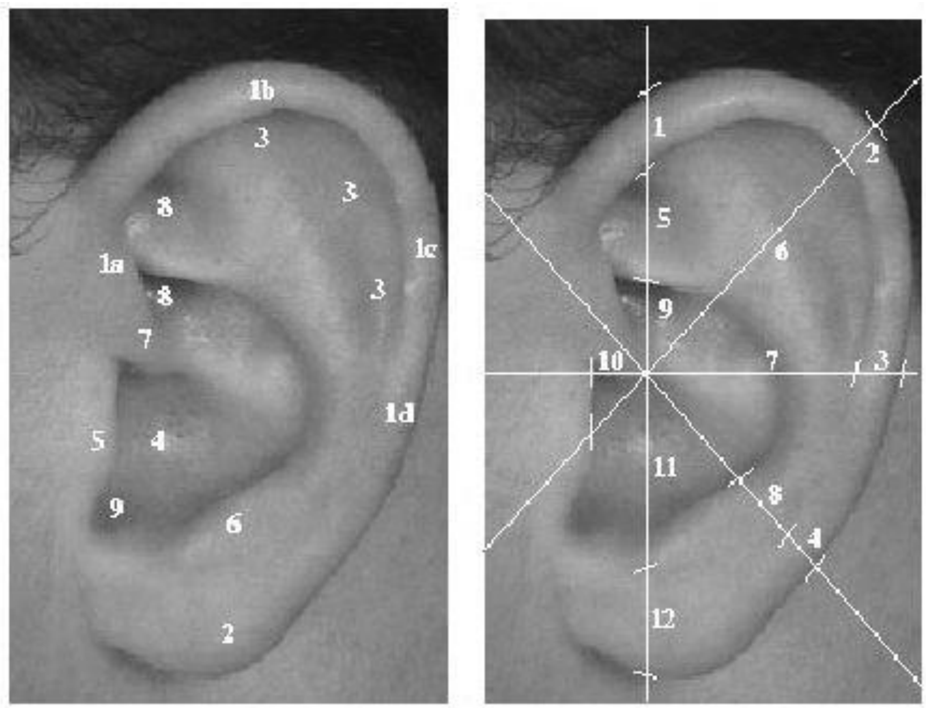


Figure 2.4: Ear Recognition

2.4.2: Fingerprints Recognition

Fingerprint recognition is a biometric technique that uses the features in individual's fingerprint for recognition. Fingerprints of every person are naturally unique. These are used from very past to identify and recognize the individuals. The reason behind is that accuracy of fingerprints is very high. Every person has unique pattern in fingerprint lines. People are identified on the basis of the narrow bands of the fingerprint lines. These lines can be in different forms like arcs, loops or in circle. These different patterns can be utilized as features for the system to take decision for identification. Figure 2.4 shows finger line patterns and figure 2.5 shows fingerprint features.

Figure 2.4: Finger Line Patterns [3]

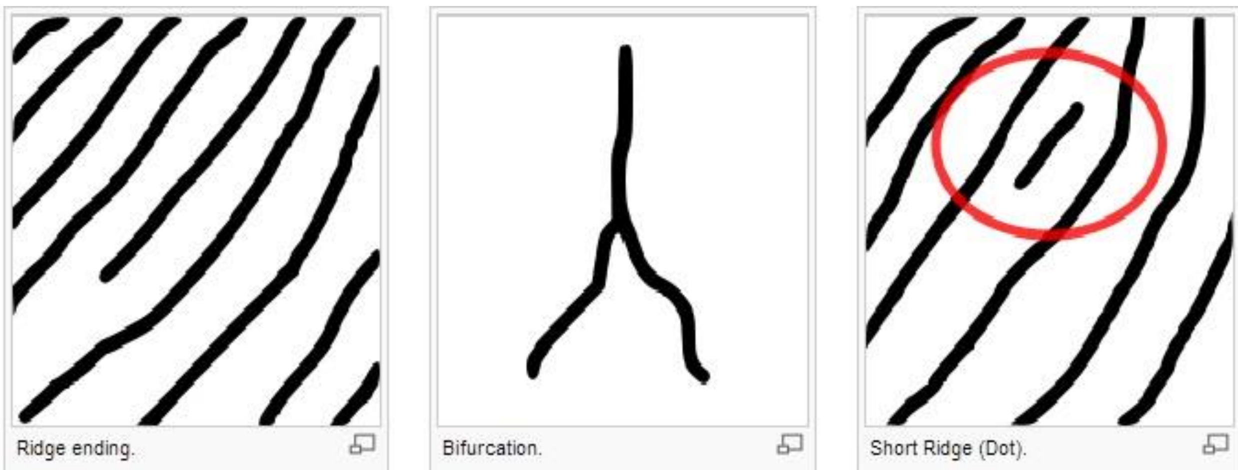


Figure 2.5: Finger Lines Ending and Bifurcation

2.4.3: Palm Print Recognition

Palm print techniques are just like finger print technique. A little difference is that it is much useful technique than the fingerprints recognition technique because fingerprint has a very small region to determine that makes difficult to extract more and efficient features than that in palm where there is a large region of irregular lines. Additional features also available here, i.e. presence of wrinkles and principle lines. Palm prints are recognition systems that are less costly than fingerprints as the patterns of lines are clear as compared to fingerprints. Secondly they can also be acquired by a low resolution scanner. But these scanners are large in taking comparison with the fingerprint scanner and also take more space. Figure 2.6 shows palm print features.

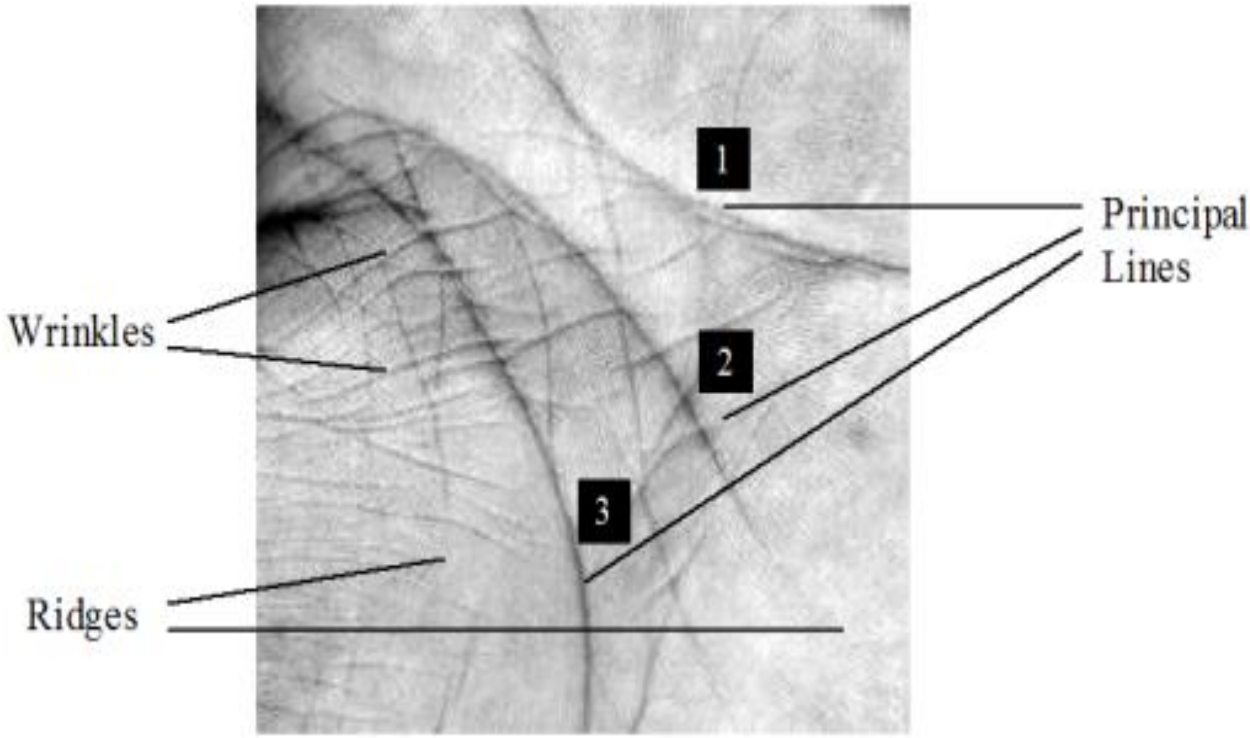


Figure 2.6: Palm Prints

2.4.4: Retina based Identification

Retina is also a useful biometric technique for human identification. Retina consists of tissues, which are basically made up of neural cells. Retina has large number of blood vessels that provide blood to the retina. The pattern of these blood vessels is similar and has no resemblance with any other person in the world. This pattern does not change from birth to death. So these patterns provide good biometric features for the person identification processes. These patterns are only changed due to different diseases like diabetes, retinal disorder, glaucoma or any other retinal disease. The process starts with a beam of low-energy which is fired into the eye. The blood vessels are more absorbent to the light beam as compared to remaining eye region. The light records a specific path when there are variations occurring in the reflection (of lights) during the scan. These variations are recorded after converting to a computer code. Figure 2.7 shows human retinal scan.

Figure 2.7: Retina Scan

2.4.5: Footprint Recognition System

Footprint recognition is another type of biometric identification and verification. It has advantages on other biometric systems that are based on the appearance of a person such as facial recognition systems. In facial recognition system, it is very difficult to identify a person due to low illumination and optional features like hairstyle etc. Systems that use speech or signature recognition need person assistance while automated systems like footprint recognition system does not need this. However this system is not used on large commercial scale but can only be used in a house for family. Footprint recognition system distinguishes persons on the basis of their foot print geometry, shape, their direction and position.

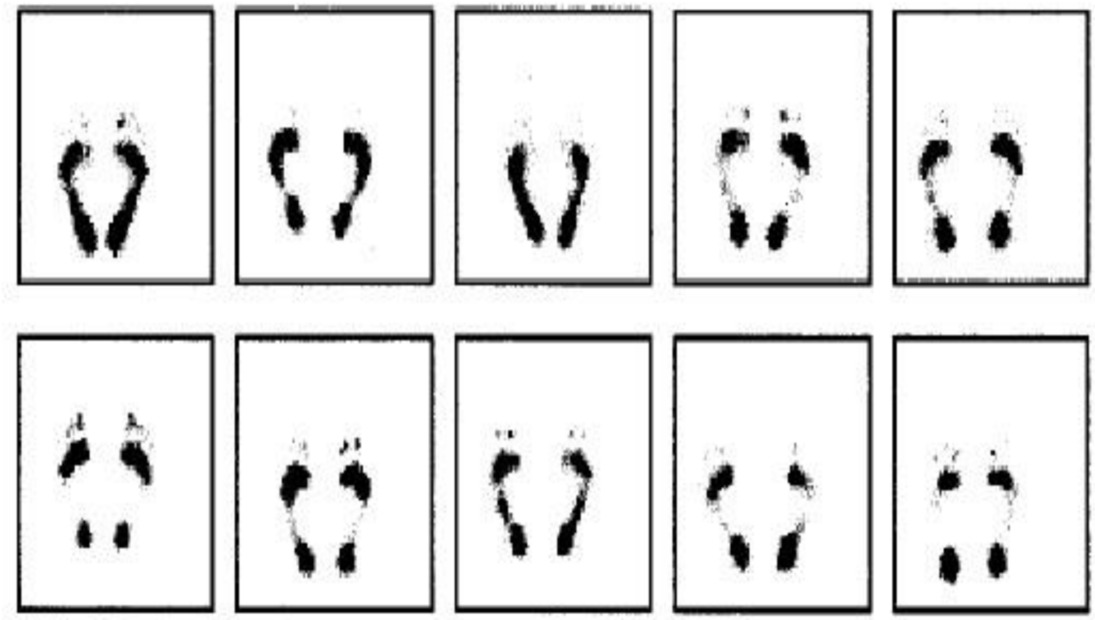


Figure 2.8: Input Raw Footprint Images

2.4.6: DNA based Recognition System

DNA (Deoxy Ribo Nucleic Acid) is a chemical constraint of a human body which is unique to every human. DNA is a one dimensional constraint. However it is bit difficult to distinguish two twins because both have same DNA. These DNA's are also called coding DNA. DNA of each person is different from others due to unique genome. Every person has different genome variations that make him/her different from other people. One main disadvantage of this recognition system is that a DNA sample can be cheated and misused. Figure 2.9 shows DNA of a human person.

