IMPLEMENTATION OF HEXAGON BASED SEARCH (HEXBS) ALGORITHM FOR MOTION ESTIMATION USING MATLAB

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This work is dedicated to my family, lecturer and also to all my friends.

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ABSTRACT

A technique known as Block Matching Motion Estimation has been widely adopted in various coding standards to achieve high compression ratio in video coding. This technique is implemented conventionally by exhaustively testing all the candidate blocks within the search window .This type of implementation, called Full Search (FS) Algorithm. This type of algorithm will gives the optimum solution. However, substantial amount of computational workload is required in this algorithm. To overcome this drawback, many other fast Block Matching Algorithm (BMAs) have been proposed and developed .Different search patterns and strategies are exploited in order to find the optimum motion vector with minimal number of required search points. The objectives of this project are to develop and implement Hexagon Based Search (HEXBS) algorithm in MATLAB. Besides, the obtained result is compared to FS algorithm as well as other common fast BMAs.

ABSTRAK

Satu teknik dikanali sebagai Block Matching Motion Estimation sering digunakan dalam pelbagai piawai pengekodan bagi mendapatkan nibah pemampatan yang tinggi dalam pengekodan video. Teknik ini telah dilaksanakan dengan menguji semua blok yang terdapat dalam tingkap pencarian. Kaedah ini dikenali sebagai Algoritma Full Search. Algoritma ini memberikan kualiti video yang optimum. Namun begitu, ianya melibatkan pemprosesan komputer yang banyak. Bagi mengatasi masalah ini, banyak algoritma-algoritma lain telah dibangunkan dan dicadangkan. Pelbagai corak dan strategi pencarian digunakan bagi mencari vector pergerakan yang optimum sambil meggunakan bilangan titk pencarian yang minimum.

Objektif projek ini adalah untuk membangunkan dan melaksanakan salah satu algoritma yang sedia ada. Algoritma Hexagon Based Search menggunakan MATLAB. Hasil prestasi algoritma ini akan dibandingkan dengan algoritma Full Search serta algoritma-algoritma lain yang biasa digunakan.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATION

BMA	-	Block Matching Algorithm
BMME	-	Block Matching Motion Estimation
CIF	-	Common Intermediate Format
DCT	-	Discrete Cosine Transform
DS	-	Diamond Search
FS	-	Full Search
FSS	-	Four Step Search
HEXBS	-	Hexagon Based Search
KCDS	-	Kite Cross Diamond Search
KSP	-	Kite Search Pattern
LDSP	-	Large Diamond Search Pattern
MAD	-	Mean Absolute Difference
MATLAB	-	Matrix Laboratory
MBD	-	Minimum Block Distortion
ME	-	Motion Estimation
MPEG	-	Moving Picture Experts Group
MSE	-	Mean Squared Error
NCDS	-	New Cross Diamond Search
NTSS	-	New Three Step Search
PSNR	-	Peak Signal-To-Noise Ratio
QCIF	-	Quarter Common Intermediate Format
SDSP	-	Small Diamond Search Pattern
TSS	-	Three Step Search

CHAPTER I

INTRODUCTION

1.1 PROJECT INTRODUCTION

In the design of any video decoder, Block Matching motion estimation (BMME) is the most crucial module. It consumed more than 85% of video encoding time due to searching of a candidate block in the search window of the reference frame [1]. This BMME technique has been widely adopted in various coding standards in order to achieve high compression ratio in video coding. Full Search (FS) Algorithm is the most conventional type of algorithm; through this algorithm it will give the optimum solution. This technique is implemented conventionally by exhaustively testing all the candidate blocks within the search window. However, substantial amount of computational workload is required in this algorithm. To overcome this drawback, many fast Block Matching Algorithms (BMA‟s) have been proposed and developed. Different search patterns and strategies are exploited in these algorithms in order to find the optimum motion vector with minimal number of required search points.

One of these fast BMA‟s, which is proposed to be implemented in this project, is called Hexagon Based Search (HEXBS) Algorithm. In this project, the algorithm is required to be implemented in MATLAB and then its performance is compared to FS algorithm as well as to other fast BMA‟s in terms of the peak signal-to-noise ratio (PSNR) produced, number of search points required and computational complexity.

1.2 PROBLEM STATEMENTS

BMME is important to many motion compensated video techniques or standards, which is aimed to exploit the temporal correlation between successive image frames to enable high amount of compression. FS algorithm can gives the optimal quality of the image but the motion estimation can consume up to 80% of the computational power of the encoder and is quite computational intensive [2]. This happened because with FS algorithm, it matches the entire possible candidate block within the search window to find the most minimum distortion. Thus, FS algorithm will have much searching point and this lead to complex computational. Therefore, fast search algorithms are required to speed up the searching process for minimum distortion without immolating the quality of the video severely. Many computationally efficient variants were developed, typically among which are three-step search (TSS), new three-step search (NTSS), four-step search (4SS), diamond search (DS), New Cross Diamond search (NCDS) and Kite Cross Diamond search (KCDS) algorithms [2].

