EXLPOITING MULTI_VIEW CORRELATION FOR MAXIMIZING LIFE TIME OF WIRELESS SENSORS

By

Saima Zareen

2008-NUST-MS PHD- CSE-17

MS-08 (SE)

Submitted to the Department of Computer Engineering in fulfillment of the requirements for the degree of

MASTER OF SCIENCE
in
SOFTWARE ENGINEERING

Thesis Supervisor

Dr Khalid Iqbal

College of Electrical & Mechanical Engineering

National University of Sciences & Technology

2011

In the name of Allah, the most

Beneficent and the most Merciful

DECLARATION

I hereby declare that I have developed this thesis entirely on the basis of my personal efforts under the sincere guidance of my supervisor (Dr. Khalid Iqbal). All the sources used in this thesis have been cited and the contents of this thesis have not been plagiarized. No portion of the work presented in this thesis has been submitted in support of any application for any other degree of qualification to this or any other university or institute of learning.

Signature

Saima Zareen

ACKNOWLEDGEMENTS

Innumerable words of praise and thanks to Allah, the Almighty, and the Creator of the universe for carving the path for me and always helping me out in the best possible way. Without His Will and Mercy, I would not have been able to accomplish this milestone. I am grateful to my parents for their immense love, moral support, encouragement and prayers throughout my academic career.

I am deeply beholden to my supervisor, Dr. Khalid Iqbal, for his continuous guidance, inspiration, and patience. His ability of management and foresightedness taught me a lot of things which will be more helpful for me in my practical life. I am highly thankful to Head of Department (Dr. Shoab A. Khan), for his continuous and valuable suggestions and guidance, especially for the provision of all kinds of facilities during my thesis work.

I gratefully acknowledge the help and guidance provided by Guidance and Examination Committee members (Dr. Muhammad Almas Anjum, Dr. Saad Rehman and Dr. Aasia Khanum). Their valuable suggestions and comments were a great source to improve the research work presented in this thesis.

DEDICATION

To my parents and teachers

ABSTRACT

The wireless multimedia sensor networks is becoming popular and is used in many important applications like surveillance systems, health monitoring system, maintaining law and order systems monitoring and control of industrial processes. These applications require good quality of information to be transmitted and received by multimedia sensors. For wireless sensor networks multimedia applications are complex and require extra memory and processing power of the sensors. Since sensors are tiny devices, they have very limited memory and processing power. The lifetime of sensor depends on its remaining power, which is less likely to be recharged. Therefore multimedia applications, which need to be run on sensor networks, should consider the limitation of such networks. On wireless sensor networks, multi-view video processing is an important application. As sensors impose constraints like limited memory, storage and battery power, therefore, these limitations should be considered while designing multi view applications for such networks.

The aim of this research is to study the existing correlation models in multi view videos and propose an approach which reduces battery consumption by minimizing the compression time of video frames based on the specific correlation model. A novel OPI model is discussed that is designed based on the decision of correlation value of sensor nodes. Algorithms for the extraction of overlapping part from the frame at the decoder and fusion of overlapping part with the modified frame at the decoder are discussed. Experimental results have been derived using OPI model and the results depict that by using this approach compression time of video frames is reduced as compared to originally encoded frames. Results show that there is remarkable decrease in compression time of processed frame using OPI model as compared to the compression time of original frame captured by the camera i.e. compression time of frames decreases from 10 to 20 percent and quality of image is also maintained as shown by PSNR values. PSNR values of reconstructed images range from 40 DBs to 45 DBs, which shows that quality of image is not degraded.

TABLE OF CONTENTS

LIST OF FIGURES

Figure	Caption	Page

LIST OF TABLES

Table **Page**

LIST OF EQUATIONS

Equation **Page**

INTRODUCTION

1.1 Introduction

Multimedia has attained greater interest of researchers, because these days, applications are much demanding for the quick receiving, and transmission of detailed information with the high quality. With the changed requirements of applications, technology trends also vary.

Multimedia has its importance because it is being used for security systems, handling law and order situations. Visual information conveys much detailed information rather than binary data and it is easy for the human analyst to analyze the visual content. Thanks to the machine vision and computer graphics for making the visual systems intelligent enough to help the human user in performing his tasks. Transmission of multimedia over the wireless network was a research interest of researchers in the past few decades, with the invention of low cost wireless sensors, applications started moving towards sensor networks. In the start, sensors were only used to gather information in the form of binary data such as environmental conditions including temperature, air pressure and weather conditions of areas where the infrastructure of wired network can be implemented. With the success of wireless sensor networks, applications such as multimedia started moving towards the sensor networks. With the passage of time multimedia applications started to increase their demands such as transmission and reception of 3D video, with high resolution, minimum delay in transmission. This gave rise to a new kind of wireless sensor network, that serves only multimedia applications called as multimedia wireless sensor networks and their sub field is multi view wireless multimedia wireless sensor networks now wireless sensor networks serve as the most fulfilling demands of multimedia applications. For multiple views of the scene to be transmitted, it requires the high bandwidth and energy and more storage space to store. But sensor networks impose constraints of limited resource consumption over the multi view video multimedia transmission.

1.2 Motivation

Wireless sensor networks have opened new horizons for the Researchers in many of its fields such as, multimedia Processing such as noise removal, compression techniques of multimedia, correlation of sources

Wireless visual sensor networks are one of the most popular applications of wireless sensor networks, where they serve for monitoring purposes and executing surveillance tasks. If we process a complex computation task, we are faced with limited battery constraint. If we gather data from multiple sensors, we are faced with minimal memory and storage constraint. How could we efficiently utilize the wireless Sensor network infrastructure for getting our jobs done? This Question opens many chapters for Research and Research is being carried out in addressing many of these issues, or issues like that.

1.3 Background

In this report a proposal is given to addresses the battery, bandwidth consumption problem and to some extent memory consumption and a solution is proposed to reserve battery time by avoiding complex computations on sensor nodes and removing redundant data transmission to avoid bandwidth consumption in multimedia sensor networks.

Visual sensors are deployed at different places for monitoring objects. To improve the visibility of objects, multiple visual sensor nodes are deployed .This way we achieve visibility, but it creates many problems like data transmission, data processing and storage consumption. However distributed source coding is a solution to the problem of redundant data transmission, but energy consumption is still an issue.

In distributed source coding multiple nodes transfer data based on the correlation. Different coding schemes have been proposed for correlated data transfer. Multimedia is an exceptional to the simple data transfer that requires large bandwidth storage capacity and minimum distortion. Many researchers modified distributed source coding schemes according to the multimedia requirements. In these coding schemes, correlation is calculated based on the temporal correlation.

In this section you can describe the background study and existing research works, problems and approaches briefly in three to four lines so to lay the base to move to problem definition.

1.4 Objective

Current research in Visual Sensors addresses the issues related to sensing, network topology, processing, resource utilization, communication and routing separately. None of the research work discusses these issues regarding the multi-view visual sensor networks in a unified technique.

The objective includes exploiting the spatial correlation among multiple cameras deployed at different view angles in WMSNs and maximizing the life time of the sensors. The algorithm is implemented in Matlab and the results are compared to analyze the performance in terms of compression time of video and its quality using PSNR values.

1.5 Methodology

In this section you can describe the methodology you have used to carry out your research work.

Consider a set A={C1,C2,C3,C4,…..Cn}of visual sensors deployed at a region ,these sensors capture the images as {Y1,Y2,Y3,Y4,…..Yn}. The correlation among these sensors could be calculated .To reduce the compression/encoding time of video frames processed by individual sensors, the correlation model can be exploited.

1.5.1 Choosing a Spatial Correlation model

Different correlation techniques are studied in multi view sensors. Considering the set A= {C1,C2,C3,C4,…..Cn``} of cameras. Choosing the correlation technique that based on simple calculations.

1.5.2 Overlapping part identifying model

Multi view videos contain redundant information in their frames and encoding this redundant information causes resource consumption, which could be minimized, if redundant information within a frame is identified and removed.

1.5.3 Applying Compression to calculate encoding time

Applying a compression technique and encoding time is calculated using a frame compression model.

1.6 Summary

The report includes the study of existing research work ,carried out in multimedia wireless sensor networks, different correlation techniques for wireless multi view video sensor networks, selection of the correlation technique that gives better results for correlation and propose a model that exploits the correlation of multi views which reduces the compression overhead of sensor and saves the battery consumption of sensor during compression of video frames.

The proposed technique can be used in Distributed Source Coding (DSC), which is used for encoding and decoding of correlated sources.

The report is divided in five chapters, chapter I includes introduction to multimedia networks and multi view multimedia sensor networks. Chapter II includes the Literature review of different camera calibration, correlation, and DSC techniques and their limitations and benefits. Chapter III includes the proposed model and algorithms for extraction of overlapping part from the image and its fusion. Chapter IV discusses the results of proposed model and chapter V concludes the model and future work.

CHAPTER 2: BACKGROUND AND LITERATURE REVIEW

This chapter discusses the existing research work that is carried out in wireless sensor networks, their limitations and benefits and the research gap, that is to needed to be addressed by new research. Encoding of video requires inter and intra frame encoding, different video encoding standards have been developed such as MPEG1,MPEG-2,MPEG4,AVC,H.264.In inter frame encoding, redundancy within the frame is minimized, in intra frame encoding the intermediate frame is constructed using the block search between the two frames

2.1 Structure of MPEG

MPEG divides information in different frames and for encoding video a term Group of Picture (GOP) is defined which contains I,P and B, where I frames are the frames that contain most of the information about the scene, B and P are the inter frames are known as Predicted frames. P frames are used to reduce the temporal redundancy between the current frame and the next frame. B frames are used to reduce the redundancy between the previous and current frame and between current frame and next frame. [1]. MPEG divides the frame into different sizes of blocks such as 4x4, 8x8,16x16 for performing quantization and these blocks are called as Macro blocks. To calculate the temporal difference between the frames, motion vectors in each Macro block are calculated called as motion estimation. Motion vectors track the movement of objects from one position to other between the frames; this phenomenon is known motion block search. Motion blocks searching increases the encoding time. Different types of Motion Block searching algorithms have been developed that could be used on the base of required encoding time and complexity of applications.

2.2 MPEG H.264 AVC

Joint video team released a product by the partnership of two standards ITU-T Video Coding Experts Group (VCEG) and International Standards of Organization (ISO), named as H.264/AVC. It was a big step towards providing the good quality and unified features in compression. The purpose of H.264/AVC was to provide good quality at lower bit rates[2].

In [2] structure of MPEG H.264 AVC is discussed which optimizes the performance of motion compensation by reducing the matching time and decreasing distortion produced due to block matching performed [3]. It is the successful standard being used in many applications such as 3D video, High definition DVD, video broadcasting and iPod video. With the extensive use of multi-view images in different applications, certain issues regarding multi-views arise, that the MPEG family of compression schemes could not address. There was the need to develop the encoding scheme that could effectively take the benefit of multi-view geometry of cameras. Next step of H.26/AVC was the Multi view video coding (MVC).

2.3 Multi view Video Coding

It encodes frames of videos captured by the cameras concurrently in to a single stream of video [22] by exploiting their spatial and temporal redundancies. The encoder receives n video streams from cameras and encodes them to a single video stream that is synchronized based on the concept that temporal information of a frame captured by a camera can be used to predict the other frames of the same camera and also this information can be utilized to predict frames of other cameras.

2.4 Estimating Disparity Vector in Multi View Images

Research has been carried out in addressing the inter-view prediction, disparity vector (DV) prediction, improving motion vector estimation and view synthesis prediction. A survey of multi-view coding schemes is provided in [3]. In [4], authors state that disparity vector value is based on the geometry of multi-views, calibration of camera and depth of information. Epipolar lines are calculated among the projection points of different cameras using Epipolar cameras geometry framework, Epipolar lines are drawn between the projection points and motion search through these projection lines is performance. This reduces the time of search and DV prediction is enhanced. The model is embedded with the original H.264.AVC for the results. However this model introduces additional complexities at the encoder and decoder side that can be reduced by using better motion searching algorithm.

According to [5], disparity compensation is based upon the degree of correlation between the views and is calculated using motion compensation. Authors proposed a novel scheme known as vector field estimation [5], which uses the linear relationship for adjacent views for a parallel camera calibration model. The proposed model increases the coding efficiency as compared to H.264/AVC. The model does not give the accurate results, as there is no criterion to determine the matching error between the true motion vector and estimated vector. Moreover the model is based on the assumption that the depth of the sight does not vary with the time, which can affect the disparity value's accuracy.

Disparity estimation is very complex and it hinders the real time applications for its use [6]. A fast multi view disparity estimation scheme is proposed in [6], which is based on the Hadamard similarity coefficient and requires operations like addition and subtraction to calculate the relationship between the neighboring inter and intra macro blocks that can reduce the computational complexity. Intermediate view is predicted based on the views taken from two other cameras or view is constructed using interpolation of values from the different views of cameras.

2.5 Limitations of Disparity Estimation Techniques

The models are discussed with reference to applications that are used where the hardware resources are not scarce and there is no limitation of bandwidth consumption. The above mentioned models proposed their approaches based on the assumptions that camera are calibrated correctly and have accuracy in measurement of fundamental matrix of camera.

2.6 Wireless Sensor Networks

With the decrease in cost of CMOS cameras that are deployed in public places to monitor the environment such as behavior and activities of people. Such applications required images of the scenes from different views, so that correct behavior could be analyzed. These are a kind of video sensors. Wireless sensor networks contain devices, which have sensors capable of sensing change in events [7].Initially wireless sensor networks were developed to capture information like weather conditions and sending and receiving information from places where the deployment of LANs, WANs is not possible. Later on the need was felt to transfer information in the form of audio and video. For the processing and transmission of audio video information, sensors required specialized software that can cope with the minimum resources of sensors. As sensor device is like a microcontroller device having less memory and storage to store operating system and information. Studies [32, 33] have shown that wireless mobile devices have limited power which is consumed during video capturing, pre-processing for encoding and transmitting or receiving information. Sensors have limited battery and their life largely depends on the amount of available battery power [33]. Here sensors used in the studies are cameras that are directional and have a specific field of view. Using sensors for complex calculations is like ending its energy making sensor unable to accomplish the desired process or task.

2.7 Multimedia Wireless Sensor Networks

When the sensors were used in past for simple information, there were no issues of resources constraints. Multimedia in wireless sensor networks lead to a new kind of wireless sensor network called as Multimedia Wireless Sensor Networks. Different applications started using wireless multimedia sensor networks rapidly like, WMSNs are used in surveillances, where these sensors are used to transmit and receive audio visual information about crimes, terrorist attacks and maintain law and order situations, traffic monitoring and avoiding traffic congestion and detect traffic rules violations such as over speed and report to the concerned department. WMNS are also used in telemedicine to assist patients by warning them from the activities that could affect their health. A major and critical application of WMSN is to control and monitor the industrial processes [8]. The above models could not be implemented in such a kind of multi video network as resources of sensors are scarce. Hence methods should be adopted to ensure that the applications being used are not too complex (with respect to power consumption) when used with the sensors for multimedia processing. Camera Calibration Techniques. For multi view video processing, these multimedia sensors are deployed at different angles of view of a region to capture the information.

Multi-view video processing requires identifying the frame of references of each camera and identifying the relationship between the camera frame and world coordinate frame and information about the camera properties, such as rotation, magnification, focal length and distortion of the cameras. In WMSNs, information, these parameters are calculated at the time of deployment. Different camera calibration techniques have been proposed for WMSNs. [9, 10, 11, 12].In [9] authors proposed that cameras 3D location and its orientation can be calculated by using degree of overlap and region of overlap using k-overlap regions of a camera and approximate tessellations of overlapped regions. [10, 12], is a simple approach based on linear equations that are designed to calculate the orientation of the camera and its location. In [11], authors enhanced camera calibration model to determine the interior orientation, exterior orientation, distortion, horizontal scale factor, rotation and focal length.

2.8 Correlation Techniques between Multi-views

Keeping in view, that multi-view cameras deployed over region capture information, which is redundant. This redundancy of information can be estimated and can help in video compression and transmission. Authors in [14] proposed a model that constructs the view of intermediate camera placed virtually between the two cameras. It defines the four parameters of camera sensors(R, α, V, P).R is the sensing radius of the camera, α is the angel of view that can be estimated using [13]. V is the sensing direction that can be estimated using any of the calibration techniques, discussed above, P is the position of the camera in 2D and 3D world's coordinate system. These parameters define the field of view (FOV) of a camera. FOV is defined as degree of the discernible domain which is seen at any given instant [31]. Knowing these four parameters, correlation among the two sensors can be calculated based upon the degree of overlapping fields of view. An object is considered in the range of the sensor if the distance between the object and location P of the sensor is less than the R of the sensor. Also if the sensing difference between the sensors is in the range of [-π/2, π/2], If these conditions meet than the sensors are correlated.

In [14], sensor is considered as a set of points, a point is selected from the sensor area, model calculates, whether that point falls within range of other sensors. If point lie in other sensor regions, overlapping between the sensors two sensors is increased and correlation matrix is calculated for the sensor. Considering the two correlated sensors, there sensing directions intersect at a point, which is the sensing direction of the camera located between the two sensors. Overlapping part between the sensors is removed from the images captured by each sensor. Image for virtual camera is constructed by taking the remaining portions from each sensor. It is difficult to calculate the position of the virtual camera, whose image is to be constructed.

[15] Transmits image only related to the field of camera and creates an aggregated image by the union of all overlapping regions. Sensors depend on the base station for getting overlapping field of view of its neighbor sensors and transmission of the non-overlapping

part. Authors proposed an optimized model to reduce the transmission energy of the sensor and extending the battery life of the network. After receiving information about the neighboring sensors, sensor calculates common region between sensors by considering intersection between fields of views of sensors. If there is no intersection, model assumes that there is no common region and hence the life of sensor cannot be minimized. This model does not provide any information about, how can we calculate intersection between the field of views of sensors and it restricts the communication between the sensor and the base station. Sensor has to take parameters from the base station and transmit image to it. This dependency makes the network to rely on the base station and no mechanism is described, when the base station fails to communicate with the sensors and whole network will be waiting for base station to be active.

A model for the calculation of spatial correlation between the sensor networks is presented in [16], this model used the idea of [14], that a sensor has four distinguishable parameters from other sensors. The model is proposed by considering the visual content of the image. It uses the concept of world coordinate transformation to the coordinate system of each camera. Model proposed that, depending upon the application chose the reference points in the world coordinate system and map using the model [16], we can visualize, where these points actually lie on each sensor plane. This gives information about the correlation of cameras. [16], also proposed a camera selection model keeping in view the correlation between cameras. When the network conditions are good, all sensors can transmit information, if the network conditions are not favorable, and then compare correlation values between two sensors, chose sensors which are less correlated and it created a cluster of the selected sensors, that transmit information. This way, quality of video is maintained and disparity is reduced. It is a simple model and efficient, author does not emphasize, how could be the lifetime of sensor extended? Most of the research work is based on the temporal correlation between multi views of frames.

