"I / We admit that I / We have read this literature work through my/our observation which has fulfilled the scope and quality in order to be qualified for the conferment of Bachelor Degree in Electronic Engineering (Computer Engineering)."

Signature : .....
Supervisor's name: Mr. REDZUAN B ABD. MANAP
Date : .....5/5/2006.....

REDZUAN BIN ABDUL MANAP
Pensyarah
Fakulti Kejuruteraan Elektronik dan Kejuruteraan Komputer
Kolej Universiti Teknikal Kebangsaan Malaysia
Karung Berkunci 1200
Ayer Keroh, 75450 Melaka

AN INVESTIGATION OF THE PERFORMANCE OF MATCHING CRITERION PARAMETERS USED IN MOTION ESTIMATION OF DIGITAL VIDEO SEQUENCE

MOHD ISZUWAN BIN YAACOB

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Electronic Engineering (Industrial Electronic)

Fakulti Kejuruteraan Elektronik dan Kejuruteraan Komputer
Kolej Universiti Teknikal Kebangsaan Malaysia

April 2006

"I admit that this is done by my self except the discussion and extracts taken from other sources that I explained each in detail."

Signature : .....
Author's Name : MOHD ISZUWAN BIN YAACOB
Date : 05/05/2006

To my beloved parents, Yaacob Baharom and Marziah Hj Zakaria:
Thank you for your love and everything.

Special dedication to:
Muhammad Nazirul Haniff
Muhammad Nazirul Rafie
Muhammad Nazirul Imran
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ABSTRACT

In Digital Video Sequence, there is a method called Motion Estimation (ME) implemented in order to make the produced image sharp, clear and gain a good image compression.

Block Matching Algorithm (BMA) is the most common method used in ME. In BMA, an error produced between the current frame and the previous frame is represented by Motion Vector (MV). In order to obtain the best MV, there are several matching parameters available. In this project, these parameters will be tested to determine the most suitable parameter to be used in motion estimation. The performance of each parameter will be analyzed in terms of Peak Signal to Noise Ratio (PSNR) and computational complexity.

ABSTRAK

Dalam Siri Digital Video, terdapat satu kaedah yang digunakan untuk menghasilkan imej yang jelas dan tepat iaitu kaedah Penilaian Gerakan. Kaedah ini juga diguna pakai untuk mendapatkan mampatan imej yang baik. Algoritma Taraan Blok merupakan cara paling efektif dan berkesan yang terdapat dalam kaedah Penilaian Gerakan. Dalam prinsip Algoritma Taraan Blok ini, perbezaan yang wujud antara rangka/bingkai semasa dan rangka/bingkai yang sebelumnya, diwakili oleh Vektor Gerakan. Dalam usaha mendapatkan Gerakan Vektor yang terbaik, terdapat beberapa parameter taraan yang boleh digunakan. Dalam penghasilan projek ini, parameter-parameter ini akan diuji untuk menentukan parameter yang paling sesuai dan efektif dan seterusnya parameter ini akan digunakan dalam kaedah Penilaian Gerakan. Prestasi atau keupayaan setiap parameter akan dianalisis dalam bentuk Nisbah Isyarat Kemuncak ke Gangguan (PSNR) dan Taksiran Kesukaran.

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LIST OF ABBREVIATION

4SS	– Four Step search Algorithm
ASL	– Adaptive Search Length Algorithm
BMA	- Block Matching Algorithm
BS	– Binary Search Algorithm
CCF	– Cross Correlation Function
CIF	– Common Intermediate Format
CPU	– Central Unit Processor
CS	– Cross Search Algorithm
DS	– Diamond Search Algorithm
FS	– Full Search Algorithm
MAD	– Mean Absolute Difference
ME	– Motion Estimation
MSD	– Mean Squared Difference
MSE	– Mean Squared Error
MPEG	– Moving Pictures Expert Groups
MV	– Motion Vector
NTSS	– New Three Step Search
OLSA	– Orthogonal Logarithmic Search Algorithm
OSA	– Orthogonal Search Algorithm
OTS	– One at A Time Algorithm
PDC	– Pixel Difference Classification
PSNR	– Peak Signal-to Noise Ratio
QCIF	– Quarter Common Intermediate Format
SAD	– Sum of Absolute Difference
SNR	– Signal-to- Noise Ratio
SS	–Spiral Search Algorithm
TDL	– Two Dimensional Logarithmic Search Algorithm
TSS	– Three Step Search