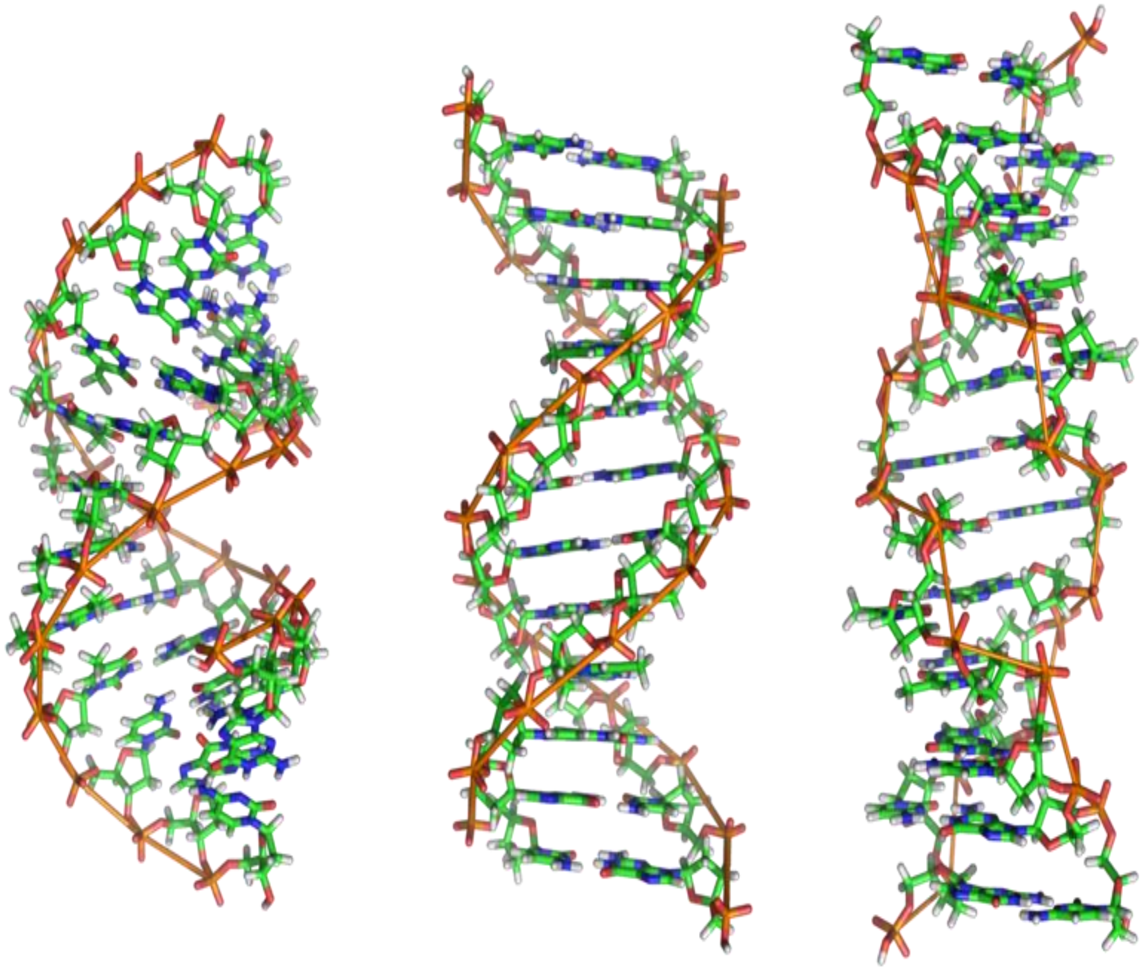


Figure 2.9: Different DNA's of a Human

2.4.7: Iris based Recognition System:

The iris is a muscle within our eye whose function is to regulate the size of the pupil to control the amount of light entering the eye. It is the region bounded with the white color area of the eye known as sclera and with pupil. This region is in of annular shape. The texture and pattern of iris is developed during the growth of child in pregnancy and stabilized in first 2 years of life. These textures hold information that differentiates the persons uniquely. Like finger prints, iris of every person is unique even though they are twins and impossible to cheat or misuse. Iris based recognition system is one of the most commonly used identification system. Figure 2.10 shows NIR Iris scan image of a human eye.

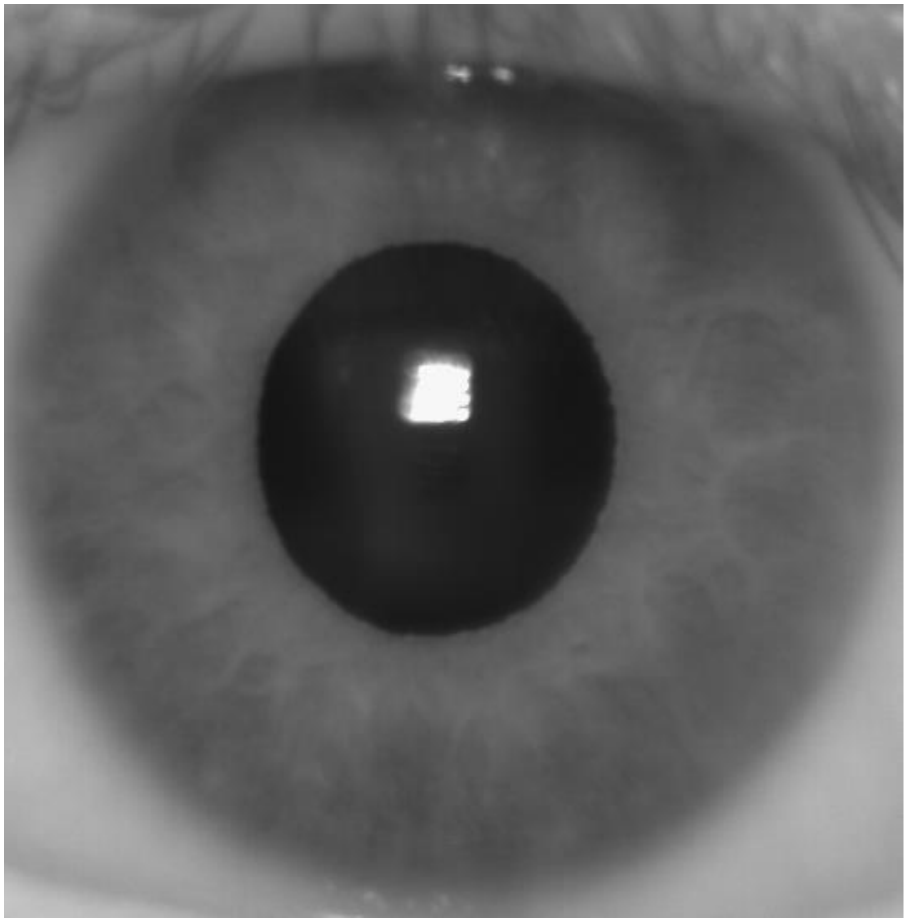


Figure 2.10: NIR Iris Image

2.4.8: Hand Geometry Recognition:

Hand geometry identification is a physical biometric technique that uses the concept of analyzing the physical structure of an individual's hand. Hand veins are the blood vessels that provide blood from the hand back to the heart or lungs for purification of blood after the exchange of carbon dioxide and oxygen. Hand veins are patterned in a specific sequence in the hand. These patterns have some features that make the hand a strong biometrics tools to differentiate between different people and helps to recognize and identify them. Different veins in the human body like hand veins, arm veins, palm veins or retinal veins can be used for person identification but the hand veins are preferred over all other veins. Dorsal Hand veins, palm veins, finger veins or wrist veins all of them provide unique biometric stability. Figure 2.8 shows the venous plexus of the hand.

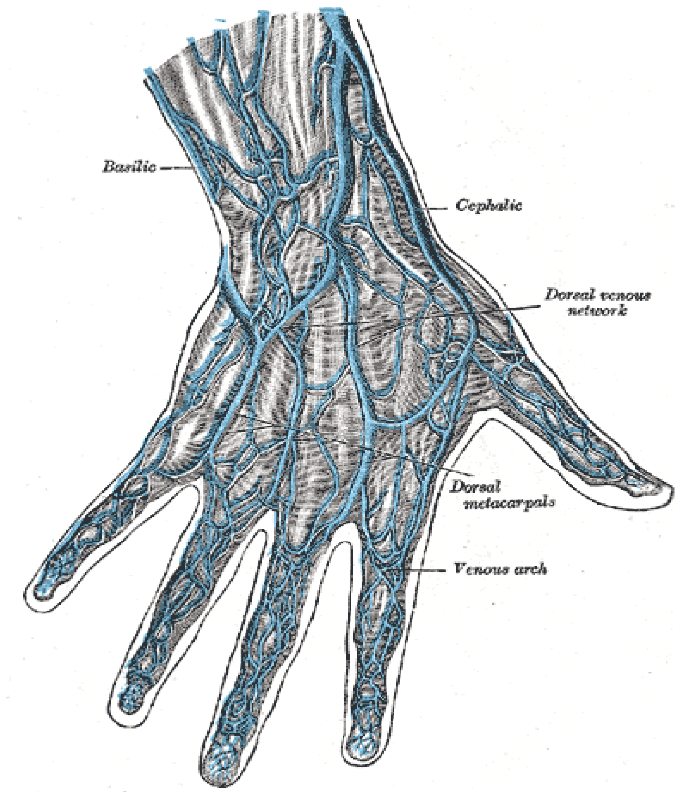


Figure 2.11: Hand Vain Recognition

2.5 Comparison of Biometric Systems

Two or more biometric systems cannot be compared if just one of the values FARs or FRRs given. Both parameters have to be provided to compare the systems because in some cases, it is possible that the system with the lower FAR has an unacceptable high FRR and vice versa.

The values FAR and FRR are dependent on the selected threshold. As mentioned before, the EER can be used to give a threshold independent performance mea-sure. Another method for a comparison is to calculate the area under the ROC curve (AUC).

Finally, to compare the results of two or more biometric systems, it is necessary that the compared EERs or AUCs values are calculated on the same test data using the same test conditions, e.g. the same test protocol.

2.6 Introduction to Dental Biometry

Teeth have biometric characteristics. They can be used to identify humans by finding appropriate features. Dental biometrics is now leading technique for identifying and authenticating human individuals. The proper identification of dental biometry system has not being developed like other systems; it requires a lot of researches to be developed properly.

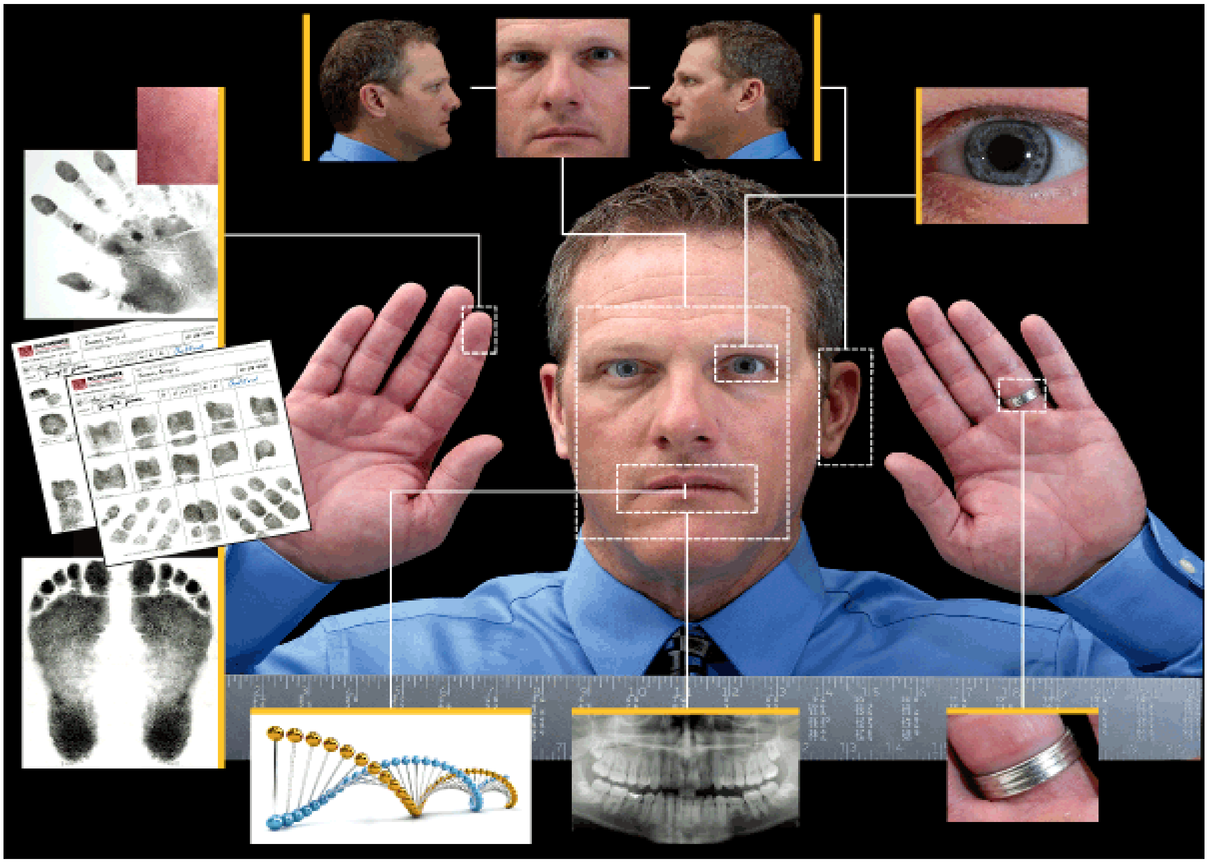


Figure 2.12: Biometrics Associated with Human Being

2.7 Usage of Dental Biometrics

Currently, identification relies on the fact that the comparison done manually between the AM and PM dental radiographs and is based on the systematic-chart created by forensic experts.

Distinctive features for all individual teeth are noted in this chart. These features include the properties of teeth like tooth presence, teeth parts morphology, teeth pathology their restorations. Also include periodontal tissue features and anatomical features.

The forensic experts conforms the unique identity of individuals depending on the maximum votes matching in the dental chart.