2.9 Distributed Source Coding

Distributed Source Coding (DSC) introduced a mechanism for the encoding of information which is correlated and sensors do not have communication with each other about the correlated information. The information is decoded jointly at the decoder, which is complex.

It helped in making encoders simple and all complex calculations to be performed at the decoder [17]. DSC consumes less energy in encoding as compare to other encoding schemes such as MPEG. Different Distributed Video Source Coding schemes are Slepian Wolf, Wyner Ziv, DISCUSS and PRISM, these codecs are being used in surveillance, mobiles and camcorders. Some applications also use as a transcoding scheme with the help of this scheme, the computation burden has been transmitted to the network [18].Distributed source coding served as inspiration for multi view video coding and lots of research work is being carried out in multi view video for distributed source coding.

2.9.1 Correlation Techniques based on Distributed Source Coding

Authors in [19], proposed a model that constructs a low resolution image by receiving information from other sensors. Decoder has access to other sensors as side information to construct a 3D scheme.in this approach authors assume that the sensors have no limited power constraint. Results showed that quality of image is good and approach is embedded in the PRISM easily. This approach cannot be applied to encode multi view video, where sensors have limited battery.

Lots of research work has been carried out in multi view coding using distributed source coding, in [20], authors discussed a model that requires minimum communication between the sensors to keep the minimum energy consumption. It calculates the Structure Digital signatures based on the temporal correlation between the two sensors and the sensors communicate for sending and receiving of the indexes for the key frames in a reference block.

Authors in [21], define a robust technique for distributed source coding based on correlation techniques. The authors discuss that robustness is achieved by exploiting the interview correlation between cameras, which have overlapping fields of view. Encoders do not need to communicate with each other. The technique proposed in [21], calculates correlation between sensors based on two techniques. First technique is the view synthesis, which calculates the depth of the scene, which depends on disparity of view and interpolation of view. Second technique of correlation is based on Epipolar geometry, to reduce the search of corresponding point at the decoder.

2.9.2 Side Information Generation at the Decoder Based On Correlation

In [23], authors proposed a model to generate side information that helps in decoding a better quality of image. Authors proposed that multi view correlation can be exploited between two sensors without any communication between them. The model generates the side information based on combination of techniques, interview homographic and intra view interpolation.

Authors in [24], addressed the problem of 3D motion estimation at the decoder with varying lightning conditions and proposed a model that calculates the lightning parameters separately and extracts the features of an image by tracking them in the sequence of frames.it calculates the initial pose parameters which are transmitted to other encoders and decoder also. The model generates three types of side information named as other view, previous frame and combination of the first and second type of side information generated, for the decoding of 3D view.

In [25],introduces error concealment for the frames that are affected by noise during transmission model proposed different modes for error prediction and concealment, these modes are based on inter-view correlation, disparity vectors and spatio temporal correlation techniques.

In [27], authors proposed a technique that calculates the motion vectors at the encoder rather than a convention DSC approach, where motion vector estimation is carried out at the decoder. This helps in better generation of side information for wyner frames to be decoded at the decoder.

2.9.3 Fusion of side information

[28], deals with side information generation using interpolation. It is the enhancement of framework proposed in [27].Authors in [28], proposed two interpolation techniques, first is the temporal interpolation and second is the spatial interpolation technique for the correct estimation of wyner ziv frames. The authors introduced a mechanism at the decoder to fuse those predicted parts (predicted at the encoder) ,which were estimated correctly by discarding the other parts.

In [29], authors proposed a fusion process is described, for which the side information has already been generated in both dimensions i.e. spatial correlation and temporal correlation.

After decoding the most recent wyner ziv frame, the model creates a binary fusion mask, if the temporal side information is similar to the decoded frame, the value of mask is set to 1 and 0 if similar to spatial correlation.

In [30], authors discussed a geometrical coding approach that calculates correlation for multi-view cameras, which are deployed densely at a scene. The technique is based on a quad tree decomposition, in which information is processed as a piecewise linear polynomial, information about the scene and camera's position is sent and along with, a subset of bits is transmitted. It is assumed that a decoder has a priori information about the correlation f camera.

2.9.4 Increasing Coding Efficiency Based On Correlation

Authors in [26], proposed a network driven coding approach to obtain high encoding efficiency for DSC. According to authors, coding efficiency of DSC is low because only intra view correlation is considered at the decoder while ignoring inter-view correlation, which results inaccurate generation of side information at the decoder. Authors in [26], proposed a model in which the complexity of decoder is shifted to the network, which produces partial disparity estimations and coding efficiency is improved by applying color correction at the central network node. This corrected information and motion vector extrapolation is then transmitted to the decoder to generate the view to be displayed.

2.10 Image Fusion Techniques

There are different types of image fusion techniques depending on the type of application and imaging devices. These techniques are multi view fusion in which images are taken from the same place but in different views, multi modal fusion in which images are captured using different devices i.e. infrared, CT, etc. multi temporal fusion i.e. images captured at different intervals, multi focus fusion in which 3D images are captured with variable focal length, and fusion for image restoration. For each type of image fusion there are two necessary steps, first is spatial alignment of two input images known as image registration, second is combining the image intensities, color in the area of overlap [35].In image registration, there are further four steps to be carried out. First step is feature detection, in which salient features of images are defined on the basis of edge detection techniques, boundaries analysis, intersection of lines etc. , second step is the feature matching, in which we find the correspondence between the input image and the reference image. Third step is the transform model estimation, in which we estimate parameters for feature matching. Fourth is the image resampling and estimation, in which input image is mapped with values [35].

Image fusion is applied at four different stages, these are signal level, in which different signals are combined to form a new signal, whose quality is better than the input signals. Second stage is the pixel level in which fusion is carried out on the basis of information of pixels. Third is the feature level fusion carried out on the basis of image features extracted. Fourth is the decision level fusion in which different input images are processed separately and extracted, then these extracted images are combined using multiple algorithms to form a final fused image [36].There are different advances made in the image fusion from the last few decades, these include different techniques such as Intensity Hue Saturation (IHS), high pass filtering, principal component analysis (PCA), multi resolution analysis such as wavelet transforms and pyramid algorithms. In [39], authors discuss different discrete wavelet transform techniques and author considered them suitable for image fusion which retains the features of images. According to authors of [37], there are different limitations of each techniques discussed, such as PCA is sensitive to registration accuracy, HIS require minimum three bands for the input image and multi resolution techniques are complex.

In [38], authors proposed a simple image fusion technique that performs fusion of images with the same size and multiplies both images for getting four image result matrices which are further classifies on the basis of even odd matrices and fuses the image accordingly. Authors in [40], discuss different statistical based method such as local mean matching, regression variable substitution and local correlation modeling for image fusion and compares their results on the basis of different image quality measures such as signal to noise ratio, standard deviation, entropy and correlation and authors conclude that regression variable substitution is suited for image fusion where high quality and resolution are required. [41], proposed an integrated framework based on intensity hue saturation and wavelet based discrete transforms which overcomes the limitations of both techniques, when applied separately for fusion.[42,43,44,45,46,48], analysed different image fusion techniques by defining its own image fusion evaluation measures and showed that different techniques perform well against some parameters while others not. It is useful for choosing proper image fusion technique for applications according to their performance against different quality measures. [47], discussed issues faced regarding image fusion and proposed different recommendations that need to address these issues. Most of the studies are applied for satellite imagery and their comparative analysis is conducted.

Some techniques such as [38], is a simple one, but it uses multiplication, which can become complex and limited storage of sensor could be a bottleneck. Sensors have limited resources, and there is the need for image fusion technique to consider sensor's limitations.

There is the need to reduce data redundancy by using both spatial and temporal correlation so that the quality of video cannot be degraded and transmitted and processed by the sensors keeping in view their limited battery, memory and storage.

2.11 Summary

This chapter discusses different camera calibration techniques, correlation techniques, DSC based correlation techniques and side information generation and fusion of side information for recovering the video frame. The chapter gives a brief introduction of these techniques and does not go in to the details of the above techniques discussed.

CHAPTER 3: METHODOLOGY

3.1 Introduction

This chapter sets up the basis of this research. It describes research methodology which is adopted by this research. It provides the system architecture and algorithm of the proposed system. It describes detailed definition of the problem and system environment. It also builds up the theoretical base of the study and explains the complete system in a comprehensive manner. Following system is proposed based on the above literature study. Following system is proposed based on the above literature study.

3.2 OPI System Model

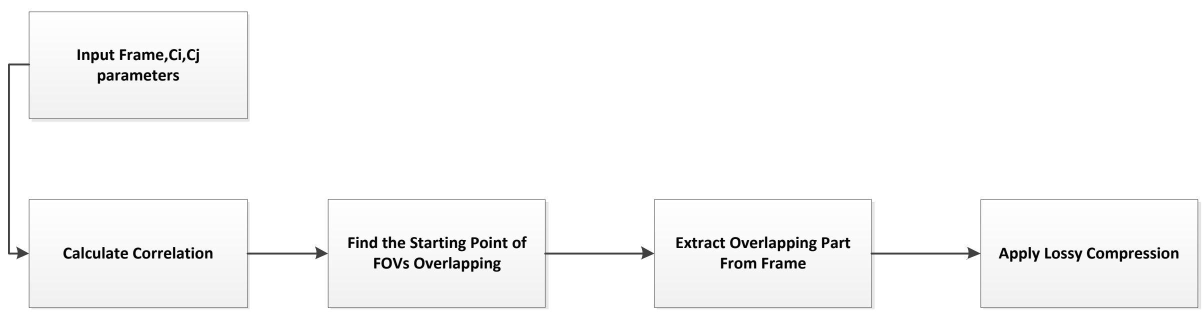


Figure 3.1: High Level System Model

Consider a set of ten cameras deployed to capture multiview of an object. Object is placed at the origin of the coordinate and sensing direction of the cameras is towards that object. Camera 1 is placed at the x-axis, camera 2 has the same direction as that of camera 1 with a rotation of θ from camera1.Camera 3 is also placed the same way as camera2, but with the varying value of θ from -15° to -135°.Images are captured from the frame.

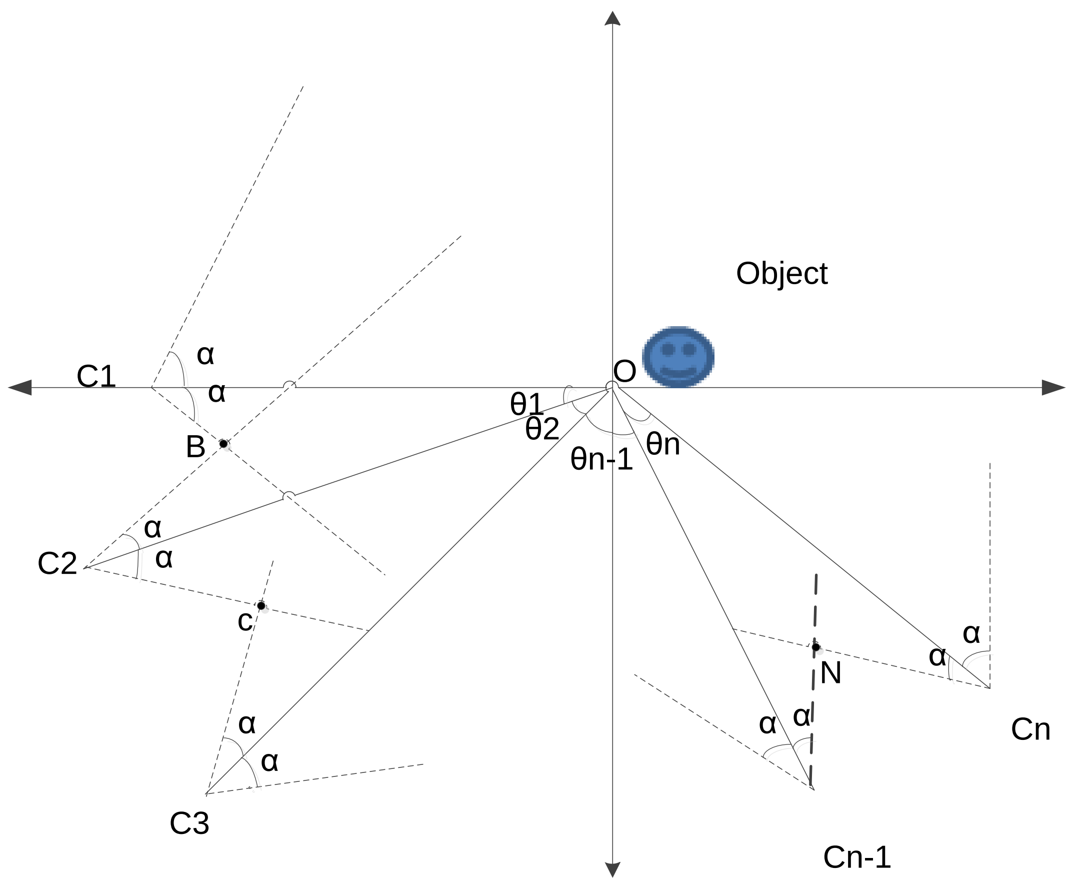


Figure 3.2: Camera Calibration model

According to [16], get the value of four parameters of each camera (α, R,V, C(x, y)). Before calibrating cameras their focal length is calculated, which is same for all cameras. Distance between the camera and the object is d. Location of camera is represented by the two coordinate system x and y, sensing direction is θ, angle of view α can be calculated [13], using the equation (1):

$$\alpha = \tan^{-1} \left(\frac{D}{2f}\right) \qquad \textbf{(1)}$$

Knowing all these parameters, proceed towards the second block of system diagram.

3.2.1 Correlation Calculation

Different models for calculating the correlation between different cameras deployed at a certain region. On the basis of literature review, a correlation model proposed in [16] is used. Correlation value will show that which cameras are strongly correlated with each other and which are weakly correlated or there might be no correlation. Model proposed in [16], showed that when the cameras are perpendicular to each other, the correlation value among them is zero.

3.3 Detection of the Starting Point of FOVs of Overlapping

FOVs of the cameras will be intersecting at different points as shown in figure 3.1. Camera 1 and camera2 intersect at point B, Camera 1 and Camera 3 intersect at point, similarly other points of intersection can be seen from figure 3.1.These are the points from where the overlapping between the cameras start. In order to calculate the overlapping part of each camera, value of intersection point should be known. To find the point of intersection, consider the case of two cameras, camera 1 and camera 2, redraw the model for two cameras for making things clearer as shown in figure 3.3

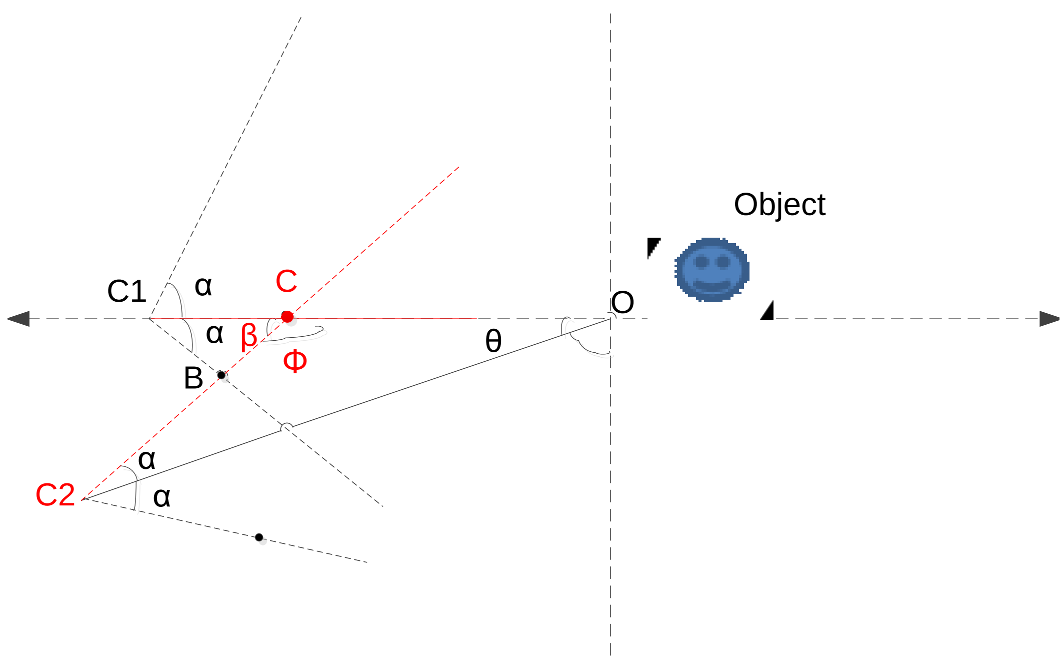


Figure 3.3: Camera 1 and Camera2 Model

Camera C1 is placed along the x-axis with its direction towards the origin. Camera 2 is rotated from Camera 1 with the angle of θ with sensing direction towards the origin. At C1 draw the angle of view α according to its sensing direction and draw the angle of view of C2 α also the same way described. The angles of view of both cameras intersect at a point B as shown in the figure.it is the point B where the cameras overlap each other. Follow the following steps to calculate B

3.3.1 Calculating angles:

We will consider a triangle OCC2 as shown in figure 3.3:(b) to calculate the angle Φ .Using the triangle theorem for sum interior angles of a triangle is 180.so α+Φ + θ=180.Knowing the values of α and θ, Φ can be calculated.