CHAPTER 1

INTRODUCTION

1.1 Introduction of Project

Briefly, this project will be the base to improve the previous related project works that might encounter some problems and troubles. ME roughly, is the process which is employs the high correlation between neighboring frames to reduce temporal redundancy in video compression particularly in video coding systems. Some of the problems that often occurred in ME process are slow processing time, errors in terms of unclear image, sharp fewer images, and the algorithm that being used are not simple and complicated

In order to encounter all these stated problems, this project will determine and identify the best matching parameter to be used in BMA and ME methods.

1.2 Objectives of Project

Generally, this project stands for the requirement to complete this bachelor degree course. Thus, the objectives to finish this project are just to apply all the knowledge that has been gained during this course study.

As for technical objectives, all the project aims and scopes are stated below:

- To gain in-depth knowledge of current ME and BMA works.
- To investigate various matching parameters available in ME method.
- To implement and simulate these parameters using MATLAB.

- To identify the best or the most suitable matching parameter to be used in BMA and ME method.

1.3 Scope of Project

This project is basically based on the ME process and not out of the works border. All the scope of works is stated below:

- An investigation in details about ME and BMA.
- An investigation in details about all the matching parameters that are commonly used in BMA.
- Implementation and testing the performance on each parameter using MATLAB software.

1.4 Methodology of Project

Methodology is used to determine all the process used to analyze the entire possible factor in this paper and are stated here:

- Literature Review and Data Acquisition.
- Video Sequence Implementation and Extraction in MATLAB.
- Development and Implementation of BMA.
- Development of Matching Parameter.
- Analysis and Testing of the Performance.
- Thesis Writing and Seminar Presentation.

1.4.1 Procedures

- Get project topic and meeting with project supervisor for discussion and understanding the whole project.
- Research the whole requirements needed in order to understand this project in-depth.
- Prepare the project proposal and submit it to the project supervisor.
- Review in-depth the previous related work to be analyzed and reviewed as references.
- Gain knowledge in ME method, video sequence coding technique and BMA and its type
- Download the appropriate video sequences for testing purpose.
- Implement the video sequences and extract into MATLAB by using developed coding.
- Develop and implement the BMA onto the video sequences using MATLAB coding.
- Gain knowledge on the matching parameters that available in this project.
- Analyze the availability of these parameters that will be used.
- Implement the selected matching parameters in BMA using MATLAB coding.
- Gain knowledge about PSNR.
- Analyze and testing the result in terms of PSNR.
- Analyze the result in terms of computing complexity.
- Conclusion and recommendation is made and thesis is written.