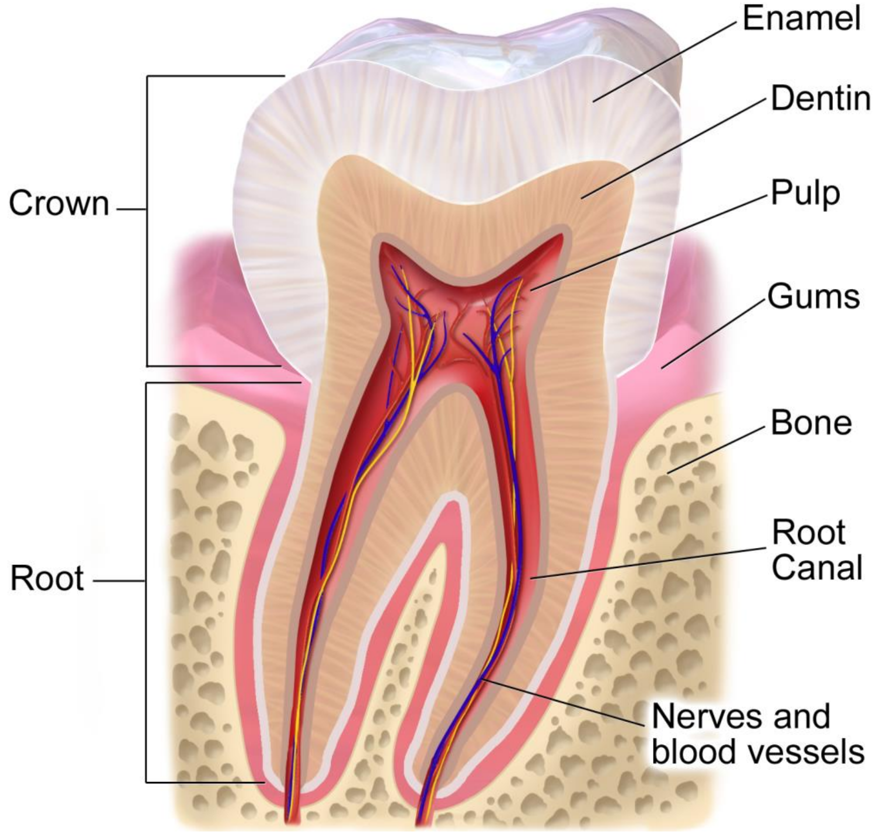


Figure 2.13: Parts of Teeth

There are two main advantages to automate this overall procedure. First, the automatic process will compare the PM data against AM database record objectively and quantitatively to determine the closest match of multiple identities and second, an automation (or semi-automation) system can performed to identify on a huge database unlike, performing manually (or non-automation) system is useful only for the verification on a small data sets.

2.8 Teeth as Biometric Characteristics

Behavioral characteristics (e.g. speech or signature) as well as most physical characteristics are not appropriate for PM identification. Especially under severe circumstances encountered in mass disasters (e.g. airplane crashes, fires accidents, etc.) or when there is no identification possible within a couple of weeks postmortem. Therefore, a postmortem biometric characteristic has to survive severe conditions and resist early decay that affects body tissues. Dental features are considered the best candidates for PM identification be-cause of their survivability. Tooth shapes, appearances, tooth fragments, metal restorations, skull and jawbone fragments may possess features that can be associated with just one person.

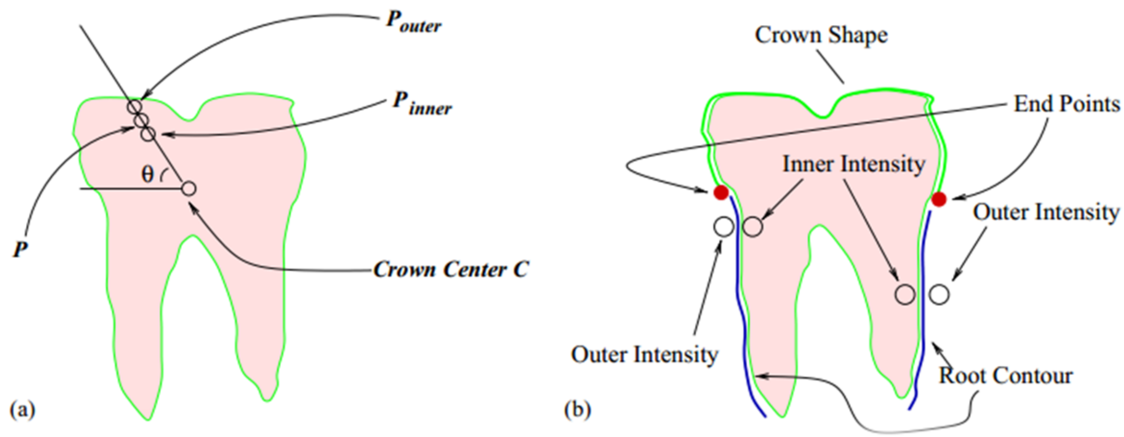


Figure 2.14: Biometric Characteristics Associated with Teeth

2.9 Teeth Universally-Numbering System

Teeth as the Universally-Numbering System, is the method to identify system of teeth and has been approved by "American Dental Association". This method has been employed as numbers with having each tooth designated by a distinguished number starting from 1 and ending to 32. Figure 2.15 clearly explains the numbering-system used by a standard dental-chart for a full set of normal adult human being teeth.

The human permanent teeth have been divided into four classes, which have been based on the appearance and functionality or position of teeth:

1. Incisors have location in the very front of mouth. They are sharp, very thin in edges, and used for cutting. They have a king of lingual-surface and have a shovel kind of shape as an appearance.

2. Cupids (canines or eyeteeth) are present at mouth angles. Each cupids having single-cusp as an alternative of an incisal-edge, it's being designed for cutting, tearing etc.

3. Bicuspids are premolars and are similar to the cupids instead they have two cusps, that are used for cutting and tearing etc, and having an occlusal surface foe crushing the food.

4. Molars have location in-the back of human mouth. Their size steadily going smaller and smaller, from first to third molar. Each molar has four/five cusps, is shorter and blunter in shape in comparing the other teeth and providing a broad-surface in grinding and chewing of solid-masses of food.

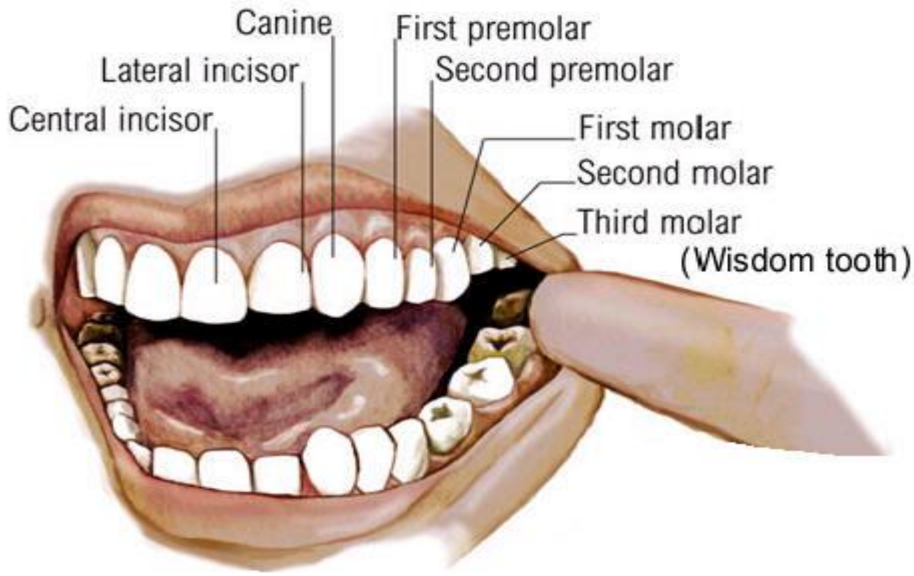


Figure 2.15: Teeth Categories in jaws

2.10 Summary

This chapter consists of a short introduction of biometric system, performance attributes, some common biometric systems that are being used in world such as: iris recognition system, DNA based system, finger and palm print recognition system and etc as well as hand veins anatomy plus hand veins recognition.

CHAPTER 3: LITERATURE REVIEW

This chapter gives the literature survey about the Dental based human identification methods. Up till now the researches have been done in this field is now being discussed in this chapter. While doing research on Dental based Human identification, researchers discovered many different algorithms and designed different systems to improve reliability and making security more and more powerful.

3.1 Pre-Processing and Segmentation:

Pre processing is the removal of unwanted noise and making the image enhanced and batter for further processing.

Elizabeth, Denise et. al. [01],[07] Uses a semi-automatic Differential Image Foresting Transform (DIFT) and extracted teeth and dental-contours of dental radiographs as dental-features. The DIFT is based on the IFT method, which is generalized method of designing, implement, and the evaluation of image operators, on the bases of connectivity. It’s a graph-based Segmentation Algorithm

Michael Hofer et. al. [10] used median filtering to improve the segmentation results. For segmentation, IDR, an algorithm used which finds a gray-level thresholding for left and right in the ROI. It separates the useful features (DWs) from the background. The gray-scale histogram of IDR is used to detect the threshold. Getting bad segmentation results like over-segmentation or under-segmentation. [10] Used different manually post-processing methods in order to improve the performance of segmentation algorithm, further manually post-processing is needed to handle the three different types of errors.

Shubhangi et. al. [06] started with Enhancement of image i.e. Dental-radiographs by converting initially into the gray scale image. After that segmentation is done by to get dental work information. The most important objective of this proposed algorithm of segmentation is the extraction of at least one of the ROI, representing exactly single tooth and used image-cropping operator for extracting the teeth.

Paulo, Elizabeth et. al. [03] converted dental radiograph images (RGB form) to a gray scale image and used median filter for reduction of noise. Having different contrast conditions in the dental radiographs, the image has been further divided into 2-regions of interests. The algorithm, then defines gray-value thresholding in the left-hand-side and in the right-handside of regions of interests in dental radiographs. Specifically the Dental Radiographs have features as the highest intensity values in grayscale images and will appear as distinctive, relatively very minute but in a definite form in the upper-range in the gray-level histogram. After creating smooth histogram by an average filtering, the threshold is made to the gray-level in the location of left and in rightmost part, which defines the required Dental-Radiographs. The algorithm has been implemented for sorting all Dental-Radiographs into the Dental-Restoration Mask by moving from left-to-right on the basis of the leftmost pixels of the dental-radiographs.

Jain, Chen et. al. [04] segmented dental radiographs in the form of blocks in such a way that each block contains a single tooth. Then found the Region of Interests for all teeth. For making simplicity, we have assumed there that each, one row in the upper-jaw and lower-jaw teeth in the image. After separation in the rows of upper and lower jaws teeth, teeth should be isolated from their neighbors. Since teeth normally have high gray-level intensities in comparing with the jaws and other tissues in the teeth-radiographs, reason being due to their higher tissue density there, the gap in-between the upper and lower jaws of teeth will create a valley in the y-axis in projection of the histogram, thus, using this concept, teeth are successfully separated both horizontally as well as vertically.

Shubhangi, Shriram et. al. [06] Prepared histogram prepared for grayscale-radiograph. Histogram equalization is performed in order to enhance image quality and then, finally returned the high quality image back by applied histogram equalization technique. [06] Used morphological techniques and image cropping operations for extracting teeth, single tooth extracted for further processing

Şoaita, Mure et. al. [13] Gave Preprocessing of images, where enhancement, segmentation and alignment are achieved to correct for possible geometric and/or intensity transformations segmentation consists of manually selection of a rectangular region containing the tooth. To differentiate by edges of adjacent teeth is done by finding the gradient

Rad, Norouzi et. al. [14] Performed segmentation and image analysis is performed by the extraction of teeth and specifically tooth forms from the image background. Each tooth or object extracted from image and represented as region of their interests that encompassed as important data for later steps. Overall the system of doing segmentation is unsupervised, leading to bad performance due to non-automation.

Hofer, Maran et. al. [08] performed Pre-processing on the dental radiographs data and segmented out the DW information. For this purpose the radiograph data in color form is converted into the gray-scale images and performed the median filtering and noise has been removed from the image.

3.2 Feature Extraction and Classification

Elizabeth, Denise et. al. [01], [07] uses the shape descriptors based on the Shape Context method and Beam Angle Statistics (BAS) were implemented and evaluated for the teeth recognition. For teeth shapes, after the segmentation by the Image Foresting Technique, the teeth contours and dental works information are used as biometric descriptors.

Fahmy, Nassar. et. al. [02] used the integral projection of histogram in x-axis to get the gap between the upper and lower jaws of teeth and then drawn an integral-projection histogram in y-axis directions to get the gap in-between neighboring teeth in the data set. [02] extracted teeth contours after that, which were the crown-contours, an assumption was made that all the intensity values of the background pixels getting form the first curve in the intensity histogram. For a pixel value with intensity curve, they found the probability for it to be a specific tooth pixel and defined the probability of it by ensuring to be a background pixel. Then in each radial line at the center of the crown part, they got the closest boundary points.

Paulo, Elizabethet et. al. [03] based on the Dental Restoration Mask, a dental code was produced. This Dental code includes all the information regarding location, the size of the Dental Radiographs and calculated the distance between two neighboring Dental Radiographs Next to each other.

Jain, Chen et. al. [05] Extracted teeth contour in three stages. That includes the initialization stage, convergence to the gradient stage and finally the fine adjustment.

“Convergence to the gradient” is done by canny operator to get “Gradient Vector Flow” field of the edges.