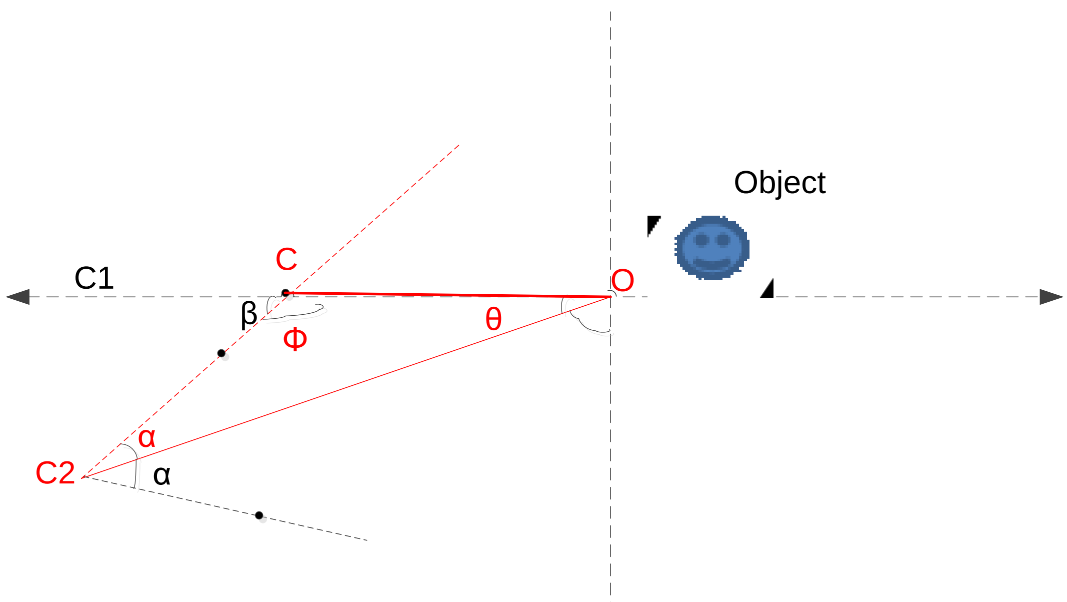


Figure 3.3: (b)Camera 1 and Camera2 Model

3.3.2 Finding the Point of Intersection of FOVs

B is the point, where the FOVs of two cameras intersect. To find the point B, consider the following the scenario:

Step 1

i. C1 and C2 intersect the Plane at C, as shown in fig 3.3c

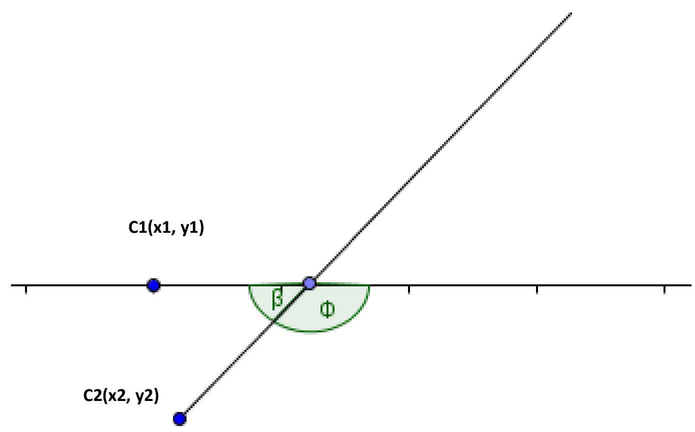


Figure 3.3: (c)Intersection of Camera1 and Camera2 with Plane

i. Calculate the angle β. Φ has already been calculated in the above step. β =180- Φ.

ii. Calculate the line of equations of both C1 and C2 passing intersecting at the point C.

Equation of line from C1 to C:

y-y1=m1(x-x1)) …………………… **(2)**

where m1=tan(0) , as C lies on the same line of C1.

y=y1+m1(x-x1) …………………… **(3)**

Equation of line from C2 to C:

y-y2=m2(x-x2)) …………………… **(4)**

where m2=tan(β) , as C1 intersects plane with the angle β.

y=y2+m2(x-x2) ……………………. **(5)**

iii. Using substitution method Solve **(3)** and **(5),** to calculate x

x= (y1-y2+m2x2-m1x1)/ (m2-m1)

iv. Value of x can be substituted in **(3)** or **(5)** for calculating value of y. Point C(xc, yc) has been calculated.

xc=x, yc=y

Step 2

Now we can calculate point by considering lines from C to B and C1 to B.

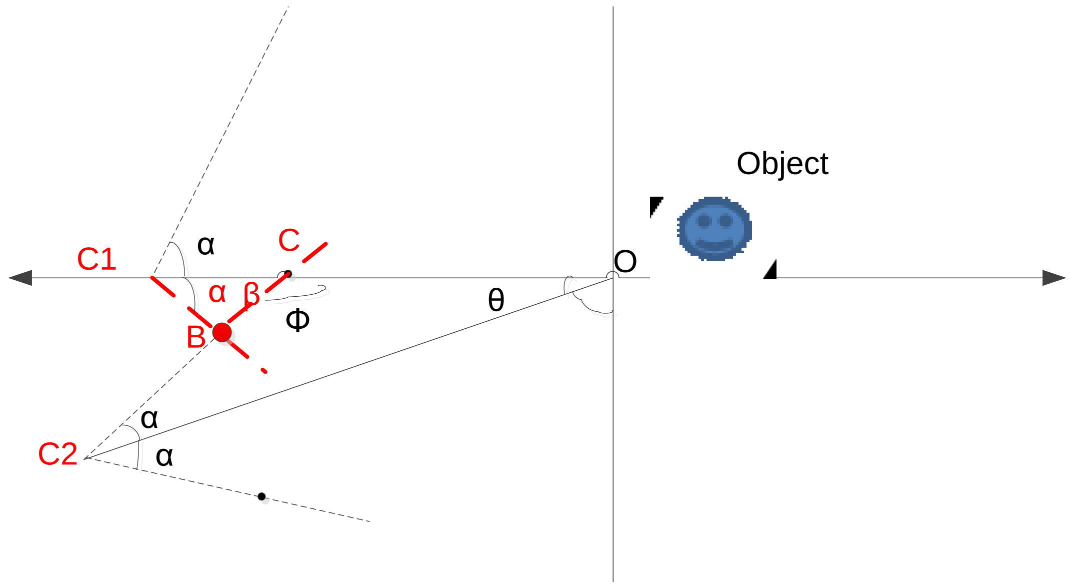


Figure 3.3 :(d) Intersection of Camera1 and Camera 2 FOVs

i. Calculate the equations of both lines CB and C1B with their angles of inclination α and β respectively using Step 1.

ii. Solve the equations to calculate x and in this way B(x, y) has been calculated, which is the required point of overlapping.

3.3.3 Generalizing the model

The model could be generalized by selecting any $camera_i$ and $camera_j$, the overlapping point could be calculated:

i. Calculate angles and slopes

$\Phi_i=180-\alpha_i-\theta_{i,j}$

$\beta_{i,j}=180-\Phi_j$

$m_i=\tan(\beta_i)$

$m_j=\tan(\beta_j)$

ii. Find intermediate point of intersection of line from cameraj to camerai's plane:

$x_{ij}=(y_i-y_j+m_jx_j-m_ix_i)/(m_j-m_i)$ …………. **(6)**

$y_{ij}=y_j+m_j(x_{ij}-x_j)$ ……………………….. **(7)**

iii. Using α_i and β_{ij} as angles of inclination of lines, calculate the point of intersection.

iv. Find the equation of lines using αi andβj.

v. Solve the equations.

3.4 Extracting Overlapping Part from Frame

To extract the overlapping part between two cameras, following algorithm is proposed.

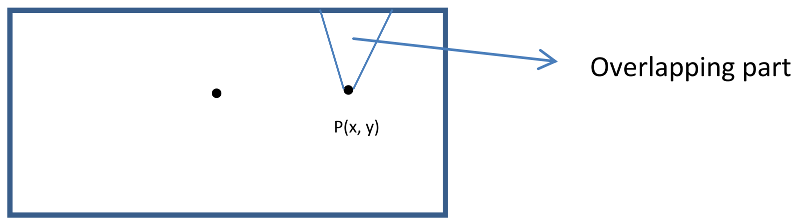


Figure 3.4: Identification of overlapping area in a frame

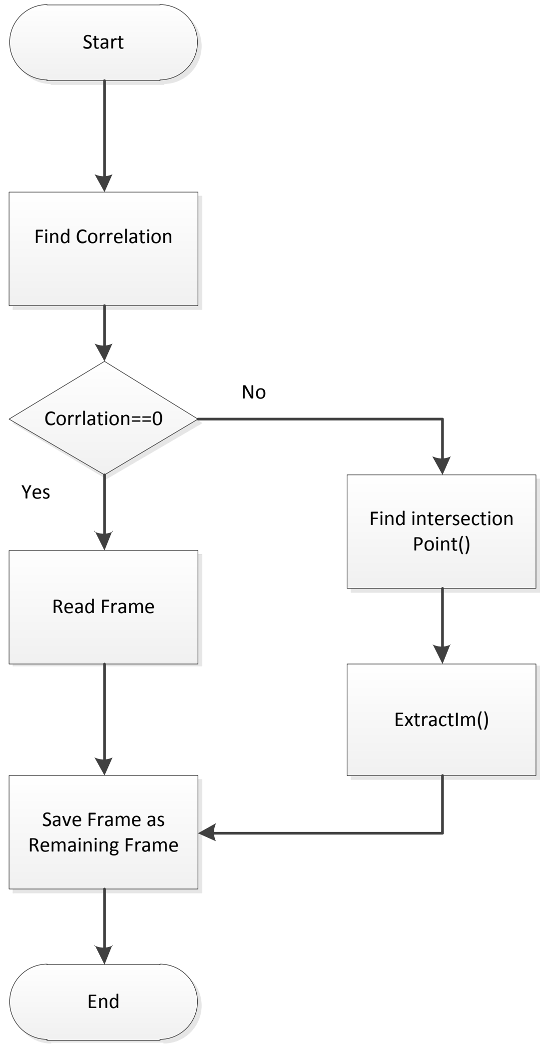


Figure 3.5: Flow chart of main module

```
Algorithm main Module
Begin
For i=1 to N-1
        Find the Corr between camerai and cameraj.
End for
For j=1 to N-1
        If Corr value =0,
        Read the Frame
        Save it as the remainingframe
        Else
Calculate Point P (xp, yp) =Calling module Find_Point(camerai(xi,yi),Cameraj(xj,yj),O(x,y),αi,αj,θij)
        End if
        Calling module ExtractIm(camerai(xi,yi),Cameraj(xj,yj),Point(x,y),αi,αj)
End for
End main module
```

Main module requires two sub routines to find the Intersection Point of Overlapping Field of Views and Overlapping Part Extraction routine.

```
module Find_Point
Find_Point(C (xi, yi), C (xj, yj), O (xo, yo), αi, αj, θij)
Inputs C(xi,yi),C(xj,yj),O(xo,yo), αi, αj, θij)
Outputs P
Cacluate x,y
Px=x
Py=y
Return P
End Find_Point module
```

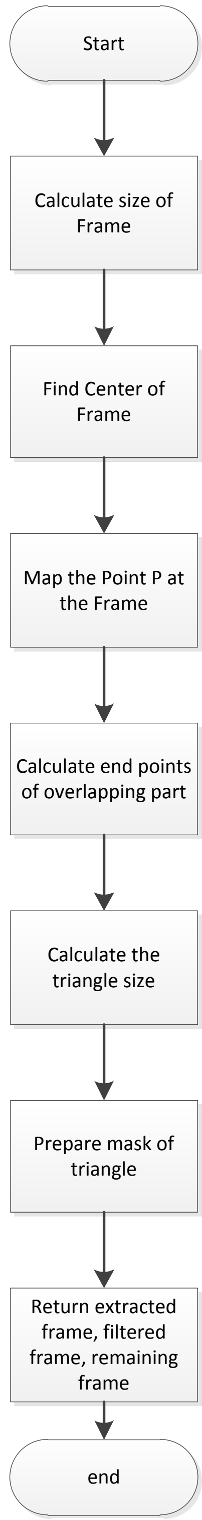


Figure 3.6: Flow chart of ExtractImage module

Module ExtractIm

Module Im(extractedFrame, filteredFrame, remainingFrame) = ImExtrct (Inpimg, C(xi, yi),C(xj, yj),αi,αj, Px, Py)

Inputs Inpimg, C(xi, yi), C(xj, yj), αi, αj, P.

Outputs extractedFrame, filteredFrame, remainingFrame.

Begin

Calculate the size of the frame [M N] =size (Inpimg)

Find the centre of the Frame Mid (xm, ym) =M/2, N/2

Map the points C (xi, yi), C (xj, yj), P (xp, yp) to the Frame pixels indices.

Calculate the end points P2 and P3 of the Frame based on the αi and αj values, where the correlation between frames ends.

Map the points C (xi, yi), C (xj, yj), P (xp, yp) to the Frame pixels indices.

Calculate the TriangleSize of Frame between P, P2, and P3.

Prepare a mask of the TriangleSize and apply it on the Inpimg.

Return extracted (Frame, filteredFrame, remaining Frame)

End

End ExtractIm module

3.5 Image fusion

Image Fusion is the reverse of the image extraction. Considering the scenario, if two cameras are correlated to each other, one camera will send a complete frame and the other will send only non-overlapping area with respect to the first camera and the frames received by the sink are already decoded.

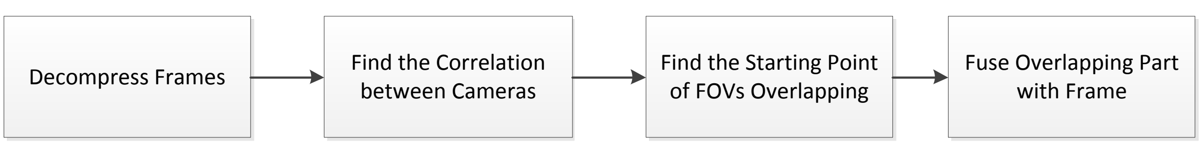


Figure 3.7: Image Fusion System Block Diagram

In order to form a complete/fuse frame for camera 2, sink should have the following information.

i. Information about the location of both cameras.
ii. Their field of view information.
iii. Correlation between the cameras
iv. Complete Frame from Camera 1
v. Extracted frame from camera 2

Sink node will calculate intersection point between camera1 and camera2, and map these points to both frames i.e. frame1 and frame 2, and copy the pixel values of frame 1 in to the frame 2. The algorithm for fusion of frame is as follows,

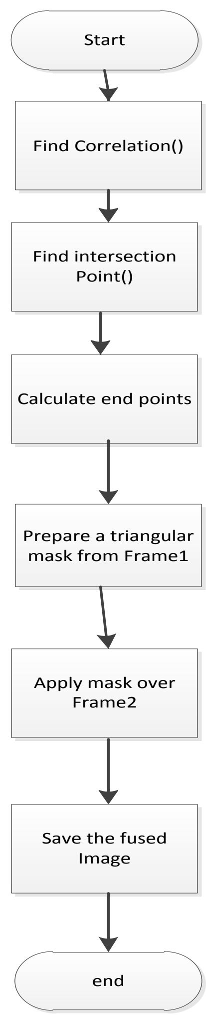


Figure 3.8: Image Fusion at the Sink

Module FuseImage

Module Fuseimage

Inputs Inpimg, extractedImage C(xi, yi), C(xj, yj), αi, αj,θij

Outputs FusedFrame

Begin

Find the Overlapping Point for both Cameras Ci, Cj.

Calculate the end points P2 and P3 of the Frame based on the αi and αj values.

Calculate the TriangleSize of Frame between P, P2, and P3.

Prepare a mask of the TriangleSize from Inpimg, apply it on the extractedImage.

Save the Fused image

End

End FuseImage module

3.6 Summary

This chapter has described detailed problem description and proposed system model. It has also discussed research methodology which is adopted to carry out this research Work using Existing spatial correlation approach for multi view videos, and proposed system architecture have been described. Subsequently, algorithms of proposed scheme and flow charts of image extraction and fusion algorithms have been described

CHAPTER 4: RESULTS AND DISCUSSION

4.1 Introduction

In this chapter, a number of scenarios for capturing images and fusing the extracted frames are described. The proposed model is implemented using MATLAB. The results obtained using the model and analysis has been described in subsequent sections.

4.2 Frame Capturing Scenario

Camera 1 is placed to take picture of the object along the x-axis which is the camera 1's calibration. Then camera is rotated with an angle θ to take other group of pictures, this is the calibration of camera2, camera3, and other cameras are calibrated same way. Camera is rotated with following different values of θ from the camera 1, θ={-15°,-30°,-45°,-60°,-75°,-90°,105°,120°,135°}. The proposed model is implemented in Matlab, points of intersection of fields of view of different cameras with the camera1 are calculated.

4.3 Image Extraction Results

Following the proposed algorithm in Matlab overlapping part is extracted from the frame. Advantage of this approach is that every node will process frames at its end, communication between sensors requires only four parameters (α, P, V, and R) from other sensor to be known for applying the OPI model. Points of intersection between FOVs of cameras are calculated. The results are shown in the following table.