1.4.2 Flow Chart

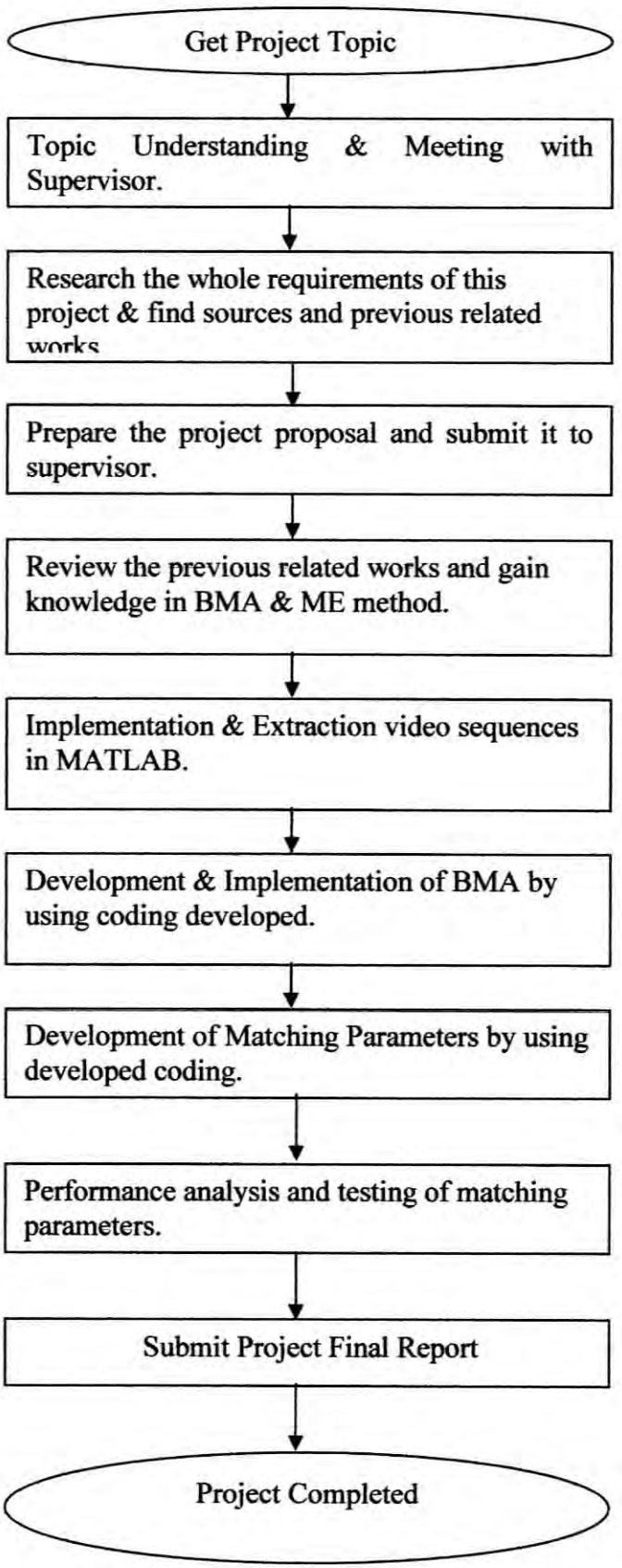

Figure 1.1: Flow Chart for the methodology process.

CHAPTER 2

LITERATURE STUDY

2.1 General Review

Generally, this project is based on an investigation on the performance of matching criterion parameters used in ME of Digital Video Sequence. As can be seen from the title, the investigation will be focused on matching criterion parameters that are often used in research on ME. The investigation will also be on comparison of the performance of each parameter chosen to be tested.

Firstly, the ME process must be studied. In order to study the ME, the terms of MV is studied in depth. This term explains the difference between the current frame and previous frame that will produce the error that exist between these two frames [1]-[11]. The en route of the project then goes into the knowledge about BMA and identifies each algorithm that being used in this type of case study.

The Three Sep Search (TSS) algorithm is chosen which is introduced in 1981 by Koga et al [1]. This algorithm becomes very popular because of its simplicity and also robust and near optimal performance. It searches for the best motion vectors in a course to fine search pattern [1].

The next phase of literature study goes to the understanding all parameters that will be used in this project. There are 3 parameters that will be used in completing this project. The explanation about these parameters will be explained later.

After all these literature studies are completed, the implementation of all these parameters in MATLAB software and the testing process will be done at the end of this project.

2.2 MOTION ESTIMATION

In video coding systems, ME employs the high correlation between neighboring frames to reduce temporal redundancy in video compression. Because of significantly improving bit rate reduction, motion estimation has been widely adopted and has become critical in video coding [1]-[11].

Inter frame predictive coding is used to eliminate the large amount of temporal and spatial redundancy that exists in video sequences and helps in compressing them [2]. In conventional predictive coding the difference between the current frame and the predicted frame (based on the previous frame) is coded and transmitted [2]. The better the prediction, the smaller the error and hence the transmission bit rate. If a scene is still, then a good prediction for a particular pixel in the current frame is the same pixel in the previous frame and the error is zero [3].

However, when there is motion in a sequence, then a pixel on the same part of the moving object is a better prediction for the current pixel. There are a large number of ME algorithms for inter frame predictive coding [4]. In this study, however, the focus only on one class of such algorithms, called the BMA.