Michael Hofer et. al. [10] created dental code to get Position of the Dental Works by introducing an algorithm to implement to categories all DWs in the DWM from moving from left to right, on the based on the “center of mass” points of all Dental Works. The next step was getting Distance between two neighbor Dental Works in order to make the “matching algorithm” more sensitive.

Hofer, Maran et. al. [08] created a “dental code” from the information extracted from Dental Works including the position upper/lower jaws, size and distance in-between two neighboring Dental Works. Finally on the Basis of the DWM, a dental-code was created.

The dental-code includes all the information about the position upper/lower jaws, the size of the DWs and the distance between two neighboring DWs

3.3 Matching

Elizabeth et. al. [01], gives matching as the PM dental radiograph images have been compared with the AM radiographs image data, that was formerly stored in the database record, and a decision of matching identification of the PM query image is performed.

Fahmy, Nassar .et. al. [02] discussed matching as the input to the matching stage as a pair of initially pre-processed segmented data from an individual and corresponding radiographs. The matching stage extracts out the desired features from the input radiographs data pairs, and then, finally determines their maximum votes for matching on the basis of the measured dissimilarity between the extracted desired features. This final stage comprises two stages: the desired feature extraction and the matching decision-making.

Michael, et. al. [10] used comparison of dental codes in order to get the desired results. It performed with the Levenshtein-distance algorithm, which has been based on Edit-distance, and is used for inferring the identification. The value-cost of the insertion, deletion and substitution operations, which were required to find the Levenshtein-distance, were adjusted properly to get the matching algorithm more powerful.

Paulo, Elizabethet et. al. [03] given the matching as, after the creation of dental-code, it is compared to other dental-codes in the database. All dental-code were differently made for the same person, due to the changes in dental-codes of the different subjects, Matching in-between the dental radiographs of the same individuals is considered as “genuine matching” and the matching between dental radiographs, that are in actual two different subjects is termed as “impostor matching”. An algorithm was designed and implemented, which is based on the universal edit-distance, also termed as Levenshtein-distance. The edit-distance between two different strings is formed by the minimum number of operations, which have been required to convert one string into the other one, where an operation may be any, like insertion, deletion, or substitution.

Hofer, Maran et. al. [08] performed Matching of particular dental-codes with other dental-codes in the formally made database. After the creation of dental-code, comparison can be made with other dental-code in the matching stage.

In actual, these may be various codes of the same person or may it be codes of different individuals. Matching between the dental radiographs of the same subject is termed as “genuine matching” and the matching between different dental radiographs is termed as “impostor matching”.

3.4 Performance

Elizabeth, et. al. [01], the experiments were performed on a database of 1126teeth samples, which are obtained from 40-panoramic dental radiographs of 20 persons. The Multi-biometric approach improved the system performance generating, in the best case, an EER of 9%.

Michael, et. al. [10], the methodology was performed on a database of 68 dental-radiographs and the obtained results are highly encouraging. The results showed an error-rate ‘EER’, i.e. 9.8%. By using ROC-analysis and got an accuracy of 82% using for top-1; retrieval has been achieved.

Fahmy, Nassar et. al. [02] did not concluded with satisfactory results; it was a proto-type for An “Automated dental-identification system”, also abbreviated as “ADIS”, which was made to be used by crime agencies for solving missed and unidentified person’s cases. An architecture, i.e. ‘ADIS’ precisely and explained its components and functions, it has a limitation that the going from region base matching to cased base matching, there is a problem in processing the poor quality of radiographs, and the getting back of Dental radiograph images have not been properly discussed.

Paulo, Elizabethet et. al. [03] did not obtained considerable results by using “dental restorations features”, as with the variation in the biometric characteristics has been got observed. In order to handle this high variation, the methodology proposed used the distance-function; which was based on generalization of edit-distance, which was also not so promising.

Jain, Chen et. al. [04] overall the proposed method was nearly satisfactory, still, it was become difficult in Appling the proposed strategy in some situations where; (a) when the images blurred, (b) when the image under analysis having some occlusion so that no sufficient information was available in order to characterize the teeth like the upper teeth, any form of considerable change in the angle between the AM and PM images data can create a lot of changes in teeth shapes, and finally some of the teeth to be extracted.

Some of the considerable issues can be tackled by making use of additional information’s and some others required to be solved.

Shubhangi, Shriram et. al. [06] Presented differentiation for matching purpose, between two different radiographs on the basis of properties like tooth-area or dental-work, histogram-mode, histogram-median, histogram-skewness and histogram-kurtosis but not giving outstanding results.

Jain, Chen et. al. [05] proposed an efficient method of extracting tooth-contours in three stages, which are Initialization stage, convergence to gradients stage and finally fine adjustment stage. But due to the limited fast variation offered by the tooth contours, matching was not performed.

Hofer, Maran et. al. [08] tested the matching performance of proposed method, the algorithm, which was designed, implemented on the database in order to compare Dental Radiographs of individuals the genuine matching occurred for two different radiographs of the same individuals and Dental Radiographs of the impostor matching occurred for two radiographs of different persons.

CHAPTER 4: PROPOSED METHODOLOGY

The following chapter will explain the proposed dental biometric identification method in detail. The four main processing stages, which include pre processing and segmentation, feature extraction, dental work creation on dental features and feature work matching. The whole process has been fully explained with figures and all supportive information.

4.1 Introduction

Biometric techniques are growing rapidly in the field of human identification and recognition fields because it uses distinct characteristics of humans that are unique in every person. The process of identification ensures that who is that person, whether the person is authorized or not. The time and power constraints of a biometric system depends on the size of database. If the size of the database is large then it will take more time and power as compared to a small database. Many biometric systems were developed throughout the world during past few years such as: palm recognition system, retina scan, iris scan, finger print and foot print recognition system and etc. Biometric systems are safe and secure because every person's features are unique and bear no resemblance with others.

The aim of a dental biometric identification method is to make a dental database which is stored and authenticating the test image with the database.

The objective of the proposed work is to implement the Dental biometric technique based on extracted dental features information. The algorithm was implemented in Matlab.

First we implemented shortly in radiographs data then moved to our main work that is identification of humans on the basis of dental colored images.

4.2 Forensic Dental Implementation

Different Researches has been done in the field of Forensic Odontology. It is used because the deceased persons are identified by dental forensic when no other biometric option available.

4.2.1 Intensity Valley Detection

The presence of upper and lower rows of teeth is detected by using the position of the separating line, "SV-Curve". Similarly, vertically and horizontally tooth are separated

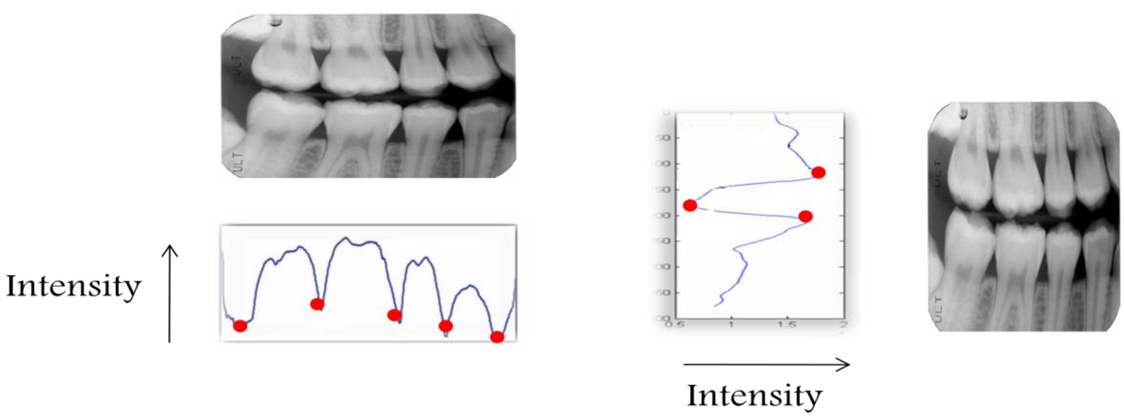


Figure 4.1: Intensity Valley Curve on Radiographs

4.2.2 Our Proposed Methodology

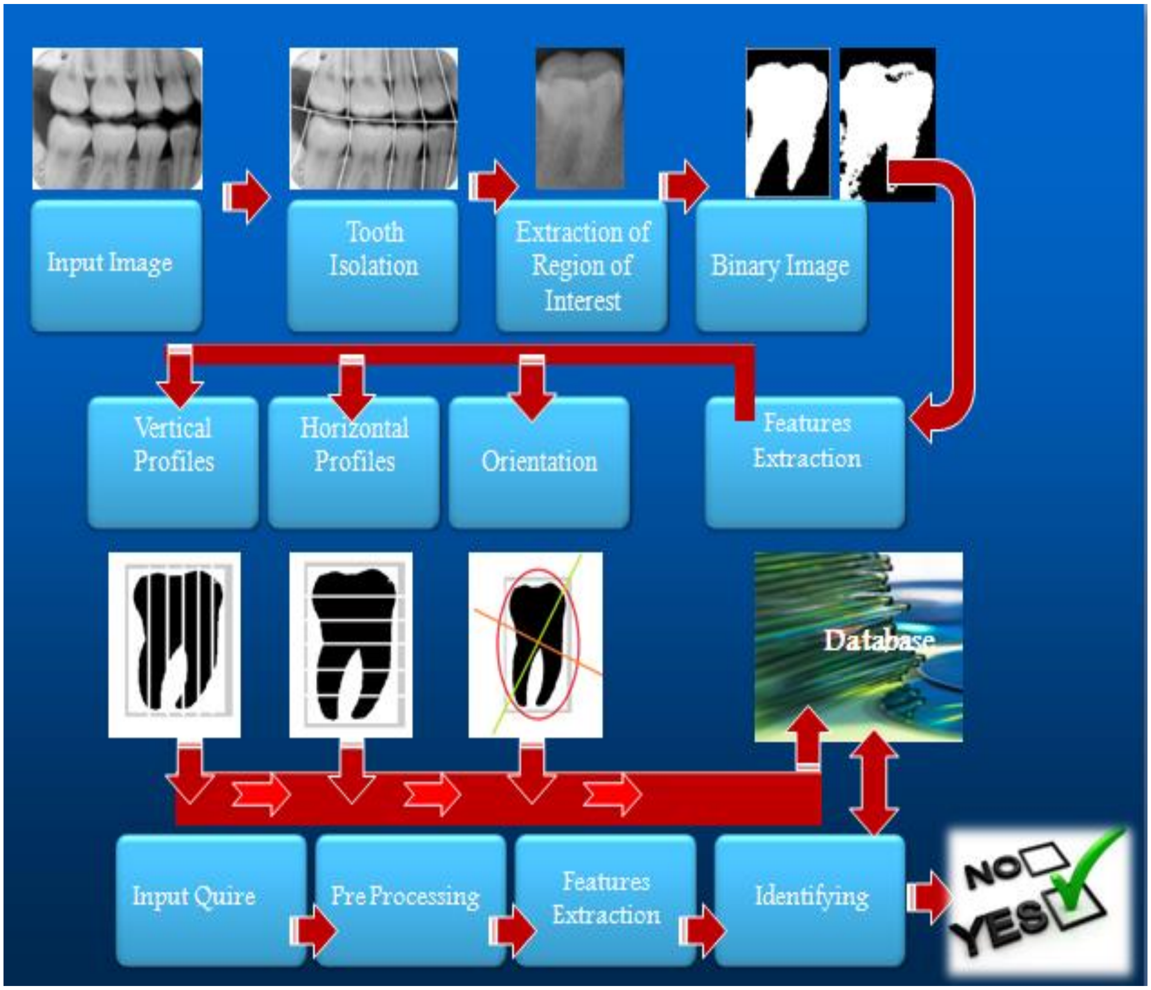


Figure 4.2: Our Proposed Methodology for Dental Radiographs

4.3 Our main Work block diagram:

To achieve comparable conditions which are needed for the matching stage, the dental data go through the following steps are drawn in block diagram.