Camera (i)	**Camera (j)**	**Point of Intersection**	
(xi, yi)	**(xj, yj)**	**X**	**Y**
(-2.5,0)	(-2.4,-.64)	-3.86	-1.74
(-2.5,0)	(-2.16, -1.25)	-3.44	-2.21
(-2.5,0)	(-1.76,-1.76)	-2.86	-2.59
(-2.5,0)	(-1.25,-2.16)	-2.15	-2.84

(-2.5,0)	(-.65,-2.41)	-1.32	-2.92
(-2.5,0)	(0,-2.5)	0.62	-2.44
(-2.5,0)	(.65,-2.41)	1.73	-1.80
(-2.5,0)	(1.25,-2.16)	3.06	-0.78
(-2.5,0)	(1.76,1.76)	-3.90	-2.56
(-2.4,-.64)	(-2.16,-1.25)	-3.40	-3.00
(-2.4,-.64)	(-1.76,-1.76)	-2.78	-3.31
(-2.4,-.64)	(-1.25,-2.16)	-2.05	-3.47
(-2.4,-.64)	(-.65,-2.41)	-1.26	-3.45
(-2.4,-.64)	(0,-2.5)	-0.44	-3.23
(-2.4,-.64)	(-65,-2.41)	0.38	-2.81
(-2.4,-.64)	(1.25,-1.25)	1.21	-2.17
(-2.4,-.64)	(1.76.-1.76)	-3.70	-3.22
(-2.16,-1.25)	(-1.76,-1.76)	-3.16	-3.60
(-2.16,-1.25)	(-1.25,-2.16)	-2.52	-3.82
(-2.16,-1.25)	(-.65,-2.41)	-1.84	-3.88
(-2.16,-1.25)	(0,-2.5)	-1.14	-3.76
(-2.16,-1.25)	(.65,-2.41)	-0.49	-3.47
(-2.16,-1.25)	(1.25,-2.16)	0.10	-3.01
(-2.16,-1.25)	(1.76, -1.76)	-3.25	-3.67

(-1.76,-1.76)	(-1.25,-2.16)	-2.69	-3.95
(-1.76,-1.76)	(-.65,-2.41)	-2.08	-4.07
(-1.76,-1.76)	(0,-2.5)	-1.48	-4.02
(-1.76,-1.76)	(.65,-2.41)	-0.93	-3.81
(-1.76,-1.76)	(1.25,-1.25)	-0.49	-3.45
(-1.76,-1.76)	(1.76,-1.76)	-2.58	-3.87
(-1.25,-2.16)	(-.65,-2.41)	-2.05	-4.04
(-1.25,-2.16)	(0,-2.5)	-1.51	-4.04
(-1.25,-2.16)	(.65,-2.41)	-1.04	-3.88
(-1.25,-2.16)	(1.25,-2.16)	-0.67	-3.59
(-1.25,-2.16)	(1.76,-1.76)	-1.75	-3.82
(-.65,-2.41)	(0,-2.5)	-1.26	-3.85
(-.65,-2.41)	(.65,-2.41)	-0.84	-3.73
(-.65,-2.41)	(1.25,-2.16)	-0.52	-3.48
(-.65,-2.41)	(1.76,-1.76)	-0.76	-3.47
(0,-2.5)	(.65,-2.41)	-0.38	-3.39
(0,-2.5)	(1.25,-2.16)	-0.09	-3.16
(.65,-2.41)	(1.25,-2.16)	0.27	-2.90
(.65,-2.41)	(1.76,-1.76)	0.53	-2.68

Table 4.1: Values of Point of Intersection

4.3.1 Camera 1 Frames

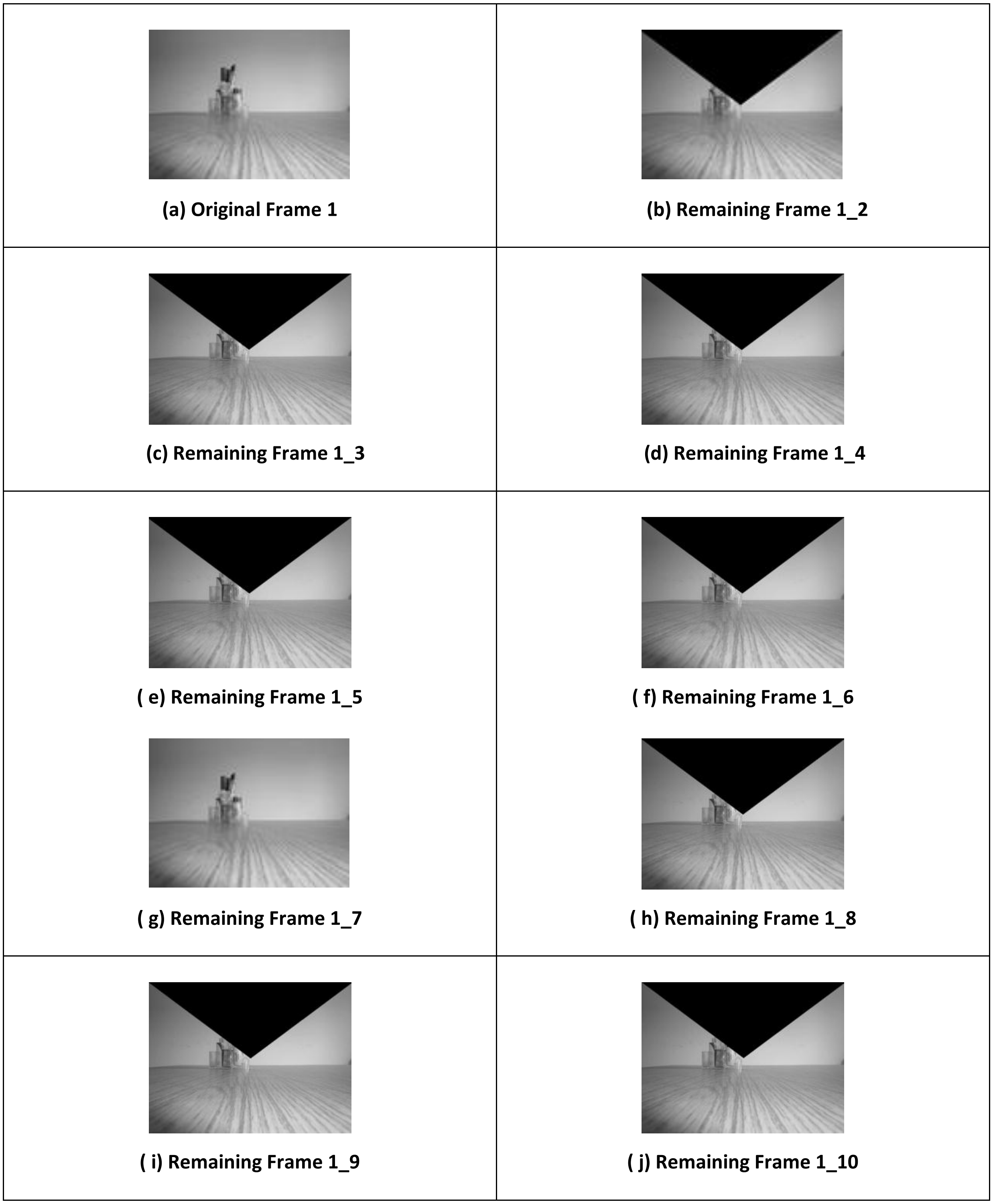


Figure 4.1: Camera 1 Frames

Compression based on discrete cosine Transform is applied over the frames and their timings of compression are calculated. Following plots show the compression timings of original frame of camera1 shown by C1 and extracted frame of camera1 with respect to correlation with other cameras shown by C2,C3,C4,C5,C6,C7,C8,C9 and C10.

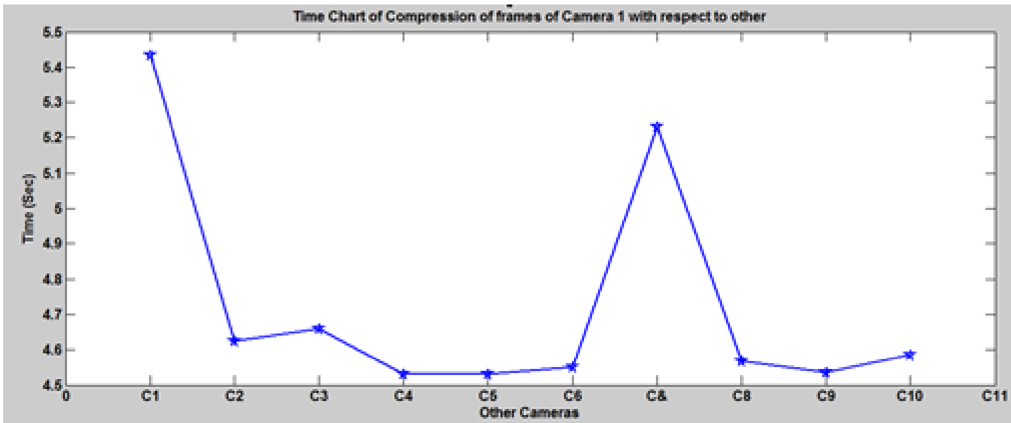


Figure 4.2: Camera 1 frame compression w.r.t other cameras

Figure 4.2 shows that compression time of C1 is greater as compared to compression time extracted frames i.e. from C2 to C10.There is no correlation between camera 1 and camera 7, so there is an increase in compression time of C7 as compared to frames of C2,C3,C4, C5, C6,C8,C9 and C10 . Camera 1 and Camera 8 were correlated therefore compression time is of C8 decreased as compared to C7, which shows that camera1 and camera8 have correlated values.

4.3.2 Camera2 Frames

(a) Original Frame _2

(b) Remaining Frame 2_3

(c) Remaining Frame 2_4

(d) Remaining Frame 2_5

(e) Remaining Frame 2_6

(f) Remaining Frame 2_7

(g) Remaining Frame 2_8

(h) Remaining Frame 2_9

(i) Remaining Frame 2_10

Figure 4.3 Camera 2 Frames

Compression is applied to the above frames captured by camera 2 and their compression time is calculated based on the correlation with other cameras. Remaining frames show that there is a small difference in correlation value of other cameras with camera 1, as cameras are densely located at a small distance and have same field of view values.

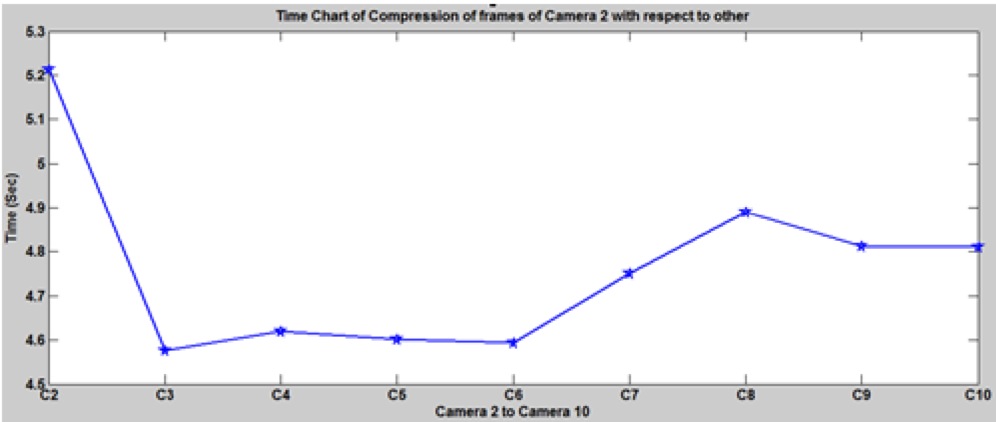


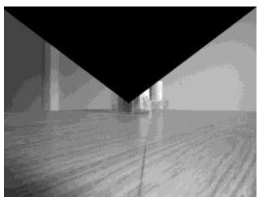
Figure 4.4: Camera 2 Frame compression w.r.t other Cameras

Figure 4.4 shows that original frame C2 of camera 2 takes time longer to encode than the C5 and C6 frames extracted based upon their correlation values with the camera 5 and camera 6. There is a slightly increase in compression time of remaining frame 2_8 of figure 4.3 (g), as correlation between camera 2 and camera 8 is minimum. Comparing figure 4.2 and figure 4.3 variations in compression timing of frames captured by camera 1 and camera 2 respectively. Camera 1 is slightly high in correlation with camera 8, camera 9 and camera 10, as compare to the correlation value of camera 2 with these cameras.

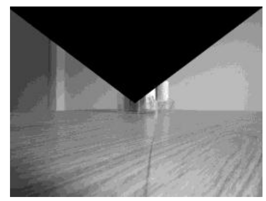
4.3.3 Camera 3 Frames

(a) Original Frame _3

(b) Remaining Frame 3_4

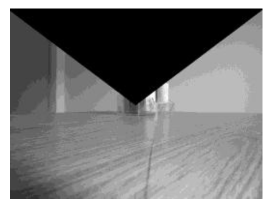


(c) Remaining Frame 3_5

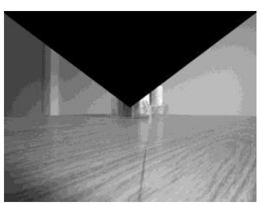


(d) Remaining Frame 3_6

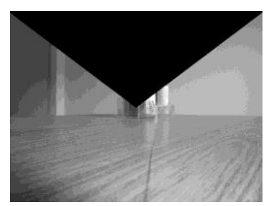
(e) Remaining Frame 3_7



(f) Remaining Frame 3_8



(g) Remaining Frame 3_9



(h) Remaining Frame 3_10

Figure 4.5: Camera 3 Frames

Above frames show that camera 3 has correlation with all other cameras ranging from camera 4 to camera 10. There is a small difference between the correlation values of other cameras with camera 3, therefore extracted frames from figure 4.5(b) to figure 4.5 (h) have difference of few pixel values of overlapping point.

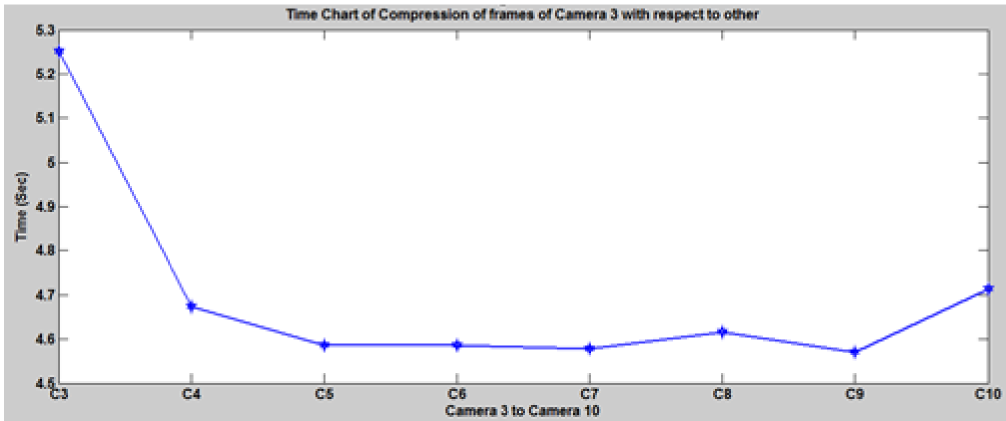


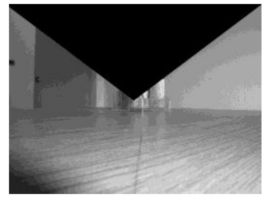
Figure 4.6: Camera 3 Frame compression w.r.t other Cameras

Figure 4.6 shows that with the increase in correlation value between camera 3 and camera 4, encoding time of C4 to C9 is decreased as compared to original image C3 and with the slight decrease in correlation value between camera 3 and camera 10, there is increase in compression time of the remaining frame 3_10 of figure 4.5:(h).

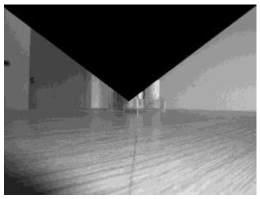
Comparing Figure 4.2, Figure 4.4 and Figure 4.6, there is a consistency in the compression time of frames captured by camera 3, with respect to correlation value with cameras ranging from camera 4 to camera 10, whereas in camera 1 and camera 2 the difference in compression time was varying largely with respect to correlation value of other cameras.

4.3.4 Camera 4 Frames

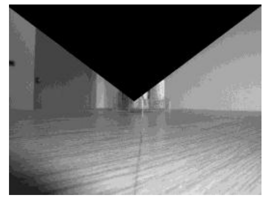
(a) Original Frame _4



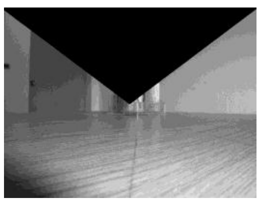
(b) Remaining Frame 4_5



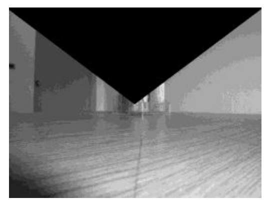
(c) Remaining Frame 4_6



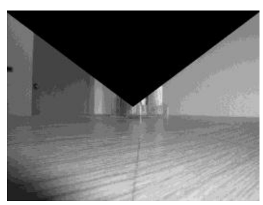
(d) Remaining Frame 4_7



(e) Remaining Frame 4_8



(f) Remaining Frame 4_9



(g) Remaining Frame 4_10

Figure 4.7: Camera 4 Frames

Above frames show that the correlation between camera 4 and its neighboring cameras is varying with small value, therefore there is similarity between remaining frames from Figure 4.7: (c) to (g). From the above frames, it can be predicted that the compression time of frames will also vary in smaller values.

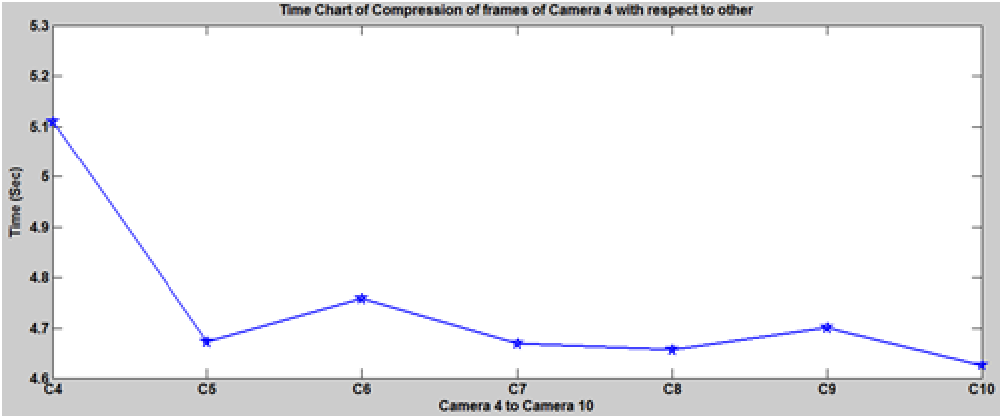


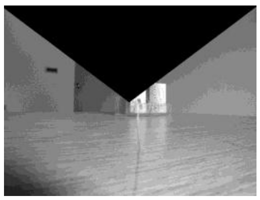
Figure 4.8 Compression time of Camera 4 frames w.r.t other Cameras

There is a strong correlation between camera 4 and camera 5, therefore the compression time of C5 is decreased, with the decrease in correlation value between camera 4 and camera 6 the compression time of C6 is increased. Comparing the time graphs with other time graphs of cameras i.e. figure 4.6, figure 4.4, figure 4.2, the compression timing of figure 4.8 decreases from camera 4 to camera 5, then increases a little from camera 4 to camera 6,again decreases from camera 4 to 7,remains constant from camera 7 to camera 8,then increases from camera 4 to camera 9 and decreases from camera 4 to camera 10.Variation is large here, whereas there was a constant decrease in compression time of camera 3 frames figure 4.4 and in figure 4.2 compression time remained constant from camera 3 to camera 6 and then varied abruptly. This can be due to the differences of sensing direction of other cameras with camera 2.

4.3.5 Camera 5 Frames

(a) Original Frame _5

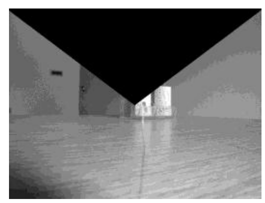
(b) Remaining Frame 5_6



(c) Remaining Frame 5_7

(d) Remaining Frame 5_8

(e) Remaining Frame 5_9



(f) Remaining Frame 5_10

Figure 4.9: Camera 5 Frames

Above frames show that the correlation between camera 5 and its neighboring cameras is varying with small value, therefore there is similarity between remaining frames from Figure 4.9: (c) to (f).