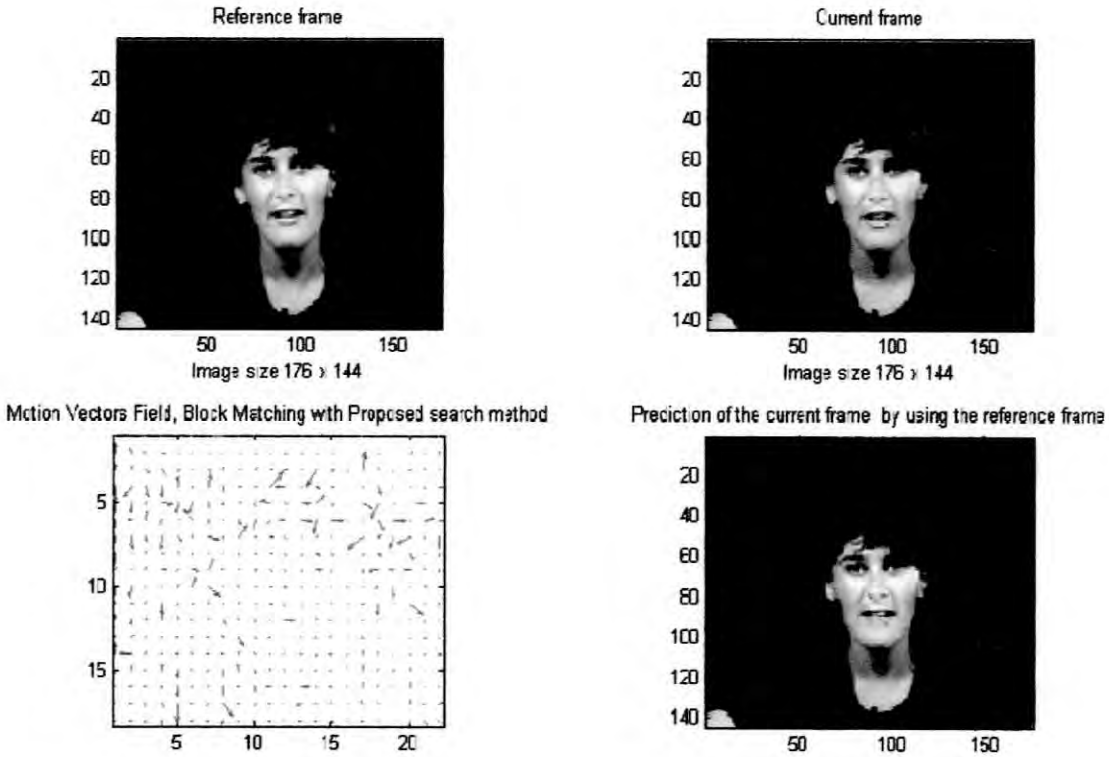

Figure 2.1: Example of ME process.