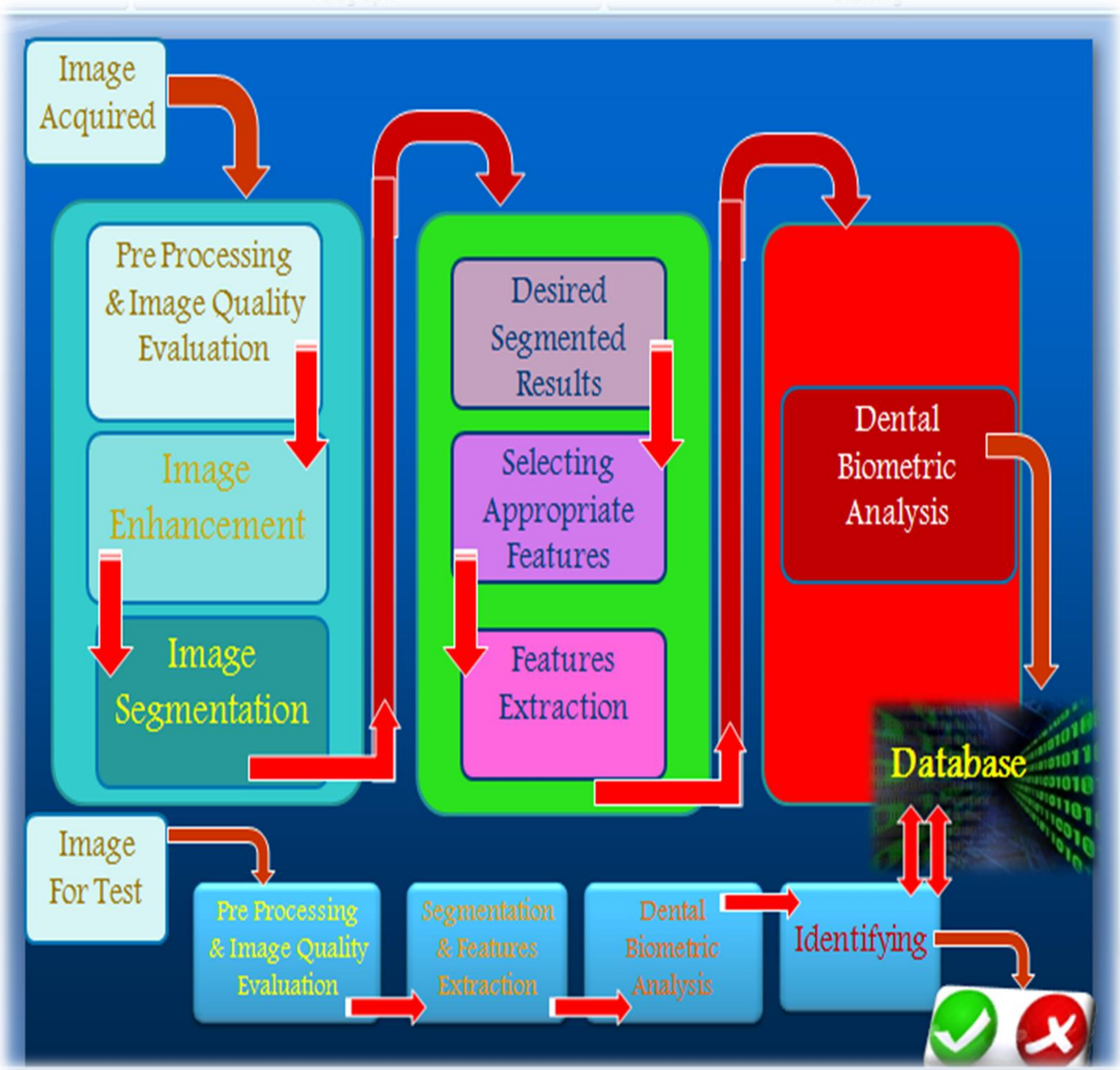


Figure 4.3: Our Proposed Methodology for Color Teeth Images

4.4 Preprocessing and Image Quality Evaluation

Preprocessing is the first and foremost step in Dental Image processing and has its importance as the whole processing is based on it. Images of Bad quality create difficulties at every stage of feature extraction and matching. In our work, we are working for a system where the images are taken from automatic photographic scanner, which is further processed by our system for identification of individuals.

The timely updating the database records for authentication system makes the system efficient and leads reduction of error rate possibility. Availability of Latest Digital Cameras and other machinery, the Evaluation of image quality is rarely required.

The evaluation of image quality comprises the following steps:

1. Image Detection;
2. Imbalances in Image intensity;
3. Detection of image blurring.

For best features extraction and accurate matching results the quality of image should be noticed and evaluated properly to get desired results.

Images may be captured with scaled to a certain size; some have more high frequency components and fewer low frequency components and similarly, with different intensity variations. Intensity imbalance means that the images are over-exposed, under- exposed, or partially over-exposed and/or partially under-exposed. Images are captured by the system may have different scaling and intensity imbalances. System is set to get proper images such that the image is best in all respect and it will avoid issues in further processing.

For our system main concern is avoiding motion blur, which can be caused. To avoid this, an algorithm has been developed which will detect and make the correct image back in original form. The figure below will explains De-blurring from motion blur is properly fixed to make system efficient.

4.5 Segmentation

Segmentation step is continued after pre processing. Here as per requirement by the work, we have done various types of segmentation and used various techniques.

The major purpose of our segmentation is to find out our interest part separation associated, which is part of the image comprises some desired teeth of the image. There is two rows of teeth. One row i.e. maxillary, the upper jaw and other i.e. mandibular, the lower jaw teeth in the image. More batter the desired results we achieve in segmentation, more batter the results we will get in next steps and eventually the identification process.

In this part, we are going to perform various types of segmentation and got the desired results. Everything in complete details and simulation results are given in details.

4.5.1 Desired Image Region:

The goal of this segmentation is to find the teeth desired part to segment out for further processing.

4.5.2 Binary Image Formation:

The goal of this part of work is to convert segmented RGB images to Gray Scale images; Features extraction part will explain the use of this work.

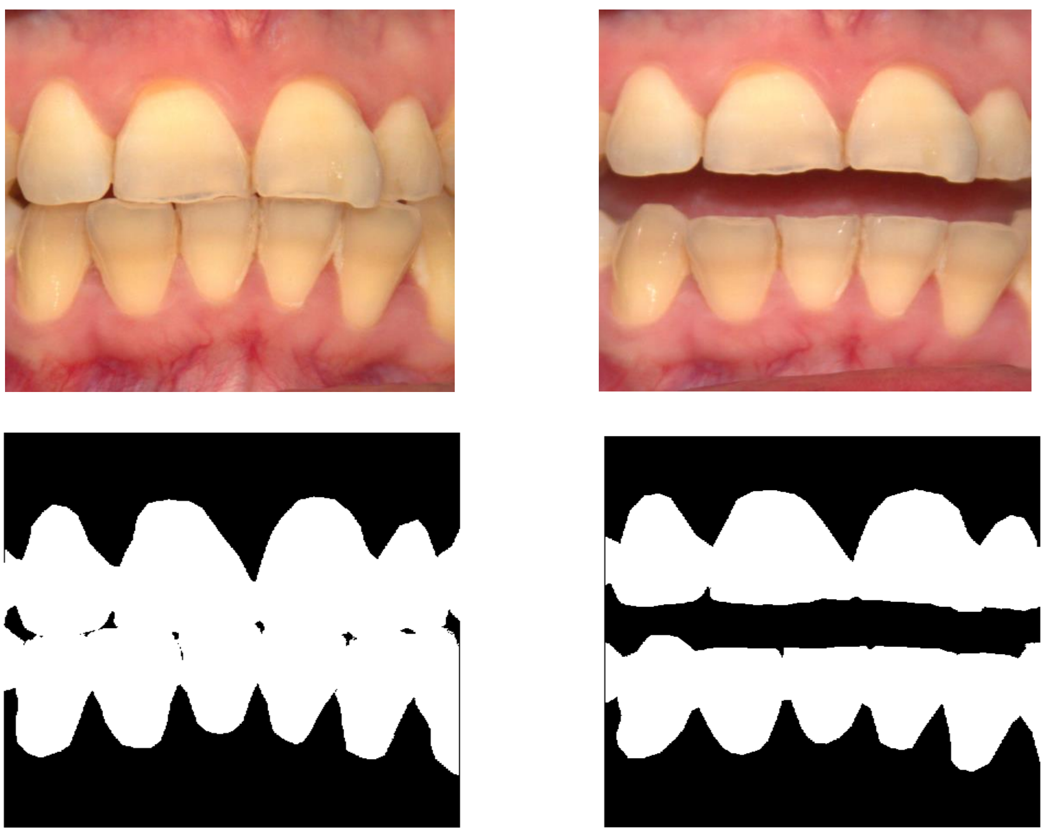


Figure 4.4: Binary Image Formation

4.5.3 Image Segmentation Results:

This part of Image Segmentation comprises image to binary formation, Figure below shows the results.

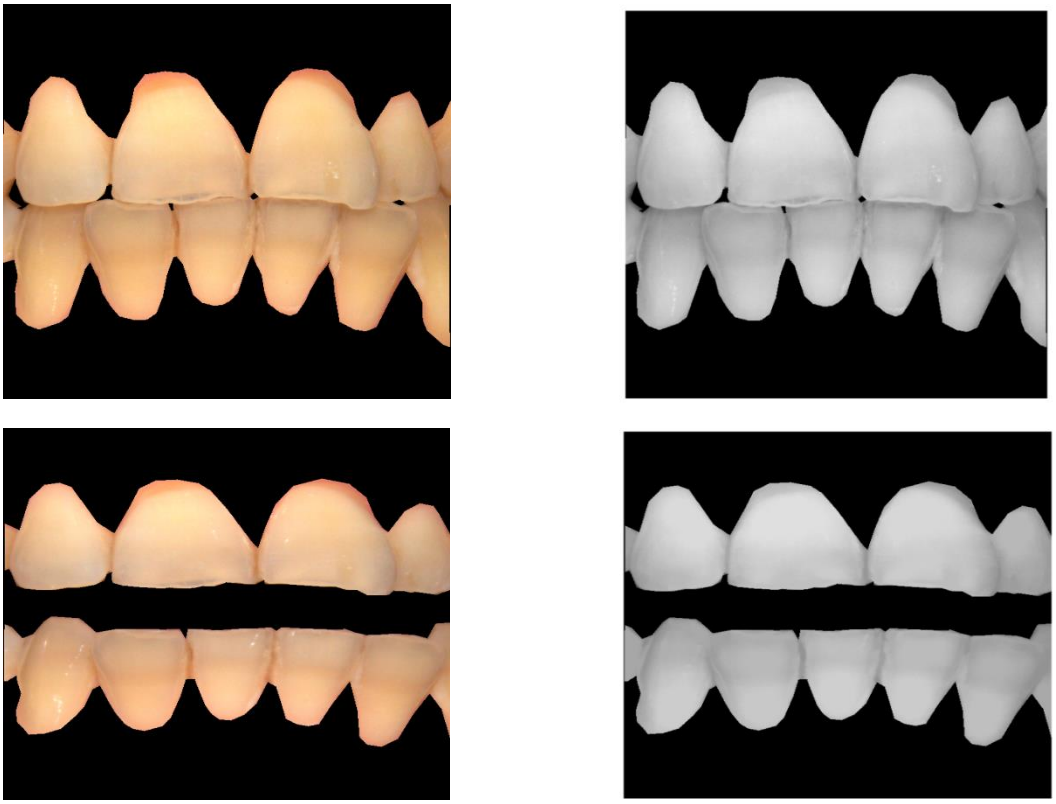


Figure 4.5: Image Segmentation Results

4.6 Features Extraction

The aim of a dental biometric identification is to authenticate humans on the basis of dental Data by comparing in our database. The objective is to implement a system, which has biometric identification method based on dental biometric calculation on dental data. The algorithm designed and then implemented in Matlab software. To achieve comparable conditions which are needed for the matching stage, the dental images are preprocessed and segmented well, before they are used for further processing

The Dental Images are in RGB color form. They are converted into a gray scale image form & different types of pre processing applied, which has been explained before.

The algorithm we have defined determines a threshold in grayscale image as an area of interest in the Dental image. Naturally the Dental features are present as the highest intensities in the image and appear distinguish and distinct. The feature results are also based on the previously performed steps like pre-processing and segmentation etc. Every region is a Dental feature. The intensity valley curve is shown as below.

On the basis of intensity variations we have separated the region of interest, which has been highlighted as figure given below

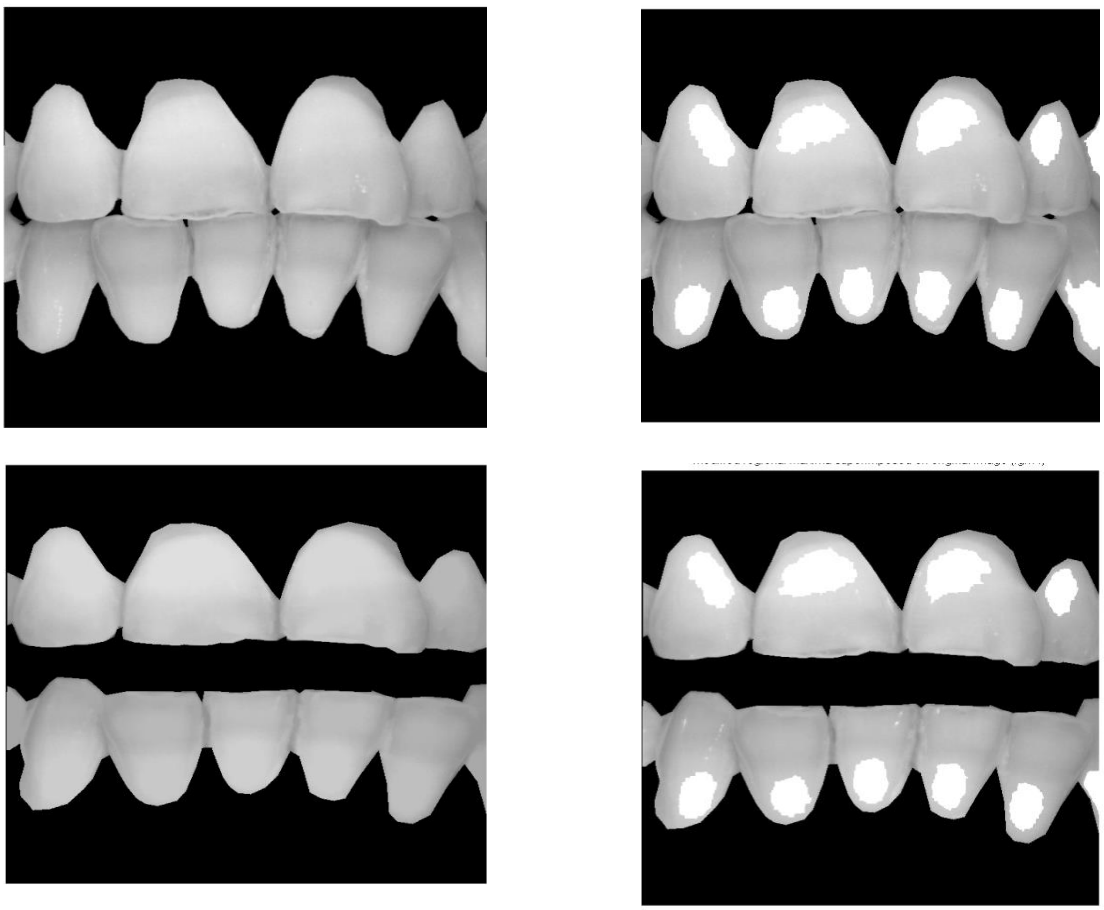


Figure 4.6: Teeth Intensity Profiles

After finding the regions of interest, teeth are separated and distinguished. As shown in figure below.