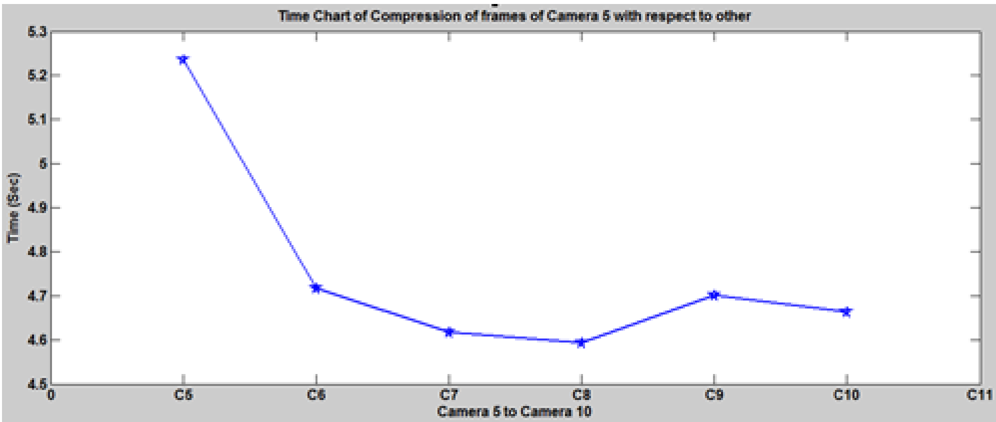


Figure 4.10 Compression time of Camera 5 w.r.t other Cameras

From the figure 4.10, a strong correlation between camera 5 and camera 6 can be observed, therefore, the compression time of frame C6 is decreased, correlation value between camera 5 and camera 8 increases a little as compared to correlation with camera 6, therefore with the increase in correlation value, there is decrease in the compression time of frames.. Compression time of C5 is somewhat greater than C10. Behavior of plot in figure 4.10 is somewhat similar to the graph in figure 4.8 and different from the other cameras in figure 4.6, figure 4.4, figure 4.2.It can be observed that two neighboring cameras show similar behavior compared to other nodes in the region.

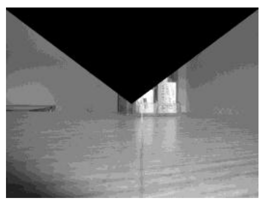
4.3.6 Results of Camera 6 Frames

(a) Original Frame _6

(b) Remaining Frame 6 _7

(c) Remaining Frame 6_8

(d) Remaining Frame 6_9



(e) Remaining Frame 6_10

Figure 4.11: Camera 6 Frames 1

Above frames show that the correlation between camera 6 and its neighboring cameras is varying with small value, therefore there is similarity between remaining frames from Figure 4.11: (c) to (e).

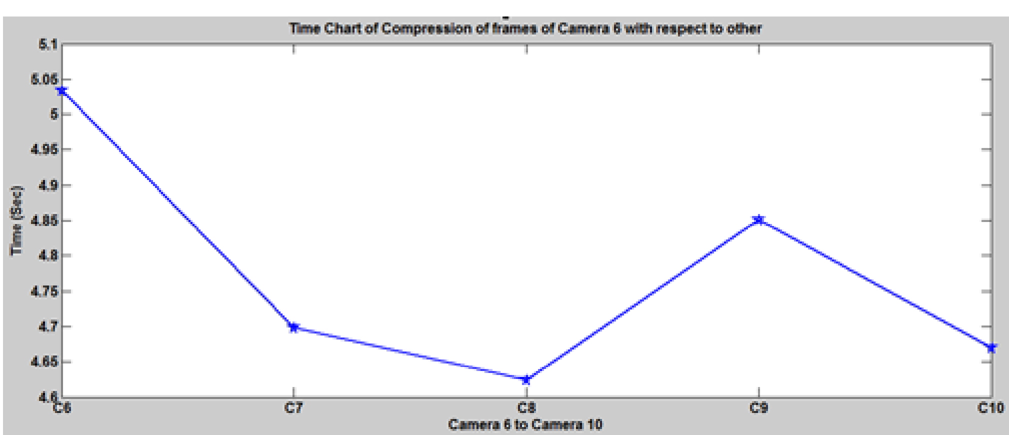
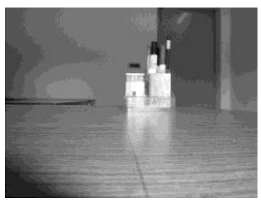


Figure 4.12: Compression time of Camera 6 w.r.t other Cameras

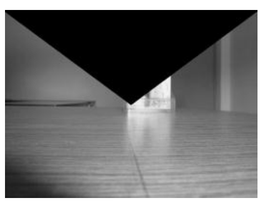
There is a strong correlation between camera 6 and camera 7, therefore the compression time of frame is decreased, correlation value between camera 6 and camera 9 decreases a little as compared to correlation with camera 7, and therefore its compression time is increased. Frame of camera 10 takes less time to compress as compare to compression time of C7. Behavior of plot is similar to plots in figure 4.10, figure 4.8, but there is large difference in of compression time of figure 4.12 which is increasing from camera 8 to camera 9.

4.3.7 Camera 7 Frames



(a) Original Frame _7

(b) Remaining Frame 7 _8



(c) Remaining Frame 7_9

(d) Remaining Frame 7_10

Figure 4.13: Camera 7 Frames

Correlation of camera 7 has been discussed in figures of camera 1,camera2, camera5 and camera 6.Cameras have same filed of views and difference in sensing direction varies with the smaller value i.e. of 15° from camera to camera, therefore the point of overlapping slightly shifts, which may be observed from the pixels location.

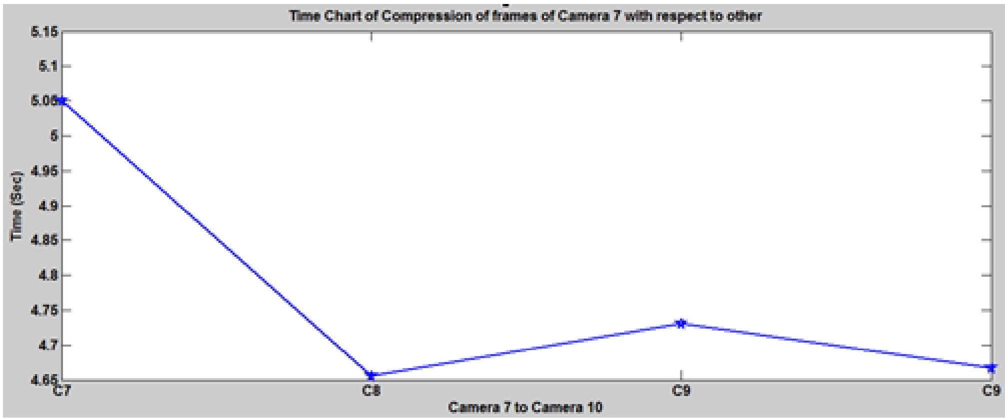
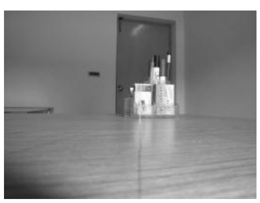


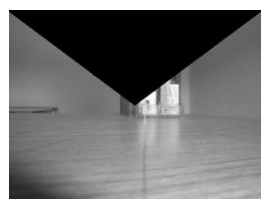
Figure 4.14: Compression time of Camera 7 w.r.t other Cameras

There is a strong correlation between camera 7 and camera 8, therefore the compression time of frame captured by camera 7 is decreased, correlation value between camera 7 and camera 9 decreases a little than camera 8, which increases the compression time of frame. Compression time of camera 7 takes less time with respect to correlation with camera 10.

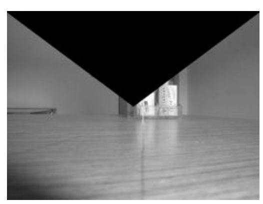
4.3.8 Camera 8 Frames



(a) Original Frame _8



(b) Remaining Frame 8 _9



(c) Remaining Frame 8_10

Figure 4.15: Camera 8 Frames

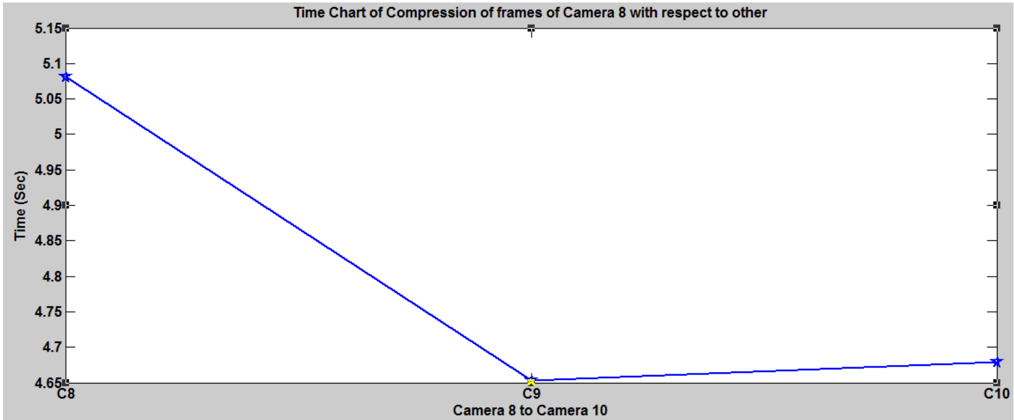
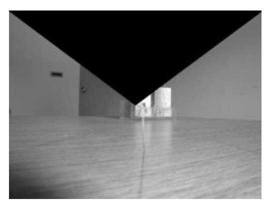


Figure 4.16: Compression time of Camera 8 w.r.t other Cameras

There is a strong correlation between camera 8 and camera 9, therefore the compression time of frame captured by camera 8 is decreased, correlation value between camera 8 and camera 10 decreases a little than correlation value of camera 9, correlation value of camera 8 can be seen from the original frame_8 to remainig frame8_10.

4.3.9 Camera 9 Frames

(a) Original Frame _9



(b) Remaining Frame 9 _10

Figure 4.17: Camera 9 Frames

Correlation of camera 9 is shown only with camera 10,correlation of camera 9 with other cameras have been shown in the above figures.Original frame with overlapping portion removed from the original frame is shown in figure 4.17 and figure 4.17(b)

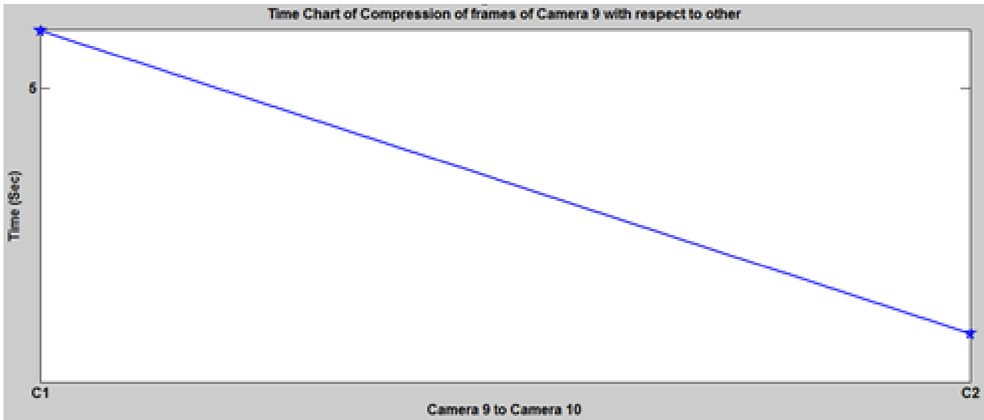


Figure 4.18: Compression time of Camera 9 w.r.t Camera 10

There is a strong correlation between camera9 and camera 10, therefore the compression time of frame captured by camera 9 is decreased, and correlation value of camera 9 can be seen from the original frame_9 to remaining frame 9_10.

Above results show that, as the correlation degree value is varies there is variation in the timings of encoding frames of a camera frames w.r.t other cameras.

4.4 Fusing Extracted Frames and their Quality Estimation

4.4.1 Frame Fusion Scenario

Considering the scenario, if two cameras are correlated to each other, one camera will send a complete frame and the other will send only non-overlapping area with respect to the first camera and the frames received by the sink are already decoded. In order to form a complete/fuse frame for camera 2, sink should have the following information.

i. Information about the location of both cameras.

ii. Their field of view information.

iii. Correlation between the cameras

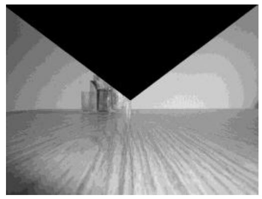
iv. Complete Frame from Camera 1

v. Extracted frame from camera 2

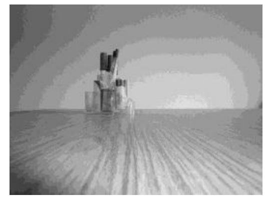
Sink node will calculate intersection point between camera1 and camera2, and map these points to both frames i.e. frame1 and frame 2, and copy the pixel values of frame 1 in to the frame 2.Implenting the algorithm of FrameFusion in Matlab, for the frame results of above cameras, and the following results are obtained.

4.4.2 Fused Frames of Camera 1

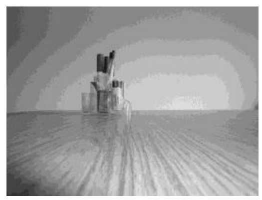
(a) Frame _C2



(b) Remaining Frame C1_2



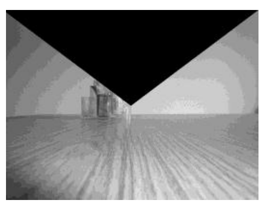
(c) Fused Frame C1_2



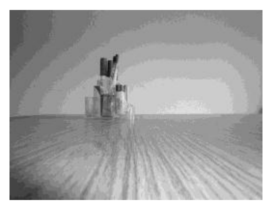
(d) Original Frame _C1

Figure 4.19: Camera 1 fused frame w.r.t camera 2

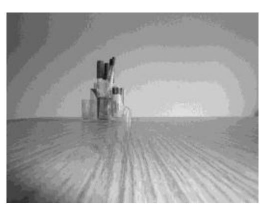
(a) Frame _C3



(b) Remaining Frame C1_3



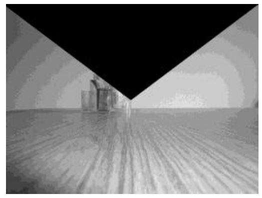
(c) Fused Frame C1_3



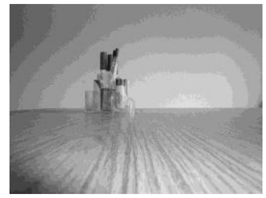
(d) Original Frame _C1

Figure 4.20: Camera 1 fused frame w.r.t camera 3

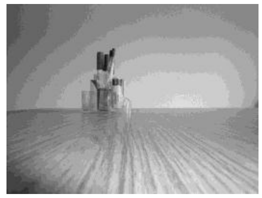
(a) Frame _C4



(b) Remaining Frame C1_4



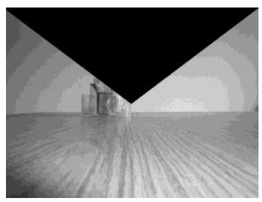
(c) Fused Frame C1_4



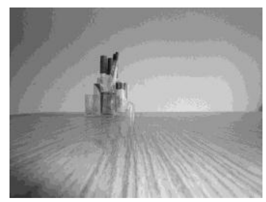
(d) Original Frame _C1

Figure 4.21: Camera 1 fused frame w.r.t camera 4

(a) Frame _C5



(b) Remaining Frame C1_5

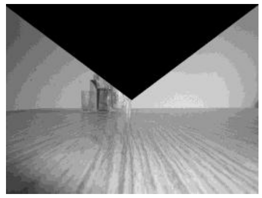


(c) Fused Frame C1_5

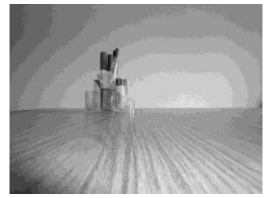
(d) Original Frame _C1

Figure 4.22: Camera 1 fused frame w.r.t camera 5

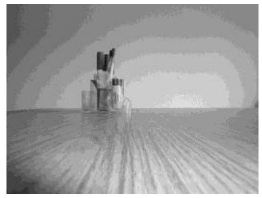
(a) Frame _C6



(b) Remaining Frame C1_6



(c) Fused Frame C1_6



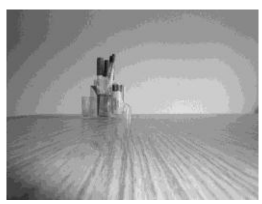
(d) Original Frame _C1

Figure 4.23: Camera 1 fused frame w.r.t camera 6

(a) Frame _C7

(b) Remaining Frame C1_7

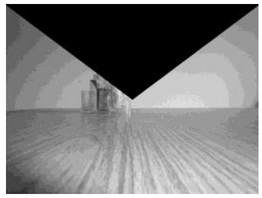
(c) Fused Frame C1_7



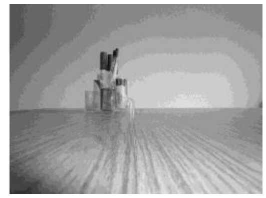
(d) Original Frame _C1

Figure 4.24: Camera 1 fused frame w.r.t camera 7

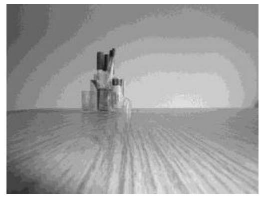
(a) Frame _C8



(b) Remaining Frame C1_8



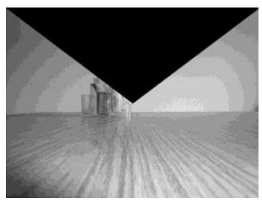
(c) Fused Frame C1_8



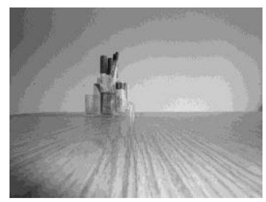
(d) Original Frame _C1

Figure 4.25: Camera 1 fused frame w.r.t camera 8

(a) Frame _C9



(b) Remaining Frame C1_9

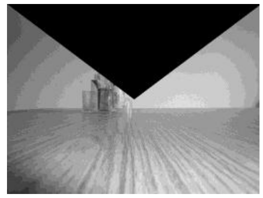


(c) Fused Frame C1_9

(d) Original Frame _C1

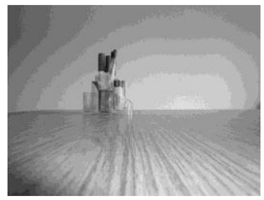
Figure 4.26: Camera 1 fused frame w.r.t camera 9

(a) Frame _C10



(b) Remaining Frame C1_10

(c) Fused Frame C1_10



(d) Original Frame _C1

Figure 4.27: Camera 1 Fused Frames w.r.t camera 10

Quality of constructed images is calculated using the mean square error between the original image and the constructed image. PSNR (Peak Signal to Noise Ratio) is calculated. PSNR value is calculated in Decibels. According to [34], typical values between the original image and its changed version lies between 30 to 50 DB, higher the value of PSNR, better will be the image quality.