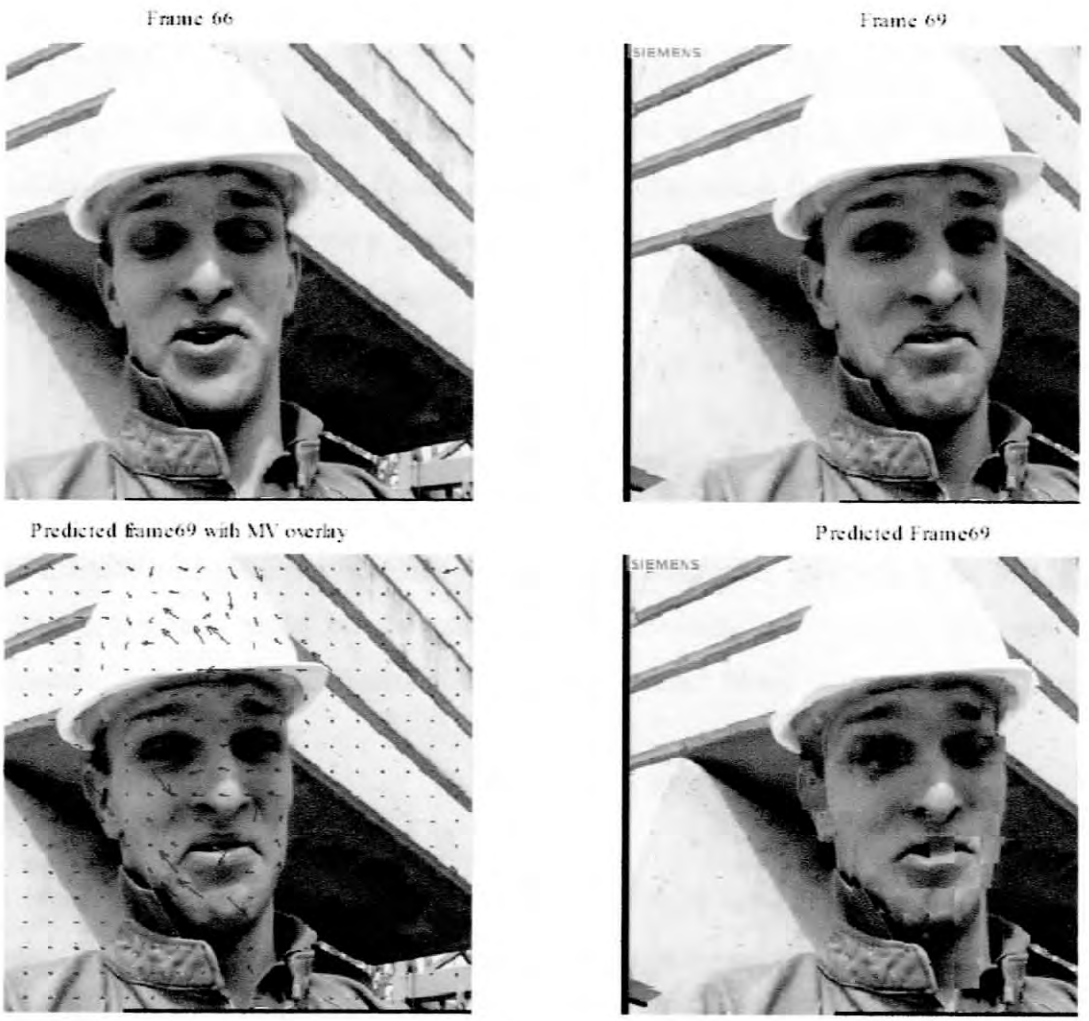

Figure 2.2: Another example of ME.

2.3 Block Matching Algorithms

BMA is the most common method that is used in analyzing ME technique in processing video sequence. There are many of algorithms that consisted in BMA Each algorithm has their own advantage and disadvantages. The differences among all algorithms can be seen in terms of time, speed and PSNR performance.

The high redundancy existing between the successive frames of a video sequence makes it possible to achieve high compression ratio in video coding [3]. To exploit the redundancy between successive frames, BMA have been used widely for ME [3]. These algorithms based on the concept of subdividing every image into square blocks and then find the displacement vector for each block within a search range that minimizes the error.

A block matching method attempts to find a block of the reference frame (past or future frame) that best matches a predefined block of the current frame [3]. Matching is performed by minimizing a matching criterion. The block in the reference frame moves inside a search region centered on the position of the block in the current frame.

The displacements of the current block with respect to the reference block in x and y directions compose the MV assigned to this block [2]-[4].
In the representation used for block matching, an image is divided into blocks of a general rectangular shape. In practical applications, these are squares of N x N dimensions. For each block in the current frame, the block of pixels in a reference frame that is the most similar—according to a particular criterion —is searched [4].

The position difference between the current block and the block that turns out to be the most similar in the reference frame represents the motion vector, given by:

$$\upsilon = \min_{\substack{|di|<\phi XMax \\ |d2|<\phi YMax}} 1/N^2 \sum_{n1=0}^{N=1} \sum_{n2=0}^{N-1} \| y(n_1,n_2,t) - y(n_1-d_1,n_2-d_2,t-\Delta\tau \|$$

Where represents the luminance component of the video signal and $\Delta\tau$ represents the time interval between the current and the reference frame. In the case of MPEG encoding, $\Delta\tau$ could also take on a negative value because of the backward prediction of the B frames (MPEG-2) or B VOP (MPEG-4) [5]. The values d_1 and d_2 in the equation above represent the horizontal and vertical displacement of the block in the reference frame and must be valid values within a certain area in which the best match is sought [5]. This area is called the *search window*. The argument of the sum in equation above is a norm.

This can be an L^2 or an L^1 norm called, respectively, the mean squared error (MSE) or mean absolute difference (MAD) – one of the listed parameter [5].
In terms of the accuracy of the estimation, they give similar results, whilst from a computational point of view; the L^1 norm is more efficient, as it does not require an extra multiplication.