In TSS, NTSS, and 4SS algorithms, squared-shaped search patterns are used. Meanwhile, diamond-shaped search patterns are introduced in DS, NCDS and KCDS algorithms. The diamond shaped search pattern has faster processing time which mean with less searching points in comparison with NTSS and 4SS. This conduces to study on the comparison between diamond search pattern and square-shaped search pattern in term of speed improvement and with minimum PSNR. People may wonder whether there is any other pattern shape can perform better than diamond shaped search for faster block motion estimation. In the project, an algorithm based on hexagon search pattern is proposed to achieve further improvement.

1.3 OBJECTIVE

The main objective of this project is to implement one of available fast BMA, called HEXBS algorithm to overcome the problems encountered in FS algorithm. Besides, the aims of this project are also:

i) To develop, implement and analyze HEXBS algorithm using MATLAB.

ii) To compare the performance of HEXBS algorithm to FS algorithm as well as other common fast BMAs.

iii) To produce a working and functional MATLAB coding.

1.4 SCOPE OF WORK

The project has 3 distinct scopes which are:

a) **Background Study**

Further reading on video or image compression, motion estimation, BMA and HEXBS algorithm.

b) **Implementation of the HEXBS algorithm using MATLAB**

The proposed algorithm is implemented and simulated using MATLAB.

c) **Performance Analysis**

The performance of HEXBS algorithm was compared with existing fast BMME algorithms.

1.5 THESIS STRUCTURE

Chapter 1 Introduction

Description on the project, reviews of the problem statement and subsequently the objectives of the project and also clarification on the scope of the project.

Chapter 2 Literature Review

This chapter includes the study on the video compression, motion estimation and also the concept of BMA. Besides that, the projects" algorithm and other algorithms will be further discussed in this chapter. The algorithms to be discussed are TSS, DS, HEXBS, NCDS and KCDS algorithms.

Chapter 3 Methodology

The project is divided into four major steps and each step is being described in this chapter.

Chapter 4 Result and Discussion

This chapter shows the obtained result and the result is compared to the results of other algorithms. The discussion and analysis is then made based on the results.

Chapter 5 Conclusion and Recommendation

This chapter concludes the overall project with recommendation to upgrade the project in future.

CHAPTER II

LITERATURE REVIEW

2.1 VIDEO COMPRESSION

It is impossible to transmit a digital video and audio through the available networks without compressing the content because an uncompressed video require a large storage space. This technique is known as video compression. Compressing video is about the reduction of amount of data without sacrificing too much of the video quality. The reduction of amount of data will help to decrease the entire size of the finished output file. Besides, compression also cope with optimizing data output, which mean the quantity of data that will steadily transmit through the playback track (pipeline). If the video is not compressed correctly, the data will not fit the track and thus the data cannot be streamed in real time.

Video is a form of sequence of images that are play at a rate. There could be pixels which remain constant among two consequences sequences. Thus the constant pixels are redundant and can be removed for faster transmission data rate. The video can be reconstructed by just sending the differences of the pixel between two frames.

Video compression plays an important role in many fields such as mobile journalism, entertainment, advertising, video conferencing and remote medicine [3]. For mobile journalism, the capacity of the camera can be increased by video compression technique and thus the recording time available by simplifying the data before recording takes place. The online games are also been compressed to ensuring the games are small enough as the games environment become more realistic to configure it online. For video conferencing, it is only possible to deploy to a desktop or mobile phone after compressed the data transfer rate to a trickle. Video compression is an important technology that saves a lot of space for data storage and also allows multiple simultaneous camera views to be transfer over distances.

2.2 MOTION ESTIMATION

Motion estimation is the process of choosing motion vectors that describes the conversion from a two-dimensional image to another and it is usually from adjacent frames in a video sequence. By sending encoded difference images which inherently have less power and can be efficiently compressed to save on the bits as compared to sending a full frame is the main concept of ME.

As in a video contains many sequences of frame, and the first frame is often been fully sent. ME extracts motion information from the video sequence. The motion in the current frame is estimated with respect to a reference frame to identify whether is there any changes in location of the blocks. In video compression, ME technique is used to find the best matching block in reference frame to get the low energy remainder. The objective is to determine motion vector which may relate to the entire image, such as rectangular blocks or even per pixel. With this technique, the temporal redundancy due to high correlation between successive frames can be reduces or eliminates [4].

The ME module will produce a model for the current frame by amending the reference frame such that it has very small difference compared to the current frame. This estimated current frame is then motion compensated and the compensated remain image is then encoded and transferred. Motion estimation‟s application includes scan rate conversion to generate temporally interpolated frames.