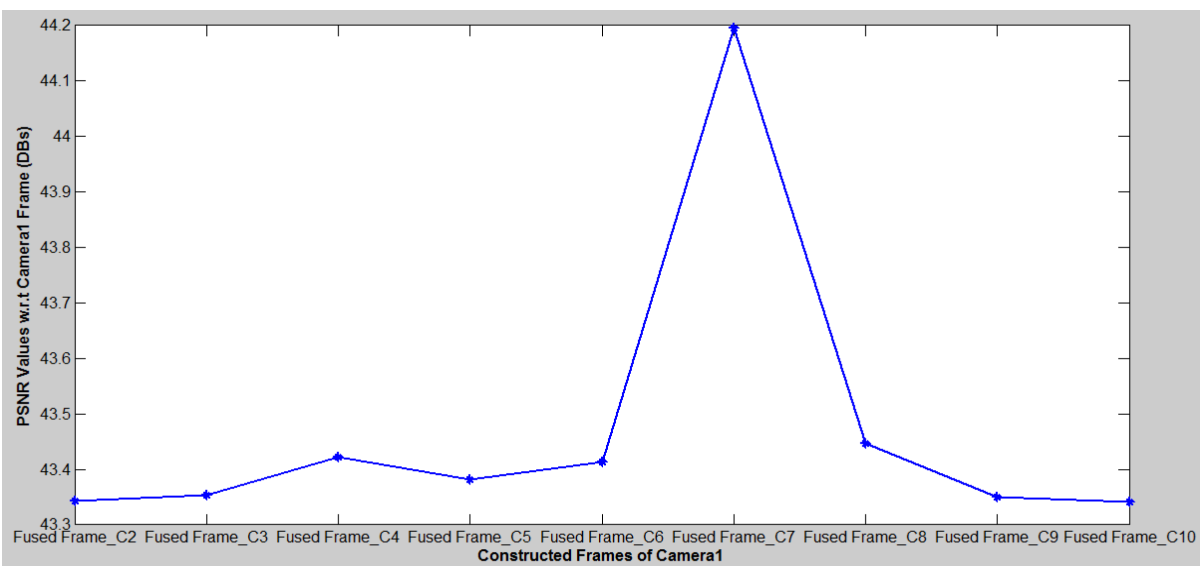
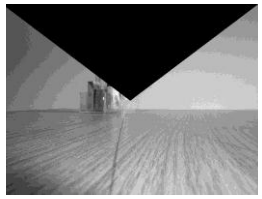


Figure 4.28: PSNR Values of Camera 1 Frames Constructed

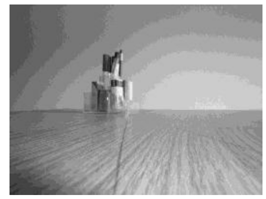
Graph values of Figure 4.28 show that the PSNR value is greater than 40 DBs for all the constructed images. PSNR value of Camera 1 Frame constructed using Camera 6 Frame decreases, this shows that they have minimum similarity, it also proves zero correlation between camera 1 and camera 7, which was discussed in figure 4.1 from these values.

4.4.3 Fused Frames of Camera 2

(a) Frame _C3



(b) Remaining Frame C2_3

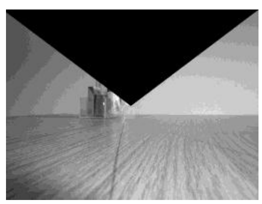


(c) Fused Frame C2_3

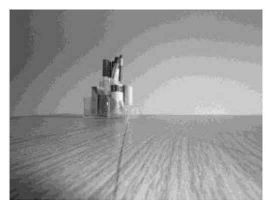
(d) Original Frame _C2

Figure 4.29: Camera 2 Fused Frames w.r.t camera 3

(a) Frame _C4



(b) Remaining Frame C2_4

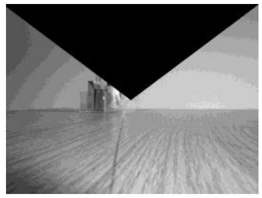


(c) Fused Frame C2_4

(d) Original Frame _C2

Figure 4.30: Camera 2 Fused Frames w.r.t camera 4

(a) Frame _C5



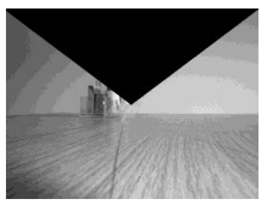
(b) Remaining Frame C2_5

(c) Fused Frame C2_5

(d) Original Frame _C2

Figure 4.31: Camera 2 Fused Frames w.r.t camera 5

a) Frame _C6

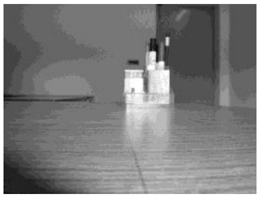


(b) Remaining Frame C2_6

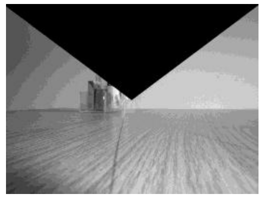
(c) Fused Frame C2_6

(d) Original Frame _C2

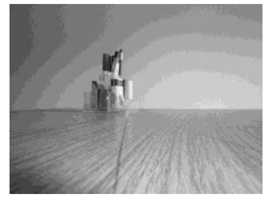
Figure 4.32: Camera 2 Fused Frames w.r.t camera 6



(a) Frame _C7



(b) Remaining Frame C2_7



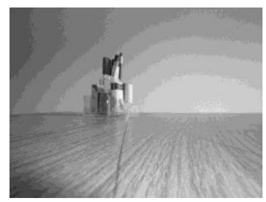
(c) Fused Frame C2_7

(d) Original Frame _C2

Figure 4.33: Camera 2 Fused Frames w.r.t camera 7

(a) Frame _C7

(b) Remaining Frame C2_8

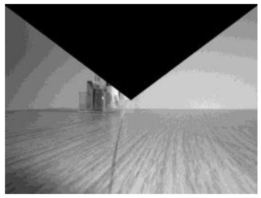


(c) Fused Frame C2_8

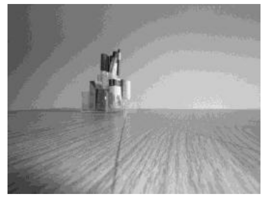
(d) Original Frame _C2

Figure 4.34: Camera 2 Fused Frames w.r.t camera 8

(a) Frame _C9



(b) Remaining Frame C2_9

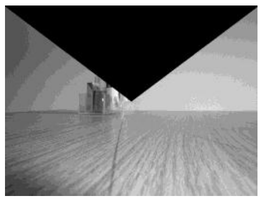


(c) Fused Frame C2_9

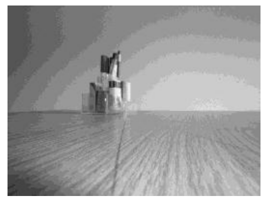
(d) Original Frame _C2

Figure 4.35: Camera 2 Fused Frames w.r.t camera 9

(a) Frame _C10



(b) Remaining Frame C2_10



(c) Fused Frame C2_10

(d) Original Frame _C2

Figure 4.36: Camera 2 Fused Frames w.r.t camera 10

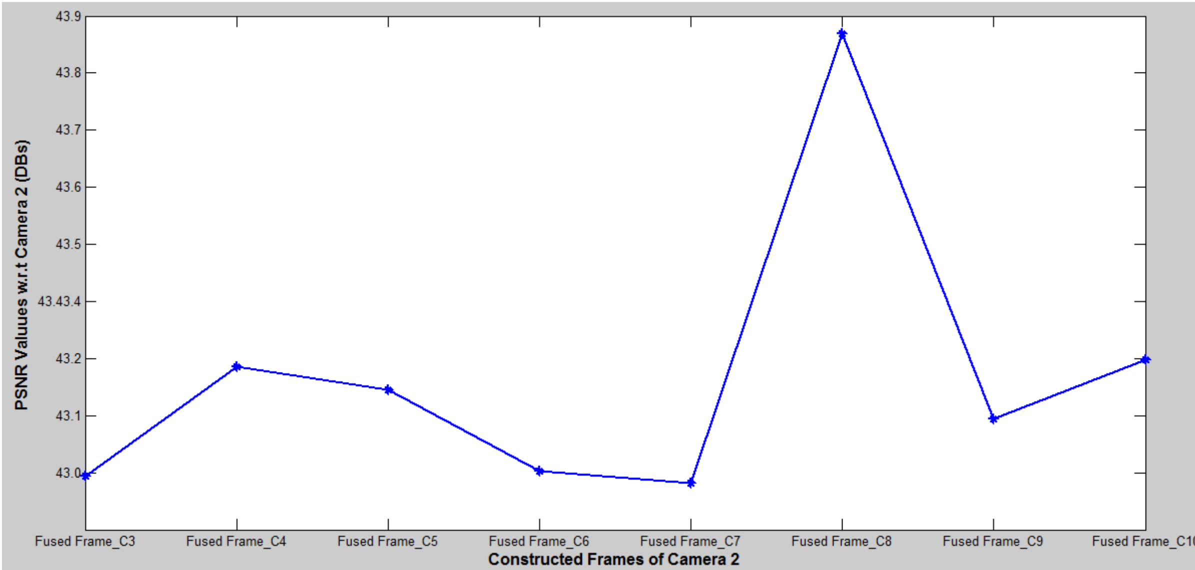
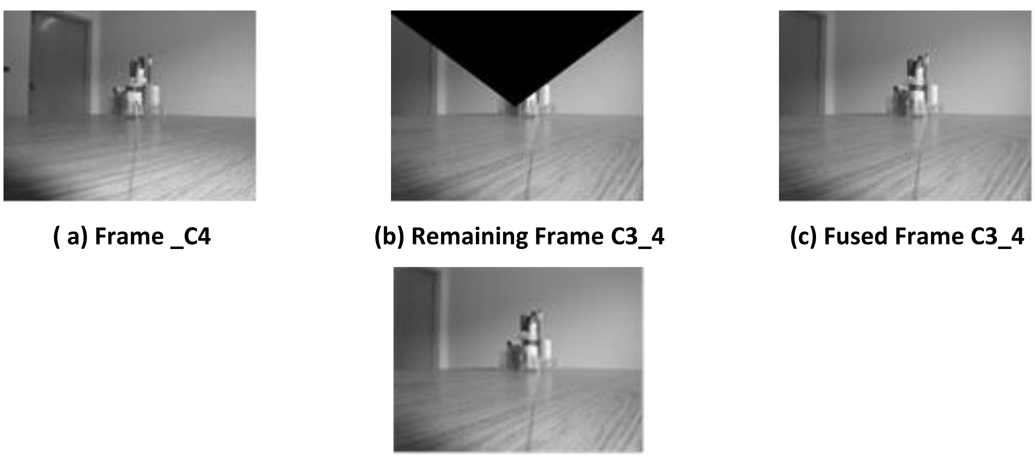


Figure 4.37: PSNR Values of Camera 2 Frames Constructed

Figure 4.37 shows that the PSNR value decreases at Camera 8, because camera 2 and camera 8 have minimum similarity

4.4.4 Fused Frames of Camera 3



(a) Frame _C4 **(b) Remaining Frame C3_4** **(c) Fused Frame C3_4**

(d) Original Frame _C3

Figure 4.38: Camera 3 fused frame w.r.t camera 4

Figure 4.38 shows camera 3 frame (c), which is constructed using the frame of camera 4 (a), original frame of camera 3 is also shown in (d) ,for the comparison of fused frame and original frame. Both frames appear same, there may be the change in the gray levels of pixel values. This difference can be shown by the PSNR values calculated. In the same way frames of camera 3 are constructed using the frames of camera 5, camera 6, camera 7, camera 8, camera 9 and camera 10.

(a) Frame _C5

(b) Remaining Frame C3_5

(c) Fused Frame C3_5

(d) Original Frame _C3

Figure 4.39: Fused Frame of camera 3 w.r.t camera 5

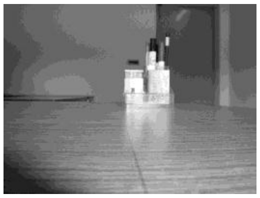
(a) Frame _C6

(b) Remaining Frame C3_6

(c) Fused Frame C3_6

(d) Original Frame _C3

Figure 4.40: Fused Frame of camera 3 w.r.t camera 6



(a) Frame _C7

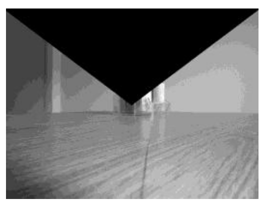
(b) Remaining Frame C3_7

(c) Fused Frame C3_7

(d) Original Frame _C3

Figure 4.41: Fused Frame of camera 3 w.r.t camera 7

(a) Frame _C8



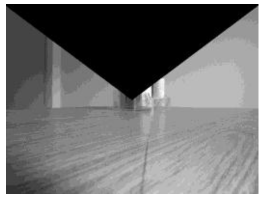
(b) Remaining Frame C3_8

(c) Fused Frame C3_8

(d) Original Frame _C3

Figure 4.42: Fused Frame of camera 3 w.r.t camera 8

(a) Frame _C9



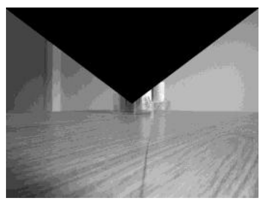
(b) Remaining Frame C3_9

(c) Fused Frame C3_9

(d) Original Frame _C3

Figure 4.43: Fused Frame of camera 3 w.r.t to camera 9

(a) Frame _C10



(b) Remaining Frame C3_10

(c) Fused Frame C3_10

(d) Original Frame _C3

Figure 4.44: Fused Frame of camera 3 w.r.t camera 10

Figure 4.38 (c), 4.39 (c),4.40 (c),4.41 (c),4.42(c),4.43(c), 4.44(c) and 4.44 (c) show the fused frames of camera 3 with respect to the frames of camera 4, camera 5, camera 6, camera 7, camera 8, camera 9, camera 10.quality of fused images is not degraded as compare to the visual content in the original image of camera 3.however, there is change in grey level values of fused images. Figure 4.45 below shows the PSNR values of above fused frames.

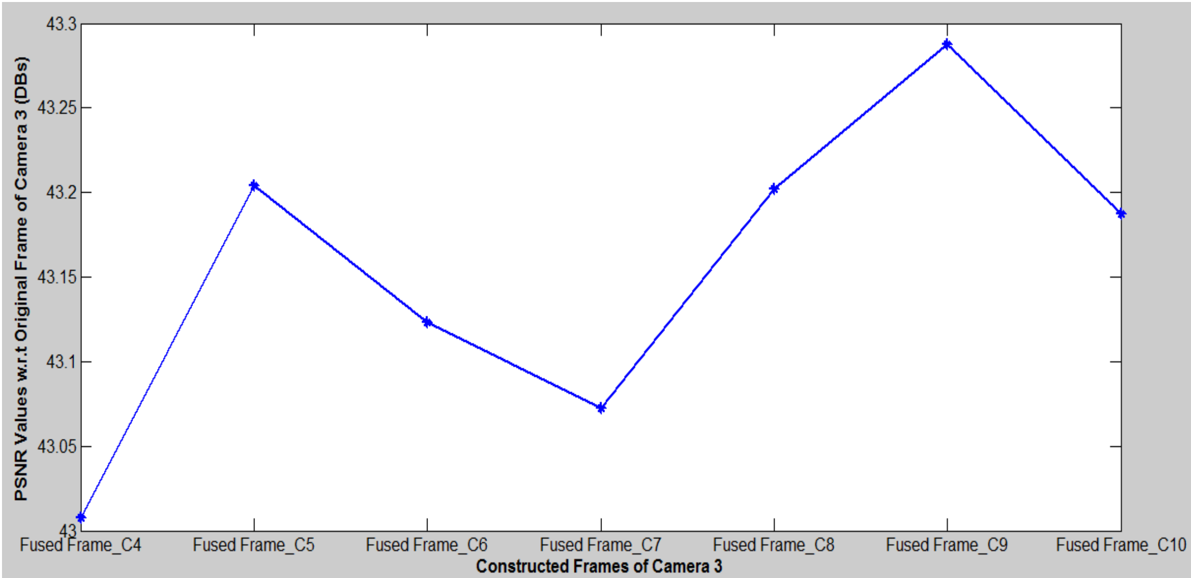
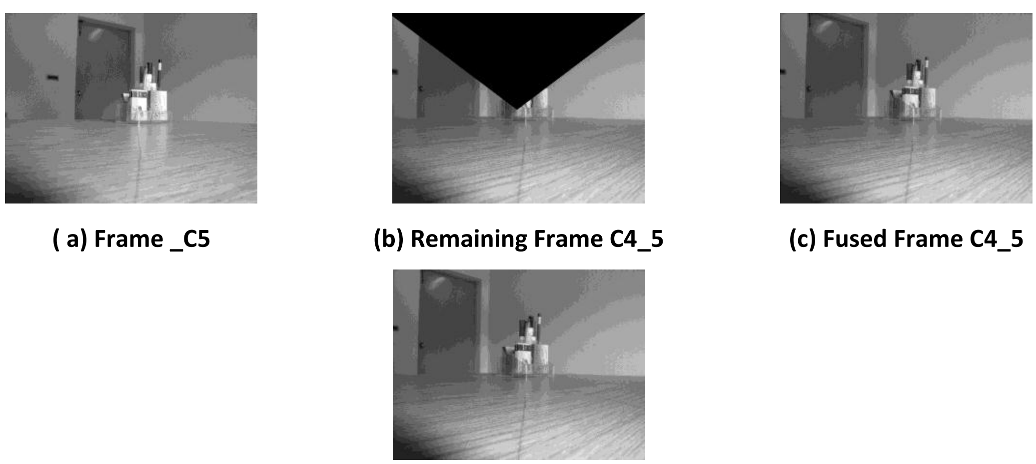


Figure 4.45: PSNR Values of Camera 3 Frames Constructed

PSNR values of fused frames are calculated w.r.t the original frame of camera 3, and the graph values show that the maximum PSNR value of 43.3 DBs for the fused frame of camera 3 constructed using the camera 9 frame. Minimum value of PSNR is 43.1 DBs for the fused frame _C7.The minimum value differs only in points from the maximum value. The plot in figure 11 also shows that camera 3 and camera 6 have less correlation and that is why the PSNR value of frame 3 constructed using camera 6 frame has low quality. As the correlation value increases from camera 7, the quality of fused frames of camera 3 also increases.