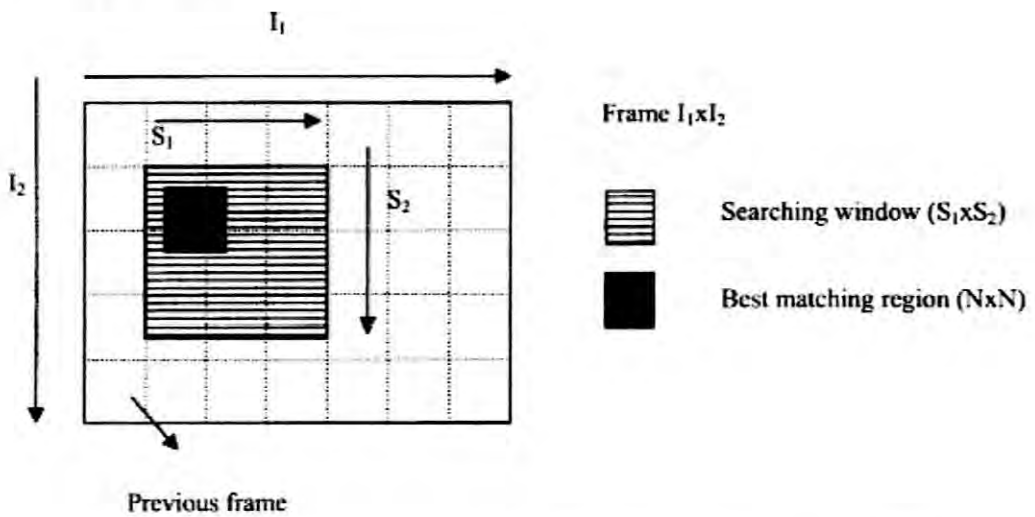

Figure 2.3: The representation of the Block matching process. [5]

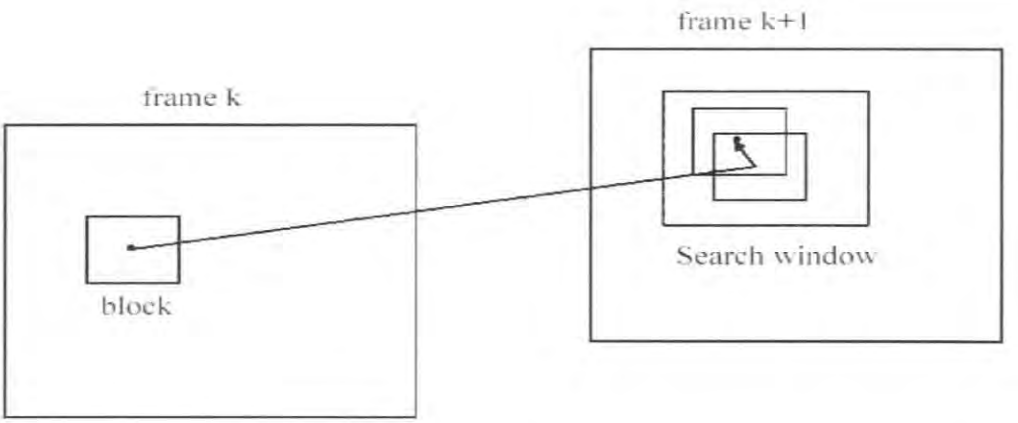

Figure 2.4: Another representation of Block matching process. [5]

In order to understand more block matching process, the next two figures illustrate the process in a better way.