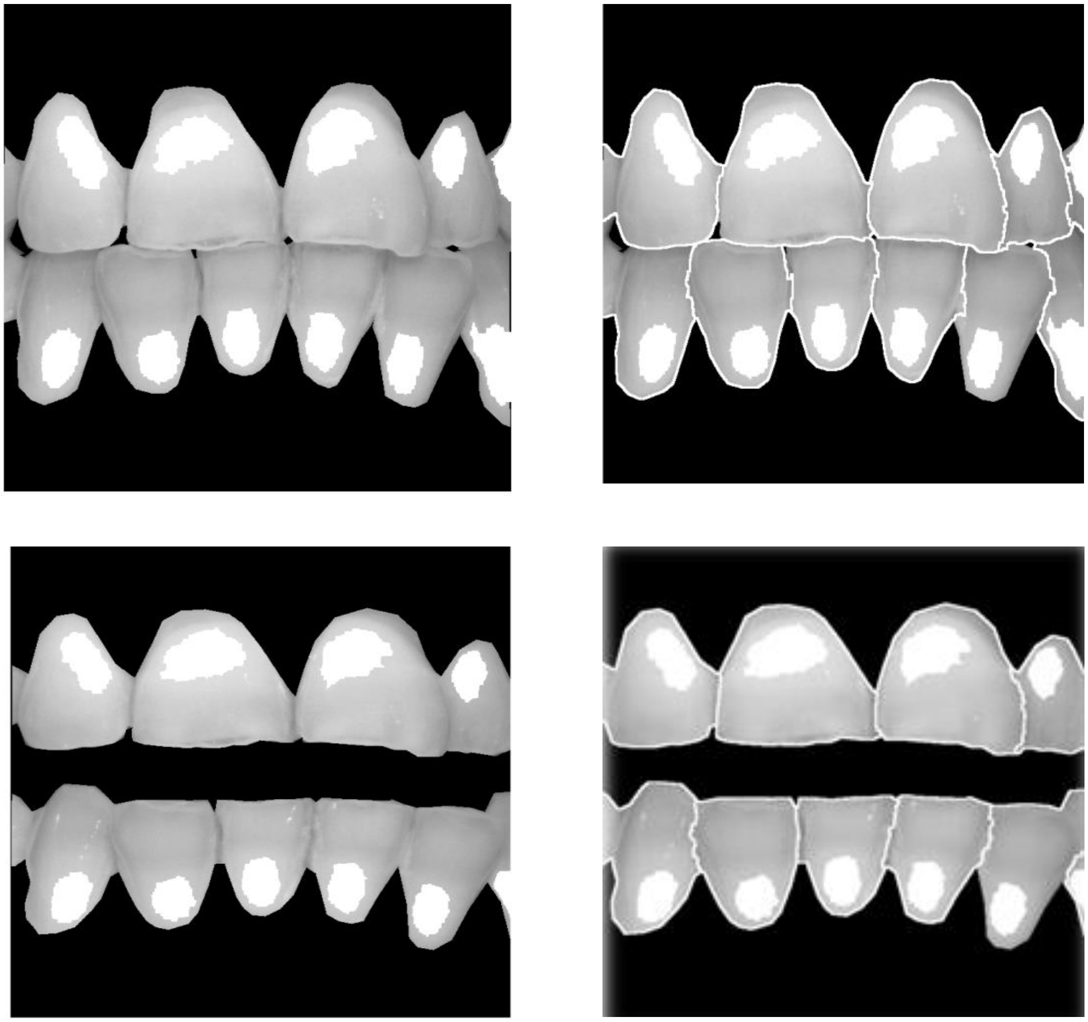


Figure 4.7: Teeth Boundary Extraction

Now moving forward, Regional Maxima is found that contains only teeth boundary and binary regions. Figure 4.8 describes this.

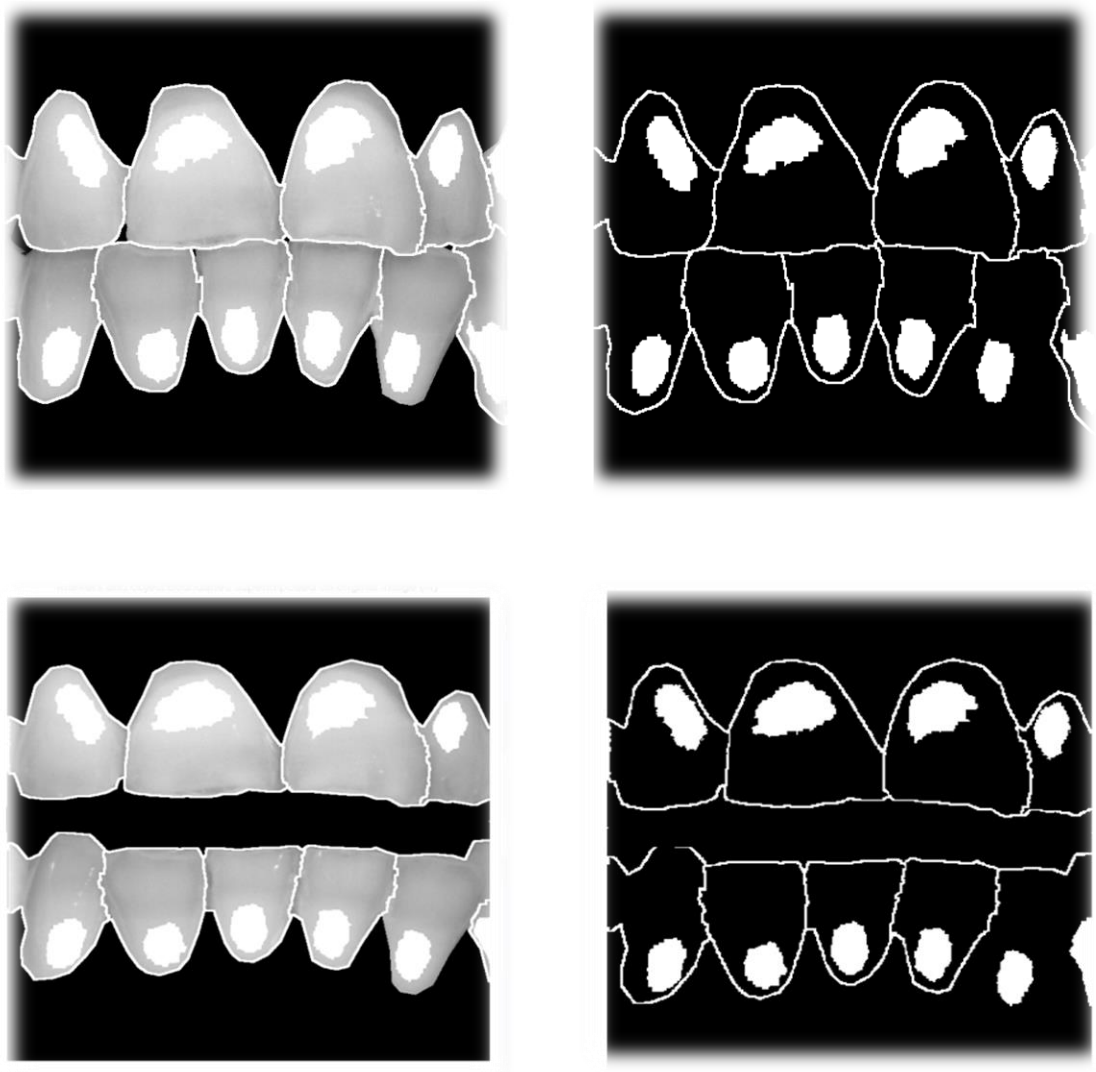


Figure 4.8: Extracted Highest intensity part of image

Now in the next step, we have applied morphological addition and subtraction, we have found the required binary regions. Figure 4.9 describes this.

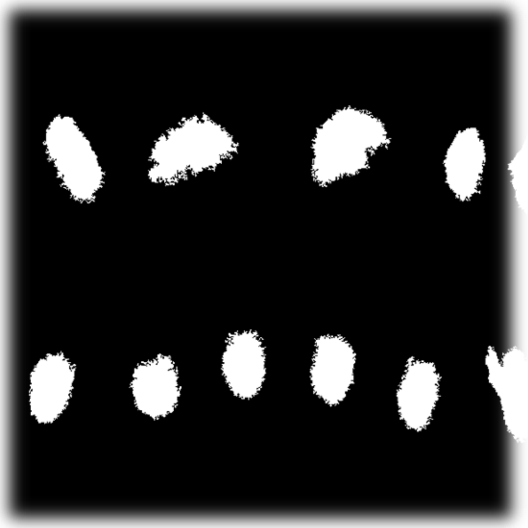


Figure 4.9: Concerned Binary Regions

The regions we have got are good for analysis but in order to get more accurate matching results, the following two steps are processed. Fist is to make a boundary around all the regions also shown in figure.

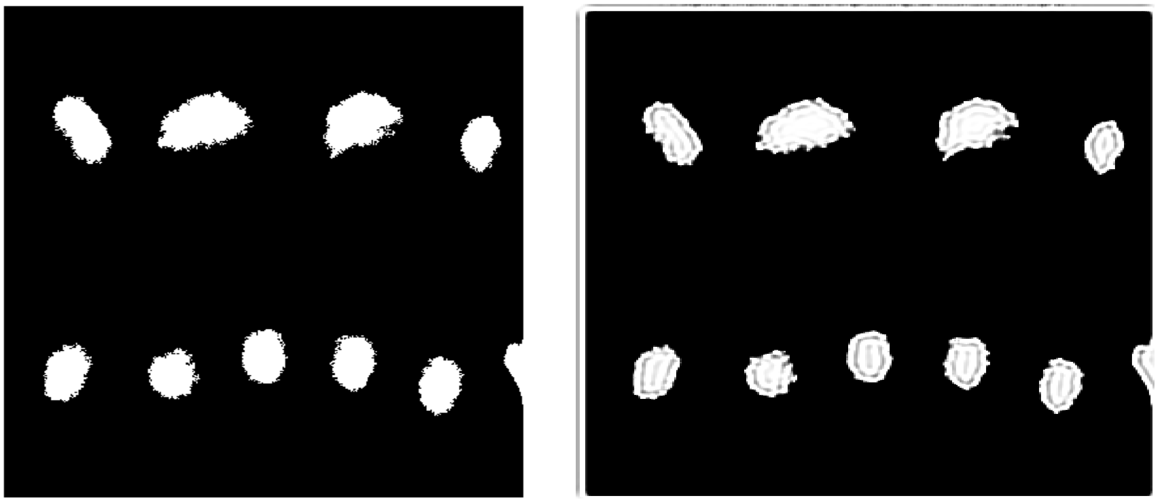


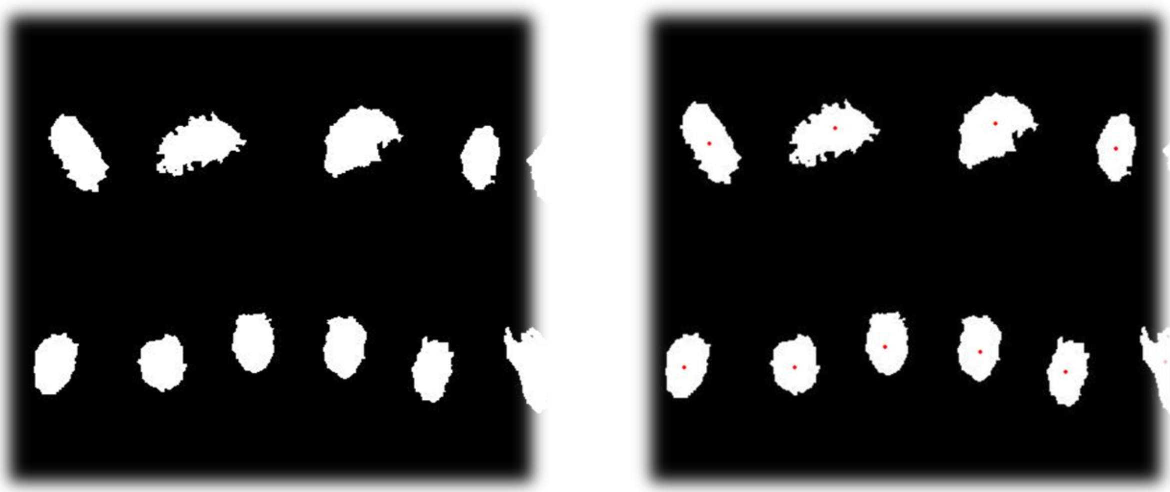
Figure 4.10: Boundary Calculations around regions

The uniform final image has been found which is now prepared for Dental biometric analysis. Shown in figure 4.11

Figure 4.11: Uniform binary Regions result

4.7 Dental Biometric Analysis:

Before we go for distance matching, first we have to prepare the intensity regions, extracted for features extraction. For this purpose we have find out the mass points in the regions extracted, so that from these mass points, we will plot lines vertically.