4.4.5 Fused Frames of Camera 4

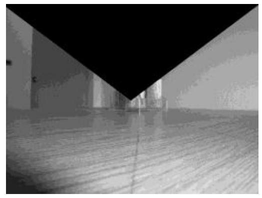


(a) Frame _C5 **(b) Remaining Frame C4_5** **(c) Fused Frame C4_5**

(d) Original Frame _C4

Figure 4.46: Fused Frame of camera 4 w.r.t camera 5

(a) Frame _C6

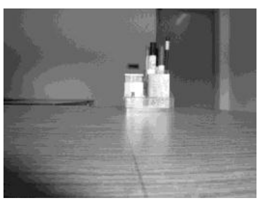


(b) Remaining Frame C4_6

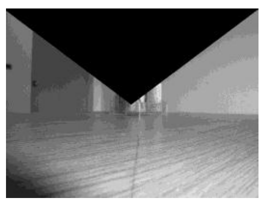
(c) Fused Frame C4_6

(d) Original Frame _C4

Figure 4.47: Fused Frame of camera 4 w.r.t camera 6



(a) Frame _C7



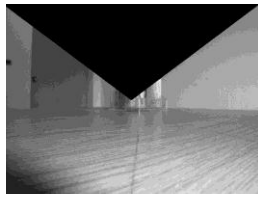
(b) Remaining Frame C4_7

(c) Fused Frame C4_7

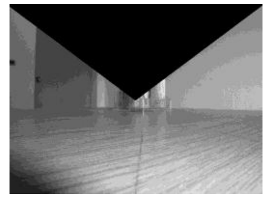
(d) Original Frame _C4

Figure 4.48: Fused Frame of camera 4 w.r.t camera 7

(a) Frame _C8



(b) Remaining Frame C4_8

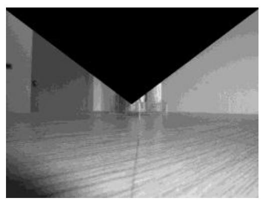


(c) Fused Frame C4_8

(d) Original Frame _C4

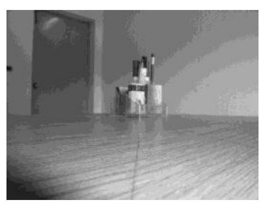
Figure 4.49: Fused Frame of camera 4 w.r.t camera 8

(a) Frame _C9



(b) Remaining Frame C4_9

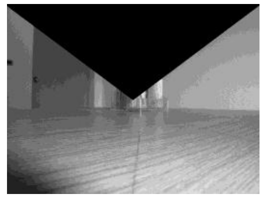
(c) Fused Frame C4_9



(d) Original Frame _C4

Figure 4.50: Fused Frame of camera 4 w.r.t camera 9

(a) Frame _C10



(b) Remaining Frame C4_10

(c) Fused Frame C4_9

(d) Original Frame _C4

Figure 4.51: Fused Frame of camera 4 w.r.t camera 10

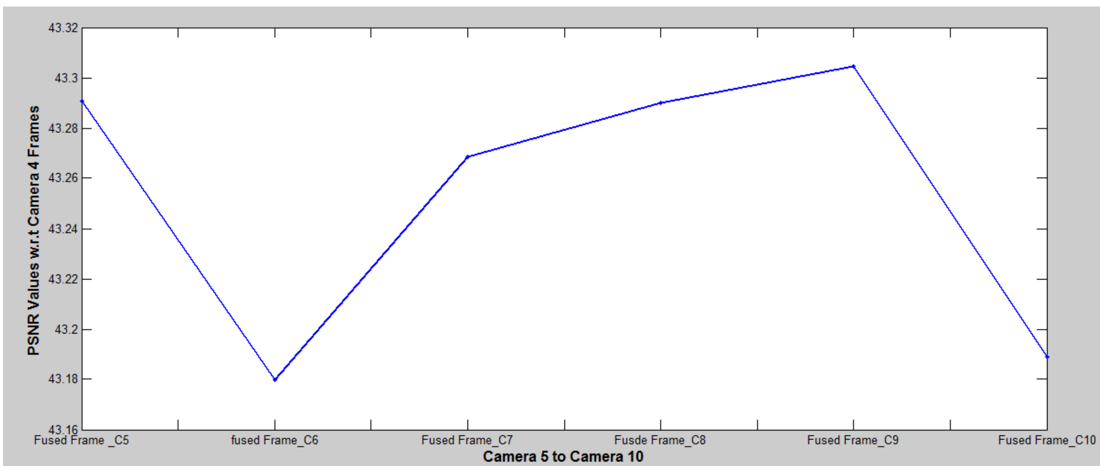


Figure 4.52: PSNR Values of Camera 4 Frame Constructed

The plot of figure 4.52 shows results similar to the plot of figure 4.45

4.4.6 Fused Frames of Camera 5

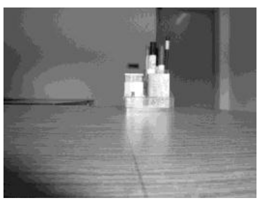
(a) Frame _C6

(b) Remaining Frame C5_6

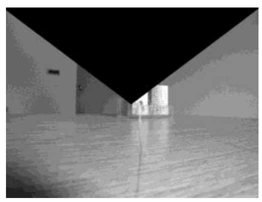
(c) Fused Frame C5_6

(d) Original Frame _C5

Figure 4.53: Fused Frame of camera 5 w.r.t camera 6



(a) Frame _C7



(b) Remaining Frame C5_7

(c) Fused Frame C5_7

(d) Original Frame _C5

Figure 4.54: Fused Frame of camera 5 w.r.t camera 7

(a) Frame _C8

(b) Remaining Frame C5_8

(c) Fused Frame C5_8

(d) Original Frame C5

Figure 4.55: Fused Frame of camera 5 w.r.t camera 8

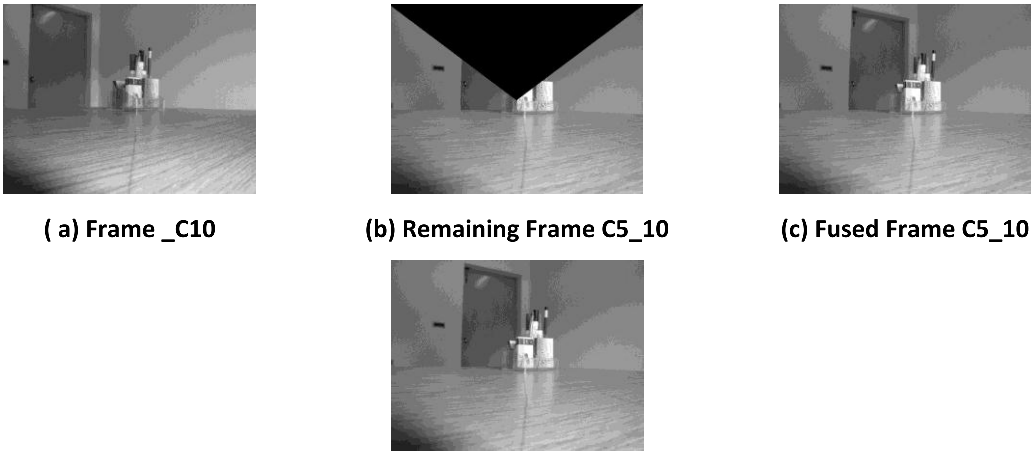
(a) Frame _C9

(b) Remaining Frame C5_9

(c) Fused Frame C5_9

(d) Original Frame C5

Figure 4.56: Fused Frame of camera 5 w.r.t camera 9



(a) Frame _C10 **(b) Remaining Frame C5_10** **(c) Fused Frame C5_10**

(d) Original Frame C5

Figure 4.57: Fused Frame of camera 5 w.r.t camera 10

Figure 4.53 to figure 4.57 show the frames of camera 5 that are constructed using the frames of camera 6, camera 7, camera 8, camera 9 and camera 10.Comparing figure 4.53(c) with figure 4.56 (c), there is the difference in gray level values of images, 4.53(c) is darker whereas 4.56 (c) is somewhat brighter than 12 (c). Quality of fused frames is maintained as in the case of camera 3 fused frames. PSNR value is also calculated for the quality estimation of above fused frames.

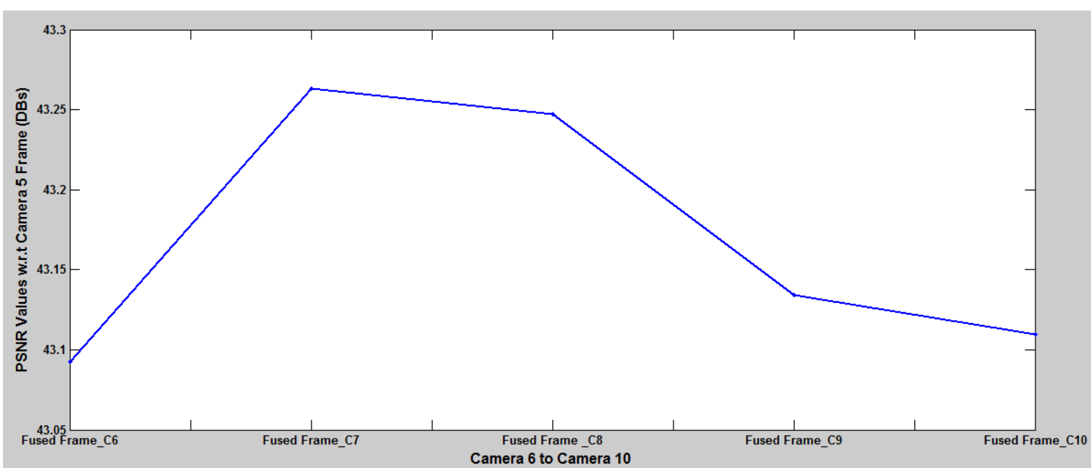
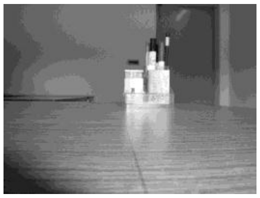


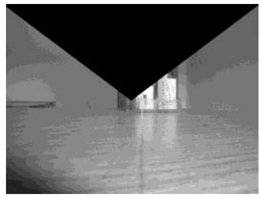
Figure 4.58: PSNR Values of Camera 5 Frames Constructed

Figure 4.58 shows that PSNR vale of fused frame_C7 increases then there is a linear decrease in PSNR values of fused frames with the increasing gap between cameras. PSNR values of all fused frames range from 43.05 DBs to 43.25 DBs, there is not much decrease in PSNR values. The figure 4.58 shows drift in PSNR values from camera 7 as compared to the above PSNR plots of camera 4 and camera 3.

4.4.7 Fused Frames of Camera 6



(a) Frame _C7



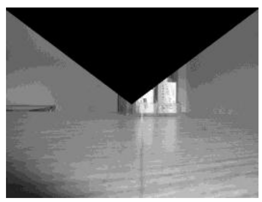
(b) Remaining Frame C6_7

(c) Fused Frame C6_7

(d) Original Frame C6

Figure 4.59: Fused Frame of camera 6 w.r.t camera 7

(a) Frame _C8



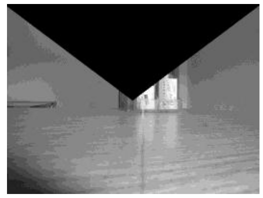
(b) Remaining Frame C6_8

(c) Fused Frame C6_8

(d) Original Frame C6

Figure 4.60: Fused Frame of camera 6 w.r.t camera 8

(a) Frame _C9



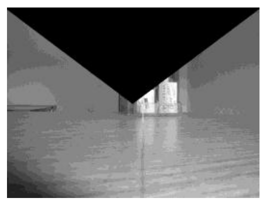
(b) Remaining Frame C6_9

(c) Fused Frame C6_9

(d) Original Frame C6

Figure 4.61: Fused Frame of camera 6 w.r.t camera 9

(a) Frame _C10



(b) Remaining Frame C6_10

(c) Fused Frame C6_10

(d) Original Frame C6

Figure 4.62: Fused Frame of camera 6 w.r.t camera 10

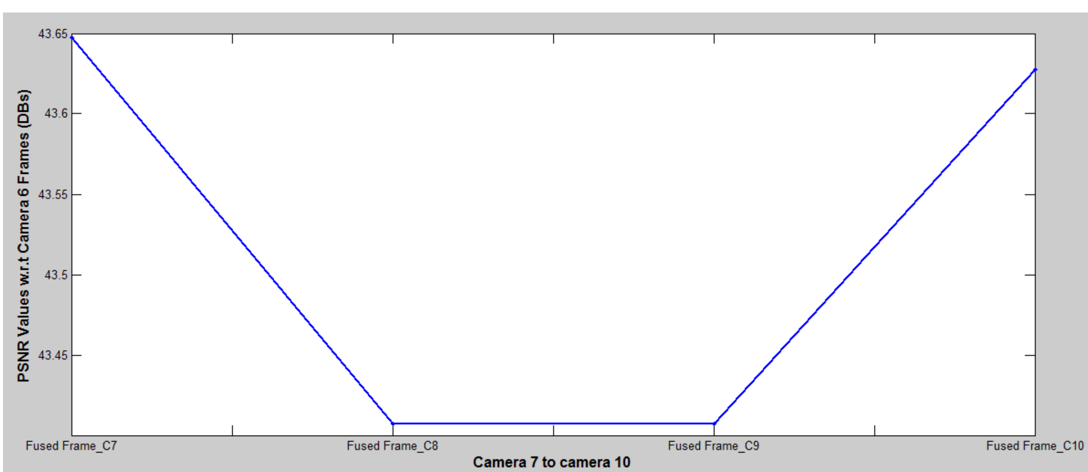


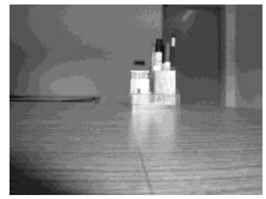
Figure 4.63: PSNR Values of Camera 6 Frames Constructed

PSNR value of camera 6 frame constructed using camera 8 frame decreases and increases from camera 9.

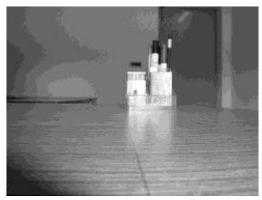
4.4.8 Fused Frames of Camera 7

(a) Frame _C8

(b) Remaining Frame C7_8



(c) Fused Frame C7_8

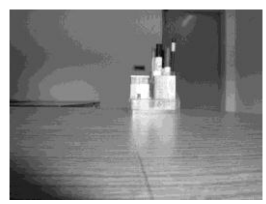


(d) Original Frame C7

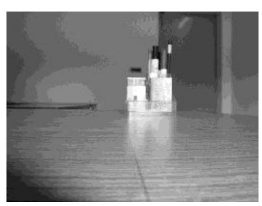
Figure 4.64: Fused Frame of camera 7 w.r.t camera 8

(a) Frame _C9

(b) Remaining Frame C7_9



(c) Fused Frame C7_9

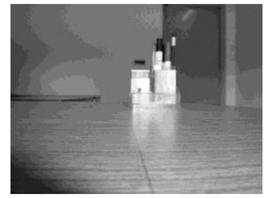


(d) Original Frame C7

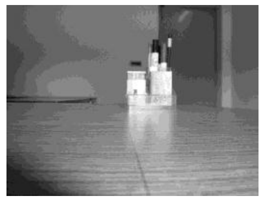
Figure 4.65: Fused Frame of camera 7 w.r.t camera 9

(a) Frame _C10

(b) Remaining Frame C7_10



(c) Fused Frame C7_10



(d) Original Frame C7

Figure 4.66: Fused Frame of camera 7 w.r.t camera 10

Figure 4.64 to 4.66 show the fused frames of camera 7 calculated with respect to the original frame of camera 8 to camera 10. Fused Frames have same visual content as the original frame but there is variation in gray level values fused frames as compare to original frame and between the fused frames themselves.

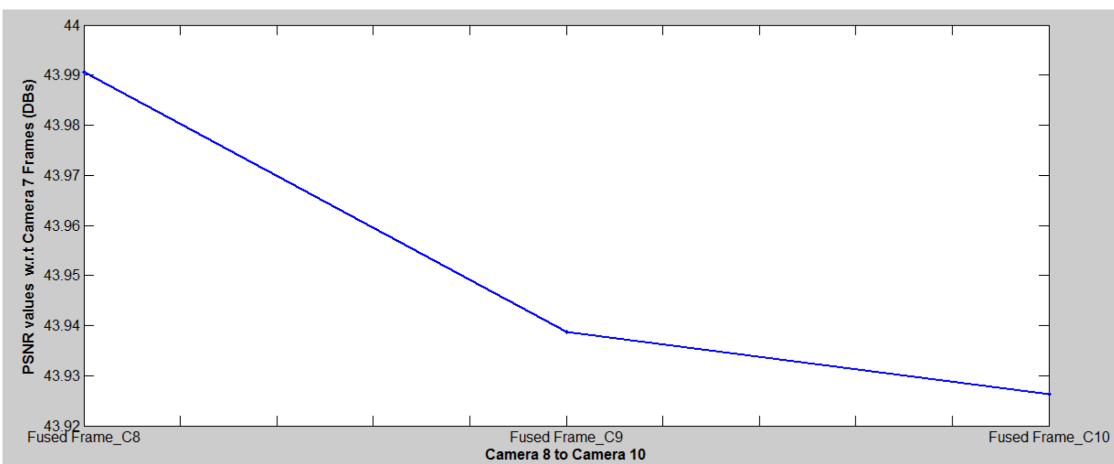
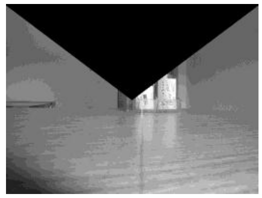


Figure 4.67: PSNR Values of Camera 7 Frames Constructed

Figure 4.65 show the PSNR values of Fused Frames of camera 7 calculated with respect to the original frame. The graph values have similar behaviour as shown in the figure 4.57, it decreases linearly with the gap between the cameras and the decrease difference is in points. Camera 7 frames are constructed using camera8, camera 9 and camera 10 frames. The plot shows that PSNR value of camera 7 frame constructed using camera 8 frame decreases and this decrease in PSNR value continues till camera 10

4.4.9 Fused Frames of Camera 8

(a) Frame _C9



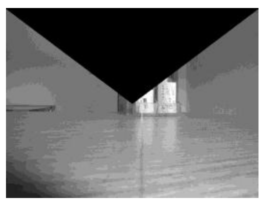
(b) Remaining Frame C8_9

(c) Fused Frame C8_9

(d) Original Frame C8

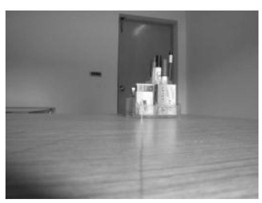
Figure 4.68: Fused Frame of camera 8 w.r.t camera 9

(a) Frame _C10



(b) Remaining Frame C8_10

(c) Fused Frame C8_10



(d) Original Frame C8

Figure 4.69: Fused Frame of camera 8 w.r.t camera 10

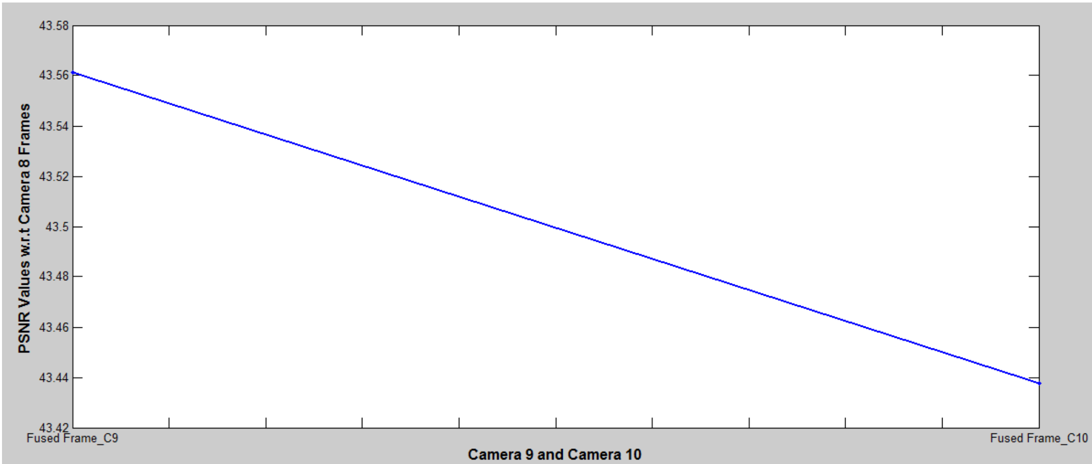
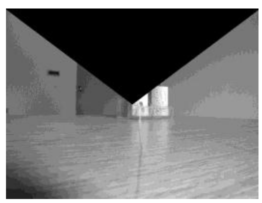


Figure 4.70: PSNR Values of Camera 8 Frames Constructed

PSNR value of camera 8 frame using the camera 9 frame has decreased to some extent as compared to the original frame of camera 8.