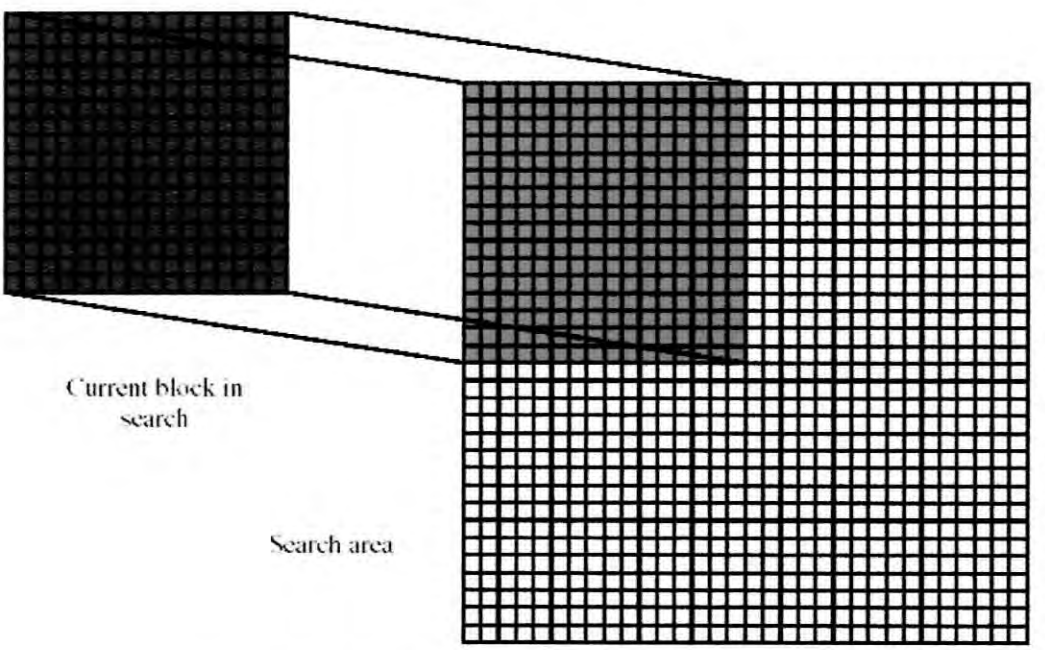

Figure 2.5: Comparing the first set of blocks. [5]

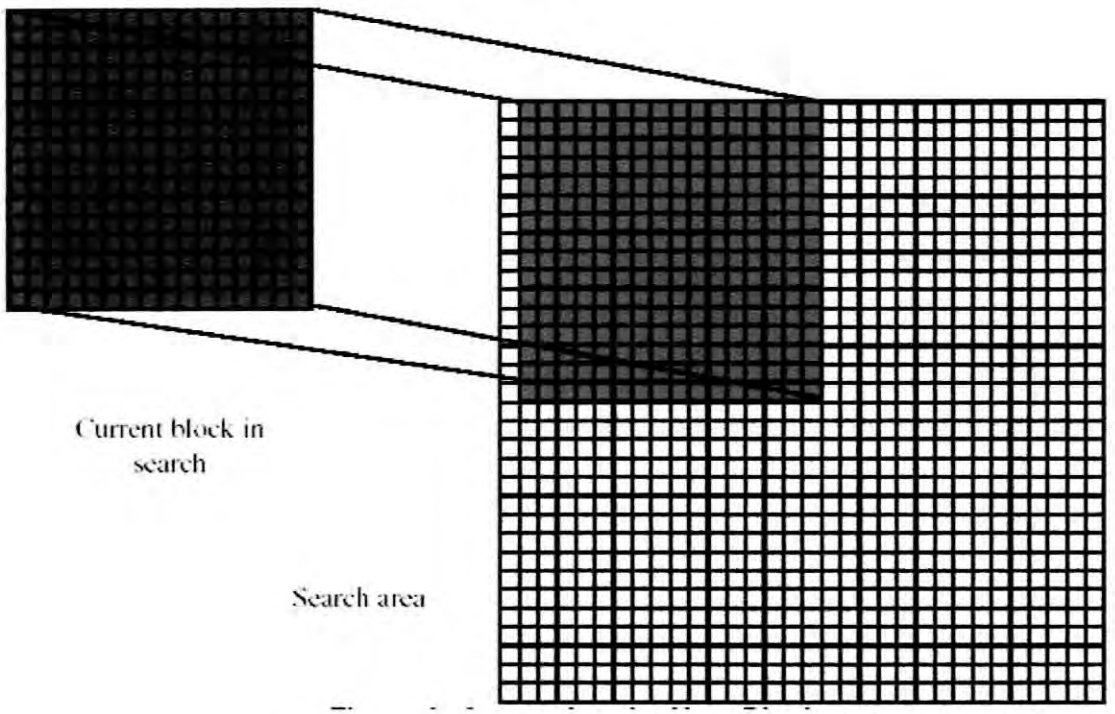

Figure 2.6: Comparing the next blocks. [6]

Figure 2.5 and Figure 2.6 show how the basic process of block matching is done in ME. Each block is compared properly to minimize the different that exists, then moving to the next step to compare the next set of blocks in order to find the minimum error.

Normally, BMA previous research works are differing in terms of:

- The Matching Criteria
- The Search Strategy (Example: Three-Step Search, Full Search, Diamond Search)
- The Determination of the block size (Example: Hierarchical, Adaptive)