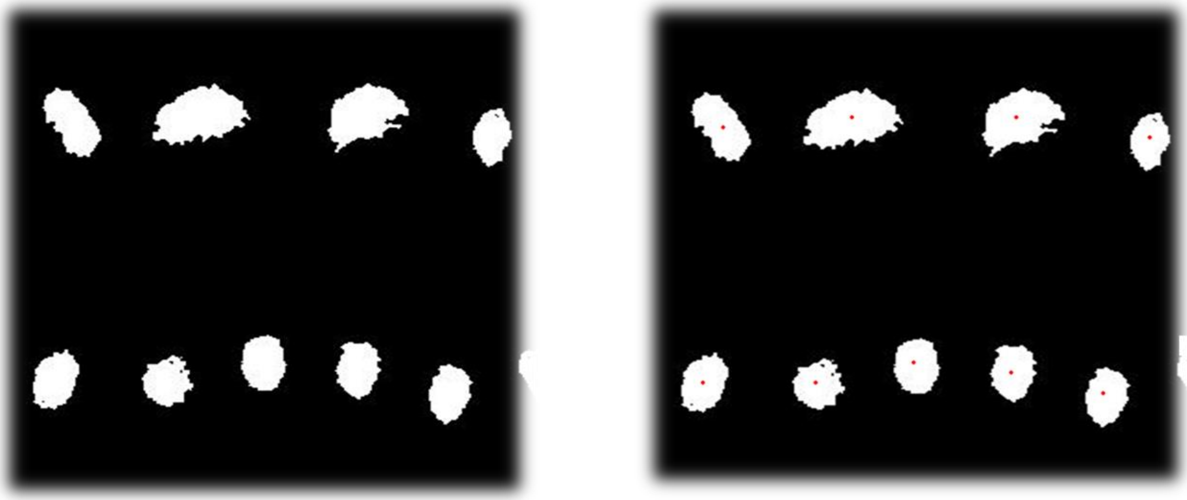
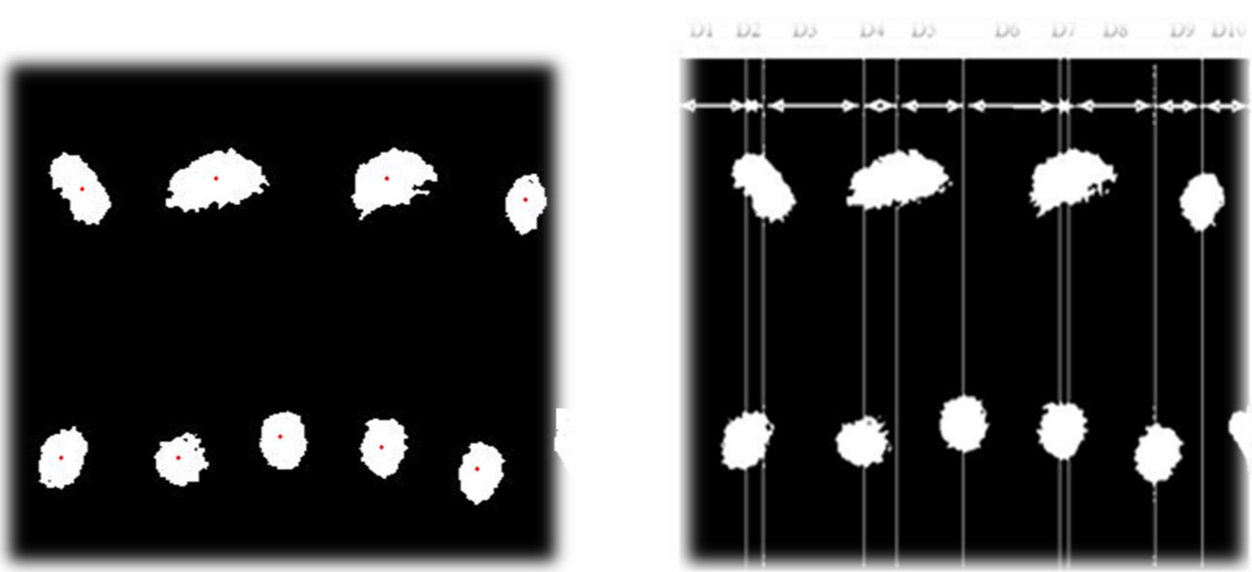


Figure 4.12: Center of Masses of Binary Regions

Now the next is to plot the lines from mass points to get the distance data base. The figure 4.13 shows the lines plot.



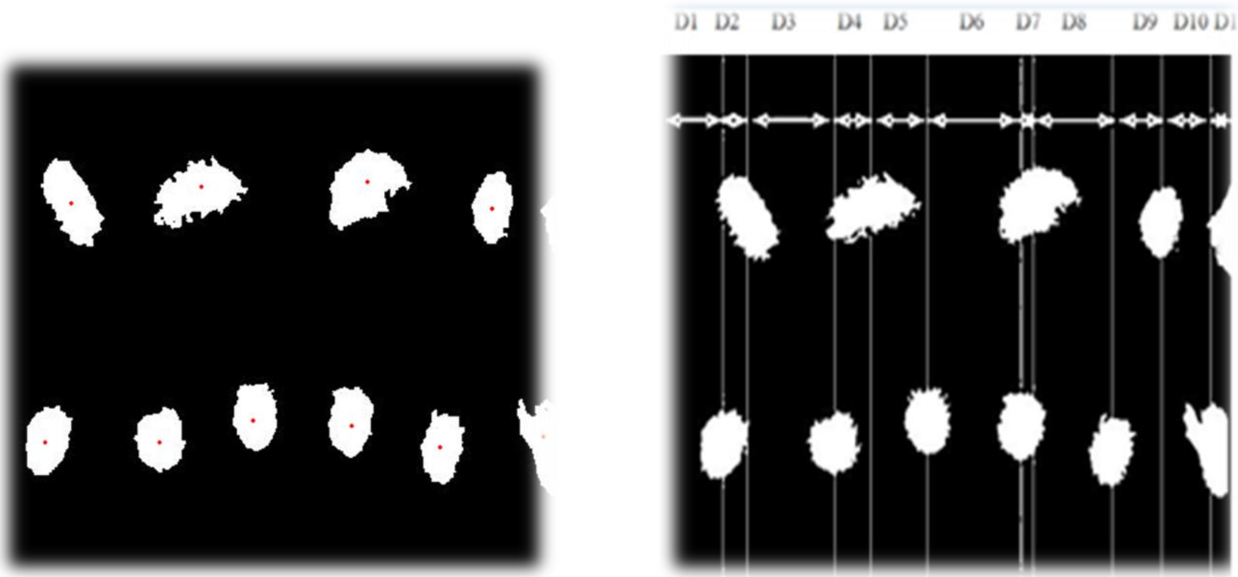


Figure 4.13: Plotting Lines from center of masses

After Dental Features extracted, Dental biometric analysis has been started, a dental biometric analysis algorithm is developed. The algorithm incorporates biometric information about the detected Dental features including various properties of images and finally getting the distance in-between neighboring features.

To make a strong algorithm, it is necessarily important to distinguish the tooth feature location, whether belong to the maxilla, the upper jaw or mandible, the lower jaw. Thus, they should be distinguished.

In order to make matching guaranteed, an algorithm is designed to perform Dental Biometric Analysis. For this purpose, various properties have been applied on features and the distance between neighbor Dental features is included into the dental biometric analysis algorithm. The possible way to define the distance is the amount of pixels of the two matching Dental features, taking from between the centers of two masses, mass points, and figure 4. Illustrate it. The initial distance, with the boundaries, are considered as zero to remove errors and matching guaranteed. By doing this, algorithm has become more and more stable for small deviations. All the analysis part returns the numeric values when applied for Dental features and feature properties are given in numeric values making an efficient and powerful dental biometric analysis algorithm.

4.8 Properties Features:

Various properties have been matched in order to make the matching results guaranteed. But first, we will define the properties then we will move towards distance matching.

Features on the basis of distance curve

- Mean
- Median
- Minimum distance
- Maximum distance
- Entropy
- Gradient
- Standard deviation

4.8.1 Mean:

When defining in the field of statistics and probability, the term mean is defined as the Average value of a series of all values

Mathematically, we have;

$$\boldsymbol{M = \frac{X1+X2+X3+\cdots Xn}{N}}$$ .... **Equation: 4.1**

And very precisely, we have

$$\boldsymbol{M = \frac{1}{n}\sum_{i=1}^{n} Xn}$$ .... **Equation: 4.2**

In matlab, by applying mean, we get the average of all value elements for different dimensions in the array.

4.8.2 Median:

When defining in the field of statistics and probability, the term median is a value which numerically separates the higher half of the data on which it is applied, from its lower half.

Mathematically, we have;

$$\boldsymbol{M = \frac{(n+1)th}{2}\,\text{value}}$$ .... **Equation: 4.3**

4.8.3 Standard Deviation:

When defining in the field of statistics and probability, the term standard deviation is defined as the measure of the amount of variation or distribution on applied data, from the average data.

It abbreviated as SD, Greek letter representation as sigma (σ).

Mathematically, we have;

$$\boldsymbol{SD = \sqrt{\frac{\sum(x-\bar{x})^2}{n-1}}} \quad \text{.......................} \quad \textbf{Equation: 4.4}$$

4.8.4 Entropy:

When defining in the field of statistics and probability, Entropy is the measure of randomness. It is used to characterize the binary parts in our case.

Mathematically, we have:

$$E = -sum(p * \log_2(p)) \quad \text{.......................} \quad \textbf{Equation: 4.5}$$

4.8.5 Minimum & Maximum Distance:

To make the algorithm more sensitive, Minimum and Maximum Distances have been calculated

It will help to distinguish different individuals and increase the accuracy.

4.8.6 Gradient:

While discussing change, we use the term Gradient, which is any change increase or decrease in the magnitude of a property

Mathematically, we have;

$$\boldsymbol{\Delta F = \frac{\partial F}{\partial x}\hat{\imath} + \frac{\partial F}{\partial x}\hat{\jmath}} \quad \text{.......................} \quad \textbf{Equation: 4.6}$$

4.9 Distance Matching:

Distance Matching is powerful tool to match regions. Various properties features have been extracted that makes the matching more and more sensitive. Accurate distance matching will leads to best identification.

4.9.1 Distance Matching Algorithm:

Up till now we have done the segmentation in all respect, extracted the desired feature and completed the dental biometric analysis on the extracted features in right way. Now the last step to complete our target is matching them. Accurate matching leads good identification, which is our desired goal.

For matching identification, we have developed an algorithm based on properties which we have already refined on image features and distance matching.

The algorithm developed is so powerful that it has neglected the half attached components. Secondly it has so elasticity that it has ability to do matching with different number of regions in the images feature regions.

4.9.2 Euclidean Distance:

In the terminology of Mathematics, the **Euclidean distance** or **Euclidean metric** is the distance between two points plane

Here it measures the similarity and distinguish between different persons.

Mathematically we have,

$$Distance(x, y) = \sqrt{\sum_{i=1}^{n} (xi - yi)^2} \qquad \text{.......................} \qquad \textbf{Equation: 4.7}$$

CHAPTER 5: RESULTS

5.1 Dental color Images & Radiographs Data:

We have not used any big database to store and train data. The data was acquired from different source as mentioned:

Shifa International Hospital Islamabad

Armed Forces institute of dentistry (AFID)

Michigan State University

Figure 5.1:1 Data from Shifa International Hospital

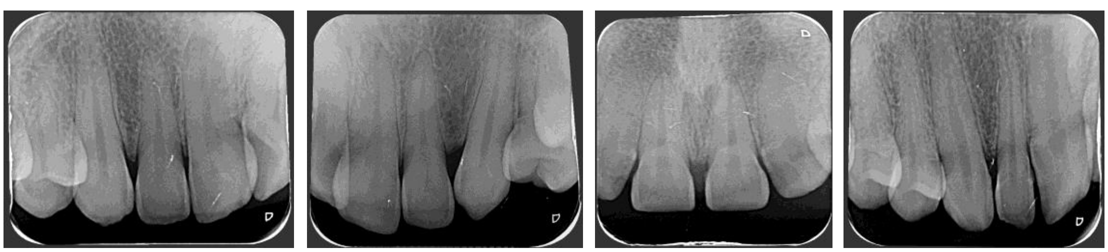


Figure 2.2 Data from Armed Forces institute of dentistry (AFID)

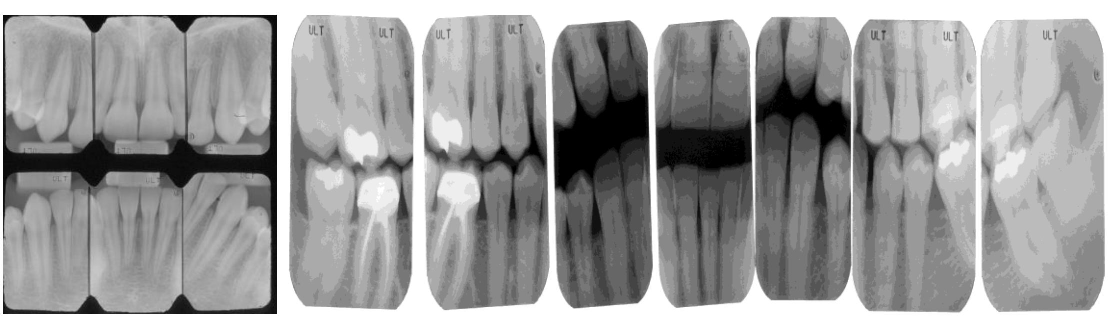


Figure 5.33 Data from Michigan State University

All the radio graphs obtained from the above mentioned source were first made clear so that the region of interest became easy to draw features out of them. He has maximum of 2 sets for each person to train data and to compare it after storing it in database. We do have post-mortem and ante-mortem of the data as well. We use ante-mortem to train data and them we compare the features of post –mortem with that stored in the database.