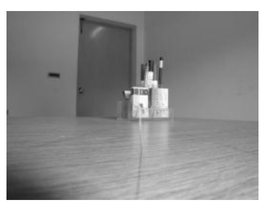
4.4.10 Fused Frames of Camera 9

(a) Frame _C10



(b) Remaining Frame C9_10

(c) Fused Frame C9_10



(d) Original Frame C9

Figure 4.71: Fused Frame of camera 9 w.r.t camera 10

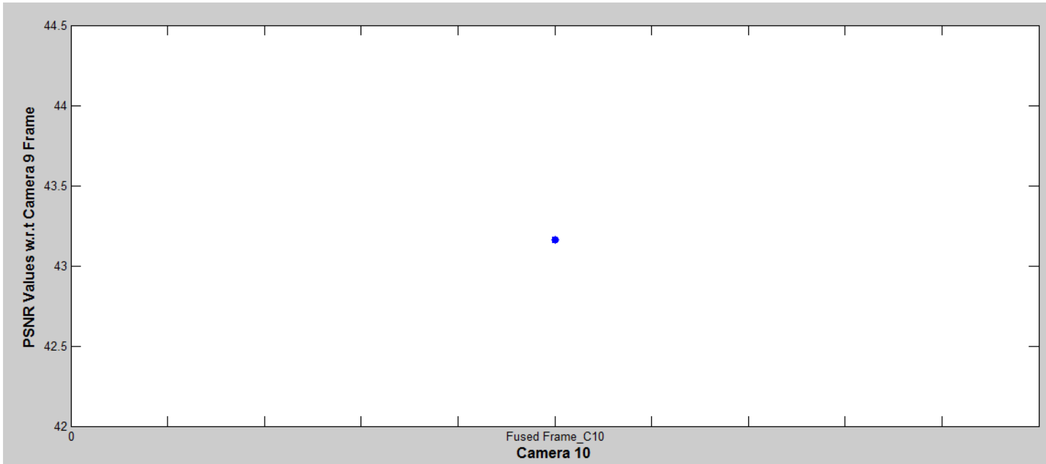


Figure 4.72: PSNR Values of Camera 9 Frame Constructed

All the PSNR plots show that, there is a little variation in their PSNR values among the plots, i.e. the decrease in PSNR values is in points, and PSNR values of all constructed frames range from 40 DBs to 44 DBs, which shows that the quality of images is not degraded, if the images are extracted and reconstructed using the proposed approach

CHAPTER 5: CONCLUSION AND FUTURE WORK

5.1 Conclusion

The objective of this thesis is the study and analysis of correlation techniques, which is aiming to provide time reduction for encoding in multi view video sensor networks. The main focus of the thesis is to design, develop and analysis of exploitation of multiview video correlation for maximizing the lifetime of sensor by reducing the video compression time at the encoder based on spatial correlation of video sensors

Different correlation techniques are investigated. The aim is to analyze the correlation techniques at the encoder and to provide a model that could efficiently utilize the existing approach to reduce the compression time.

To do meaningful research work, research thesis, research papers and journals are reviewed which are related to the camera calibration, spatial and temporal correlation, good quality of side information generation based on the correlation ,improving coding efficiency based on the correlation of sources and fusion of side information for recovering frame at the decoder. In order to meet the objectives, system model has been developed. The main work of this thesis is to implement the existing correlation technique based on spatial correlation in multi view frames and extracting the overlapping part between the cameras to avoid redundancy of information and reduce the time consumption while encoding frames by keeping minimum communication between sensors.

In the camera calibration techniques, different methods have led to different parameters measurement, which helped in calculating correlation between cameras with minimum communication. This correlation technique is used to remove the overlapping part from the frame for improving coding efficiency of encoder.

In the frame extraction algorithm, the point of intersection of overlapping fields of view is calculate, overlapping part from framed using the proposed model and based on intersection point overlapping part is extracted from the input frame. Encoding is applied to the processed frame and original frame (unextracted overlapping part from frame), separately and their compression values showed that, there is significant decrease in the compression timings of processed frame as compare to the compression timings of original frame. Compression time of extracted frames decreases from 10 to 20 percent. Finally, the image fusion at the decoder is also described and quality of fused image is calculated using PSNR values. The PSNR value of constructed frames is in the range of 40 to 45 DBs, that shows the quality of constructed frames is not degraded and quality of frames is acceptable.

The system is implemented in Matlab (2010) based environment and simulation of the proposed system scenarios is performed in Matlab. The extracted image files and timings graphs of frame compression are analyzed. The simulated system scenarios are equally feasible in real world environment. These can be in wireless sensor networks with respect to proposed approach.

To check the efficiency and effectiveness of the system, it is subjected through comprehensive and detailed simulation scenarios. The analyses of the results indicate that system performed extremely well in situations where the sensors are deployed densely at a scene. The comparative analysis of compression timings frames processed with the system with original frames of sensor shows considerable improvement and proves the technique is workable in real-time scenarios.

5.2 Future Work

There are many issues in designing an efficient image extraction based on spatial correlation vertical for the different hops of sensors and abstractions between the sensors that limit the field of view of sensor and can reduce the correlation. They should be further investigated. In this thesis, the implementation of image extraction at the encoder is performed. Decoding the correlated sources based on the spatial correlation needs to be investigated in DSC where side information is generated based on spatial correlation also as compare to side information that is generated based on temporal correlation usually. The design of a decoder for integrating such scheme becomes a main challenge if the spatial correlation is also considered. In that case a scenario is to be proposed that can be implemented in real time decoding of correlated sources.

There is another crucial factor which is power consumption in transmission and rate distortion of video from the sensors. Due to transmission of high quality video, sensors power will dissipate more quickly. This will waste energy because when sensor is using one interface for encoding and the other interface will still be in a power on status to check for available networks. There should be a mechanism to make the other interface in sleep or idle mode for some time to save power, but it may lead to a large delay. So there is a need to analyze the tradeoff between a good quality of video transmission and power consumption.

REFERENCES

[1] "MPEG1", http://en.wikipedia.org/wiki/MPEG-1

[2] "H.264/AVC", http://en.wikipedia.org/wiki/H.264/MPEG-4_AVC

[3] F. Dufax, "Multi view distributed Video Coding".

[4] Xing San, Hua Cai, Member IEE, Jian-Guang Lou, Member IEEE, and Jiang Li, Senior Member, IEEE," Multiview Image Coding Based on Geometric Prediction"," IEEE Transactions on Circuits and Systems for Video Technology",2007,vol.17 no. 11,pp. 1536-1548.

[5] Suxing Liu, Ping An, Zhaoyang Zhang, Qian Zhang and Tao Yan," Multi-View Video Coding Based on Vector Estimation and Weighted Disparity Interpolation " ,"Studies in Computational Intelligence, 2010, Intelligent Multimedia Communication: Techniques and Applications",2010, Volume 280, Pages 51-73

[6] Gangyi Jiang, Mei Yu, Feng shao, You Yang and Haitao Dong,"Fast Multi-biew Disparity Estimation for Multi-view Video Systems"," Advanced Concepts for Intelligent Vision Systems, Lecture Notes in Computer Science", 2006, vol. 4179/2006,pp. 493-500

[7] "What is Wireless Sensor Network", http://zone.ni.com/devzone/cda/tut/p/id/8707.

[8] Ian F. Akyildiz , Tommaso Melodia, and Kaushik R. Chowdhury," A Survey on Wireless Multimedia Sensor Networks","Computer Networks Journal",2007,vol. 51,pp.921-960.

[9] Purushottam Kulkarni, Prashant Shenoy, and Deepak Ganesan," Approximate Initialization of Camera Sensor Networks"," Proceedings of the 4th European Conference on Wireless Sensor Networks EWSN",2007,pp.67-82

[10] Vimal Mehta and Weihua Sheng," Distributed Calibration of a Camera Sensor Network" , "Proceedings of the 2008 IEEE International Conference on Robotics and Biomimetics",2009 ,pages 1974 - 1979 .

[11] Berthold K.P. Horn," Tsai's camera calibration method revisited", Copyright, Online: http://people.csail.mit.edu/bkph/articles/Tsai_Revisited.pdf, 2000.

[12] Xiaotao Liu, Purushottam Kulkarni, Prashant Shenoy and Deepak Ganesan," Snapshot: A Self-Calibration Protocol for Camera Sensor Networks","Broadband Communications, Networks and Systems", 2006, pages 1-10.

[13] D. A. Forsyth and J. Ponce, "Computer Vision: A Modern Approach.Englewood Cliffs, NJ: Prentice-Hall", 2002.

[14] Huadong Mat and Yonghe Liut," Correlation Based Video Processing in Video Sensor Networks", " International Conference on Wireless Networks, Communications and Mobile Computing ",2005, vol. 2 pages 987 – 992.

[15] Joseph C. Dagher, Michael W. Marcellin, Fellow, IEEE, and Mark A. Neifeld, Member, IEEE, "A Method for Coordinating the Distributed Transmission of Imagery", "IEEE Transactions on Image Processing ",2006, vol. 15, no. 7, pages 1705 - 1717.

[16] Rui Dai, Student Member, IEEE, and Ian F. Akyildiz, Fellow, IEEE, "A Spatial Correlation Model for Visual Information in Wireless Multimedia Sensor Networks" ," IEEE Transactions On Multimedia ", 2009, vol. 11, no. 6, pages 1148 – 1159.

[17] Zixiang Xiong, Angelos D. Liveris, and Samuel Cheng, "Distributed Source Coding for Sensor Networks", Handbook on Array Processing and Sensor Networks, S. Haykin and K. J. R. Liu (Eds.), Wiley, 2009.

[18] Grup de Tecnologies AudioVisuals (GTAV),"Distributed Video Coding", gps-tsc.upc.es/GTAV/CICYT/Distributed%20Video%20Coding.pdf

[19] G. Toffetti, M. Tagliasacchi, M. Marcon, S. Tubaro, A. Sarti and K. Ramchandran, "Image Compression in A Multi-Camera System Based On A Distributed Source Coding Approach", "EURASIP European Signal Processing Conference" ,2005, pp. 1-4

[20] Li-Wei Kang and Chun-Shien Lu, "Multi-View Distributed Video Coding With Low-Complexity Inter-Sensor Communication Over Wireless Video Sensor Networks","International Confrence on Image Processing ICIP",2007,pp. III - 13 - III - 16

[21] Chuohao Yeo, Member, IEEE, and Kannan Ramchandran, Fellow, IEEE," Robust Distributed Multiview Video Compression for Wireless Camera Networks "," IEEE Transactions On Image Processing", Vol. 19, No. 4, pp. 995-1007,2010 "

[22] "MVC", http://en.wikipedia.org/wiki/Multiview_Video_Coding

[23] Frederic Dufaux, Mourad Ouaret and Touradj Ebrahimi", "Recent Advances In Multi-View Distributed Video Coding"," SPIE Mobile Multimedia/Image Processing for Military and Security Applications", 2007,

[24] Jayanth Nayak, Bi Song, Ertem Tuncel, and Amit K. Roy-Chowdhury ,"Model-based Multi-view Video Compression Using Distributed Source Coding Principles"," http://citeseerx.ist.psu.edu/

[25] Kwanwoong Song a, Taeyoung Chung a, Yunje Ohb and Chang-Su Kim a," Error Concealment Of Multi-View Video Sequences Using Inter-View And Intra-View Correlations"," J. Visual Communication and Image Representation ",2009,pp.12

[26] Feng Shao, Gangyi Jiang and Mei Yu," Network-driven low complexity coding for wireless multi-view video system"," J Real-Time Image Processing",2010,vol. 5, pp. 33–43.

[27] Xavi Artigas, Francesc Tarrés and Luis Torres," A Comparison Of Different Side Information Generation Methods For Multiview Distributed Video Coding" Proceedings. of Internationational Conference on Signal Processing and Multimedia Applications, Barcelona, Spain, July 2007.

[28] Xavi Artigas, Egon Angeli, and Luis Torres, “Side Information Generation for Multiview Distributed Video Coding Using a Fusion Approach”, ” Proceedings of the 7th Nordic Signal Processing Symposium NORSIG 2006”, 2006.”,pp.250-253.

[29] José Diogo Areia, Catarina Brites and Fernando Pereira ,“Wyner-Ziv Stereo Video Coding using a Side Information Fusion Approach”,” IEEE 9th Workshop on Multimedia Signal Processing MMSP 2007”, 2007,pp.453-456.

[30] Nicolas Gehrig and Pier Luigi Dragotti, “Distributed Compression Of Multi-View Images Using A Geometrical Coding Approach”, ” IEEE International Conference on Image Processing, 2007. ICIP 2007” , 2007, vol. 6 , pp. VI - 421 - VI – 424

[31] “Field of View”, http://en.wikipedia.org/wiki/Field_of_view.

[32] Sklavos N.and Touliou K. “A System Level Analysis of Power Consumption and & Optimizations in 3G Mobile Devices”, 2007, pages 217-227.

[33] P. Vijayakumar1 and V. Ravichadran,” Wireless Sensor Network Issues-An Overview”, “International Journal of Wireless Networks and Communications”,2009, vol. 1, no. 1 , pages 17–28.

[34] “Peak Signal to Noise Ratio (PSNR)”, http://en.wikipedia.org/wiki/Peak_signal-to-noise_ratio

[35] Jan Flusser, Filip Sroubek, and Barbara Zitova, Image Fusion:Principles, Methods, and Applications”,” Institute of Information Theory and Automation Academy of Sciences of the Czech Republic”,

[36] Yufeng Zheng, , “Image Fusion And Its Applications”, “Janeza Trdine 9, 51000 Rijeka, Croatia”, 2011, pages 252.

[37] “Image Fusion”, http://en.wikipedia.org/wiki/Image_fusion.

[38] A. Umaamaheshvari and K. Thanushkodi,” image Fusion Techniques”,” IJRRAS 4”, 2010, vol. 1 pages 69-74.

[39] Paul Hill, Nishan Canagarajah and Dave Bull, “Image Fusion using ComplexWavelets”, “ BMVC”, 2002, pages 487-496.

[40] Firouz Abdullah Al-Wassai, and N.V. Kalyankar, "The Statistical methods of Pixel-Based Image Fusion Techniques", "International Journal of Artificial Intelligence and Knowledge Discovery", 2011,vol.1, Issue 3, pages

[41] M. E. Nasr, S. M. Elkaffas, T. A.El-Tobely, A. M. Ragheb, and F. E. Abd El-Samie," An Integrated Image Fusion Technique for Boosting the Quality of Noisy Remote sensing Images", "24th NATIONAL RADIO SCIENCE CONFERENCE (NRSC 2007)", 2007, pages.

[42] Firooz Sadjadi," Comparative Image Fusion Analysais", "IEEE Computer Society Conference on Computer Vision and Pattern Recognition CVPR05 Workshops (2005)," 2005, vol. 3, pages 8-8

[43] R. Riyahia, C. Kleinna and H. Fuchsa, "Comparison Of Different Image Fusion Techniques for Individual Tree Crown Identification Using Quickbird Images", " International Society of Photogrammetry and Remote sensing", 200,vol. XXXVIII/part1/08/08_05_Paper_189

[44] V. S. Veena Devi and H. Gangadhara Bhat, "The critical analysis of various image fusion techniques for enhanced image features interpretation in remote sensing applications"," Scholars Research Library,Archives of Applied Science Research,", 2011, vol 3.No. 4, pages 206-217.

[45] Nupoor Prasad*, Sameer Saran, S. P. S. Kushwaha and P. S. Roy," Evaluation of various image fusion techniques and imaging scales for forest features interpretation", " Current Science", 2001, vol. 81 No.9, pages 1218-1224.

[46] Manjusha Deshmukh and Udhav Bhosale," Image Fusion and Image Quality Assessment of Fused Images"," International Journal of Image Processing (IJIP)", ,vol. 4,Issue 5, pages 484-508.

[47] Jiang Dong , Dafang Zhuang, Yaohuan Huang and Jingying Fu," Advances in Multi-Sensor Data Fusion: Algorithms and Applications", "Sensors 2009", 2009, vol.9, pages 7771-7784.

[48] M. Fallah Yakhdani and A. Azizi," Quality Assessment Of Image Fusion Techniques For Multisensor High Resolution Satellite Images (Case Study: Irs-P5 And Irs-P6 Satellite Images)", "ISPRS TC VII Symposium, IAPRS", 2007, Vol. XXXVIII, Part 7B, pages 204-209.