Its application includes video stabilizing, motion tracking, scan rate conversion to generate temporally interpolated frames, and motion compensated de-interlacing. In the area of ME, many techniques have been applied such as block matching techniques and frequency-domain techniques. Block matching is the suitable in video compression schemes based on discrete cosine transform (DCT) such as those adopted by the standards H.261, H.263 and MPEG family [4] [5].

2.3 BLOCK MATCHING ALGORITHM (BMA)

In between a successive video sequences, there may consists of some stationary objects. ME will determines the movement of object and obtain the motion vectors that can represent the estimated motion.

The BMA is a standard technique for encoding motion in video sequences [6]. It is a standard technique to eliminate the temporal redundancy between continuous frames and has been widely adopted by video coding method such as H.261 and MPEG-1/2/4 [2]. BMA is the block based search technique used to detect the motion between two successive images. The current frame is divided into non overlapping macro blocks. The macro block is then compared between corresponding block over a predefined neighborhood frame to produce a motion vector that determine the movement of a block from original frame to destination frame. The movement which provides the smallest value of difference is considered the best matching. In the ideal case, two matching block have their corresponding pixels exactly equal.

The macro block that results in the least cost is the one that matches the closet to current block. There are various cost functions based on pixel differencing are mean absolute difference (MAD) given by equation (2.1) and mean squared error (MSE) given by equation (2.2) [1] [6].

$$MAD = \frac{1}{N^2}\sum_{i=0}^{N-1}\sum_{j=0}^{N-1}\left|C_{ij} - R_{ij}\right| \dots\dots\dots\dots\dots\dots (2.1)$$

$$MSE = \frac{1}{N^2}\sum_{i=0}^{N-1}\sum_{j=0}^{N-1}\left(C_{ij} - R_{ij}\right)^2 \dots\dots\dots\dots\dots\dots (2.2)$$

Where

N = side of the macro-block

C_{ij} *and* R_{ij} = pixels being compared in current macro-block and reference block

Block distortion form an error surface over the search window, and the minimum matching error point over the search window corresponds to the motion vector where the best matching occurs. The motion vectors and residues between the current block and reference block are computed after the best match is found. The more accurate estimation, the less distortion between best matched block and current block will be.

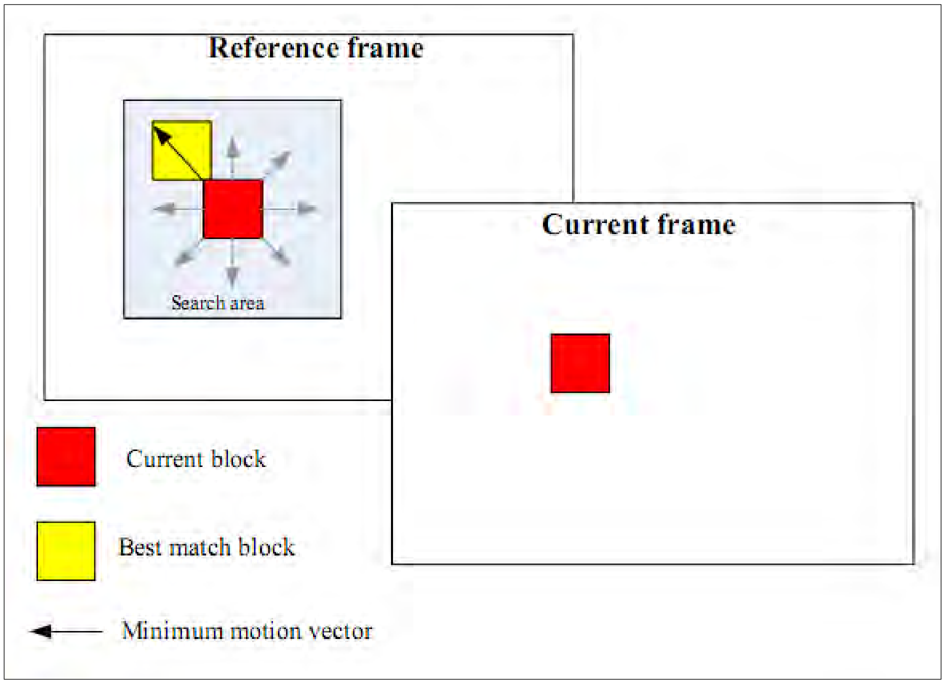

Figure 2.1 Block based motion estimation [8]

Many fast BMA have been developed, for example, TSS, NTSS, DS and etc. These fast BMAs exploit different search patterns and search strategies for finding the optimum motion vector with reduced number of search points as compared with the FS algorithm.

2.3.1 HEXAGON BASED SEARCH ALGORITHM [2]

Ideally, to achieve the fastest search speed, a circle-shaped search pattern with a uniform distribution of minimum number of search points is desirable. This is because each search point in a circle shaped can be equally utilized. As a result, a