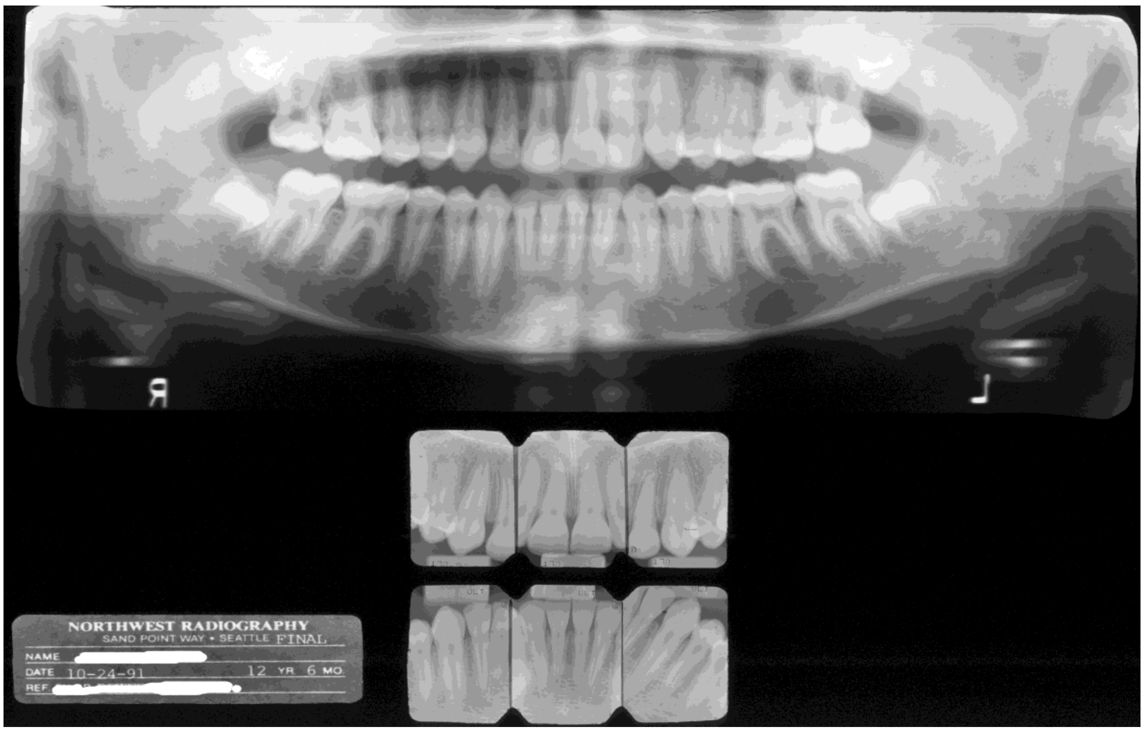


Figure 5.4 X-ray of Jaws

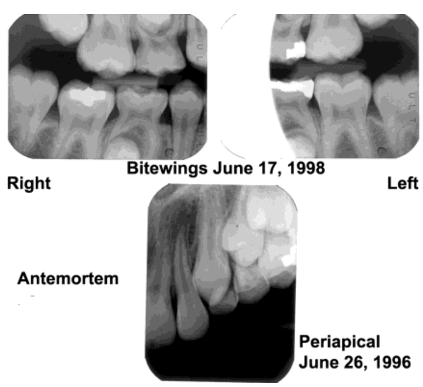


Figure 5.5 Anti-Mortem images of specific teeth

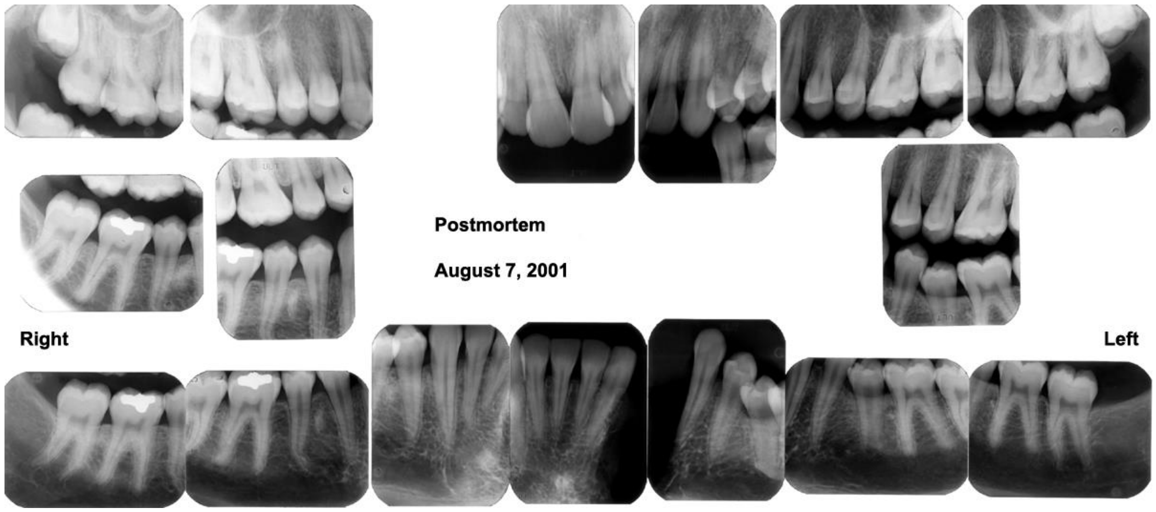


Figure 5.6 Post-Mortem images

Figure 5.7: RGB Images

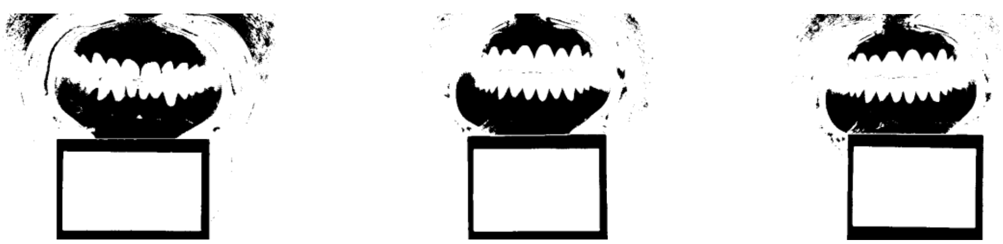


Figure 5.8 RGB Image after thresholding

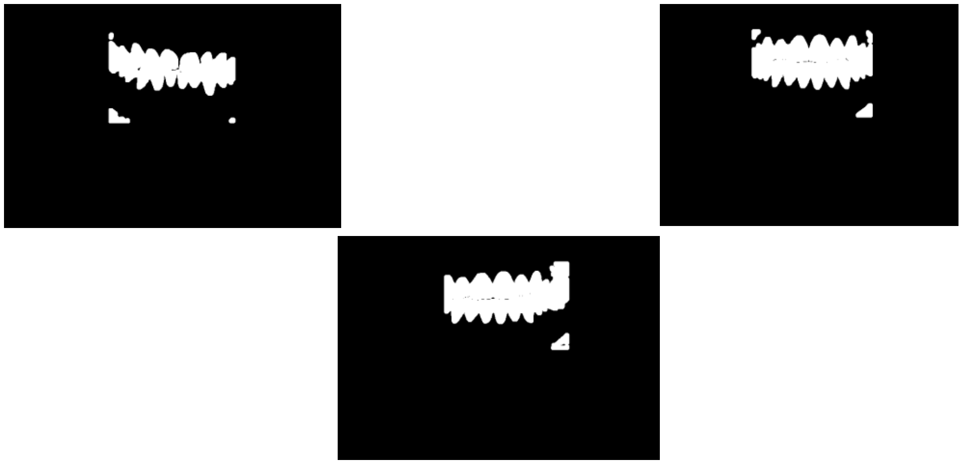


Figure 5.9 RGB Image after removing extra noise

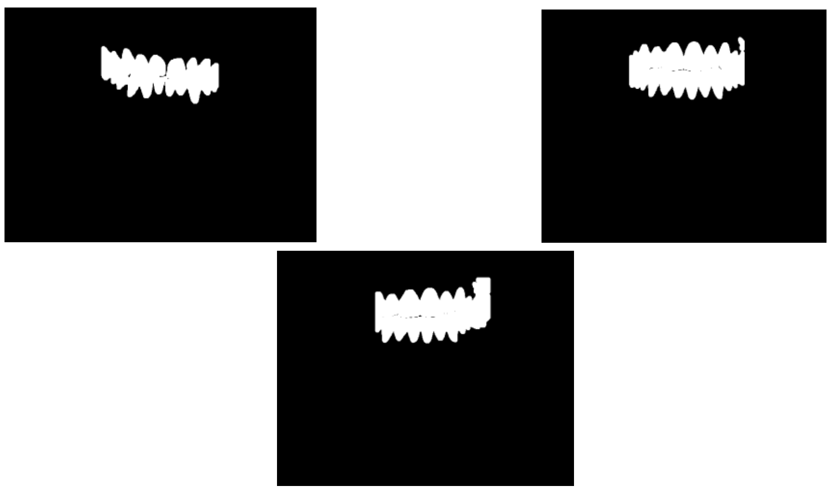


Figure 5.10: RGB Image after Post processing

5.2 Matching:

Matching has been performed using two stages:

1. Feature properties extraction
2. Distance matching

5.3 Matching Results:

For Distance matching, an algorithm is developed for Euclidean Distance. Feature vectors are created and matched using Euclidean Distance. The Algorithm is created in such a way that it has an ability to avoid presence of minor issues in binary regions extracted.

5.3.1 Accuracy (Identity Rate)

Accuracy is defined as how much the calculated value is close to actual value. Accuracy is high if the maximum correctly identification and vice versa. There is an indirect proportional relation between accuracy and EER.

Table 5.1: Accuracy Rate

Data Set	Total Person	Total Images	Correctly Identified Person	Identity Rate
Radiographs	14	84	12	85.7%
Colored Images	45	90	40	88.8%

5.3.2 Processing Time of each Phase:

The proposed system is implemented and tested on a 64bit Ci-3system with 3-GHz processor, 2-GB RAM and MATLAB 2012b. The computational time for each step is given in table 5.1.

Table 5.2: Processing Time of each Phase

Phase	**Processing Time (sec)**
Image Enhancement Phase	1.1365
Filter bank image Phase	2.96
Feature Extraction Phase	0.4667
Classification Phase	0.9975
Total Time	5.5607

5.4 Biometrics Similarity Matrix:

Biometric similarity matrix shows the results in gray-scale matrix. In order to visualize this, let's check the black spots from left top to the bottom right. The black spots show the accuracy rate. The points in the diagonal where there is an absence of black spots, we conclude unidentified case. Both the Similarity Matrix for Color Images Results as well as for Dental Radiographs is shown in the figures below;

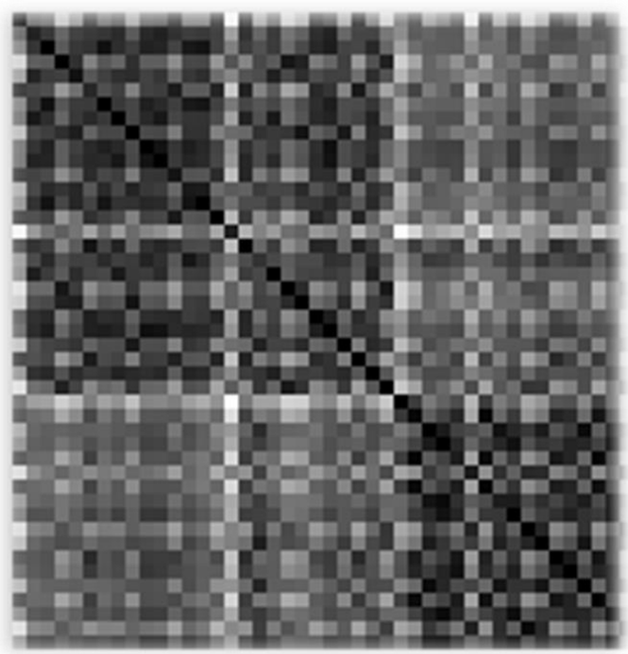


Figure 5.11: Biometric Similarity Matrix For Color Images Results

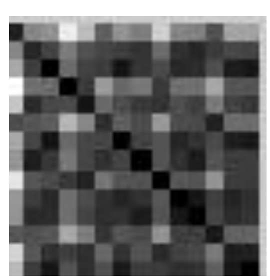


Figure 5.12 Biometric Similarity Matrix For Dental Radiographs