IMPLEMENTATION OF NEW CROSS DIAMOND SEARCH (NCDS) ALGORITHM FOR MOTION ESTIMATION USING MATLAB

SAM WENG YIK

Thesis is submitted in partial fulfillment of the requirements for the award of Bachelor of Electronic Engineering (Telecommunication Electronics) With Honours

Faculty of Electronic and Computer Engineering
Universiti Teknikal Malaysia Melaka

May 2011

UNIVERSTI TEKNIKAL MALAYSIA MELAKA
FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

Tajuk Projek : IMPLEMENTATION OF NEW CROSS DIAMOND SEARCH (NCDS) ALGORITHM FOR MOTION ESTIMATION USING MATLAB

Sesi Pengajian : 1 0 / 1 1

Saya SAM WENG YIK mengaku membenarkan Laporan Projek Sarjana Muda ini disimpan di Perpustakaan dengan syarat-syarat kegunaan seperti berikut:

1. Laporan adalah hakmilik Universiti Teknikal Malaysia Melaka.
2. Perpustakaan dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan laporan ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. Sila tandakan (√) :

☐	**SULIT***	*(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972)
☐	**TERHAD****	**(Mengandungi maklumat terhad yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)
☑	**TIDAK TERHAD**	

Disahkan oleh:

(TANDATANGAN PENULIS)

(COP DAN TANDATANGAN PENYELIA)

Alamat Tetap: 6E-02-06, Kenanga Apartment,
Jalan Wawasan 2/3, Pusat Bdr
Puchong, 47100, Puchong ,
Selangor, Darul Ehsan.

Redzuan Bin Abdul Manap
Pensyarah Kanan
Fakulti Kejuruteraan Elektronik Dan Kejuruteraan Komputer
Universiti Teknikal Malaysia Melaka (UTeM)
Karung Berkunci No 1752
Pejabat Pos Durian Tunggal
76109 Durian Tunggal, Melaka.

Tarikh: 29/4/2011

Tarikh: 29/4/2011

"I hereby, declare that this report is the results of my own work except for quotes as citied in the references."

Signature : ....

Author's Name : SAM WENG YIK

Date : 29/4/2011

"I hereby declare that I have read this report and in my opinion this report is sufficient in terms of the scope and quality for the award of Bachelor of Electronic Engineering (Telecommunication Electronics) With Honours."

Signature : ....

Supervisor's Name : ....REDZUAN BIN ABDUL MANAP..........

Date : ....29/4/2011..............................

ACKNOWLEDGEMENTS

I would like to send my appreciation to Mr. Redzuan Bin Abdul Manap who guided me throughout this final year project and for his advices that improves my knowledge in MATLAB software and in completing this final year project.

ABSTRACT

The purpose of this project is to implement New Cross Diamond Search (NCDS) Algorithm, which uses small cross and diamond search patterns to achieve the fast searching process. Full Search (FS) algorithm is the initial method to search the block with minimum distortion but it requires substantial amount of computational workload. To overcome this problem, may fast Block Matching Algorithm (BMA's) have been designed and developed, where NCDS algorithm is the one of these fast BMA. The NCDS algorithm was tested using several video sequences and have a better performance in search points and elapsed time compared to other algorithms. The simulation results indicate that NCDS algorithm is suitable for all fast and slow motion video sequences.

ABSTRAK

Projek ini bertujuan untuk melaksanakan algoritma 'New Cross Diamond Search' (NCDS) yang menggunakan corak pencarian 'small cross' dan 'diamond' untuk mencapai proses pencarian yang cepat. Algoritma 'Full Search' (FS) adalah kaedah awal untuk mencari blok dengan gangguan minimal tetapi ianya memerlukan beban kerja perkomputeran yang tinggi. Untuk mengatasi masalah ini, banyak 'Block Matching Algorithm' (BMA) yang cepat telah direka dan dibangunkan di mana algoritma NCDS adalah salah satu BMA yang cepat. Algoritma NCDS diuji dengan beberapa video and mempunyai prestasi yang lebih baik dari aspek titik pencarian dan masa simulasi berbanding dengan algoritma-algoritma yang lain. Keputusan simulasi menunjukkan bahawa algoritma NCDS sesuai untuk video yang mempunyai gerakan cepat mahupun gerakan lambat.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

BDM	-	Block Distortion Measure
BMA	-	Block Matching Algorithms
BMME	-	Block Matching Motion Estimation
DS	-	Diamond Search
FS	-	Full Search
HEXBS	-	Hexagon Based Search
KCDS	-	Kite Cross Diamond Search
KSP	-	Kite-Shaped Pattern
LCSP	-	Large Cross-Shaped Pattern
LDSP	-	Large Diamond-Shapes Pattern
MAD	-	Mean Absolute Difference
MB	-	Macroblocks
MBD	-	Minimum Block Distortion
ME	-	Motion Estimation
MSE	-	Mean Squared Error
NCDS	-	New Cross Diamond Search

PSNR	-	Peak Signal-to-Noise Ratio
SAE	-	Sum of Absolute Error
SCSP	-	Small Cross-Shaped Pattern
SDSP	-	Small Diamond-Shaped Pattern
TSS	-	Three Search Steps

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

To achieve high compression ratio in video coding, a technique known as Block Matching Motion Estimation (BMME) has been widely adopted in various coding standards. 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, gives the optimum solution. 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.

1.2 PROBLEM STATEMENT

Motion Estimation (ME) is a key problem in image and video processing. Optical flow ME can achieve high estimation accuracy when motion vector is small while FS algorithm can handle large motion vector but not very accurate. It is the simplest BMA technique that can be implemented into compression. However, it has a disadvantage in which a high amount of computational work is required. Therefore, to overcome this disadvantage, a new algorithm called New Cross Diamond Search (NCDS) is proposed to maintain the accuracy and precision of the compression video coding technique.

1.3 OBJECTIVE

The main objective of this project is to implement NCDS algorithm to solve FS algorithms' problem. This implement will be done using MATLAB software.

Other objectives of this project are:

a) To make comparison of NCDS algorithm performance to other common BMAs.
b) To produce a working program code for the algorithm.

1.4 WORK SCOPE

The project has 3 distinct scopes which are:

a) **Background Study:**

Further readings and studies on video or image compression, ME, BMA and NCDS Algorithm are required to ensure sound understanding and knowledge is gained for implementation of the project.

b) **Implementation of the NCDS algorithm using MATLAB.**

The proposed algorithm is implemented and simulated using MATLAB.

c) **Performance Analysis**

The performance of NCDS algorithm is compared with existing fast BMME algorithms in terms of peak signal-to-noise ratio (PSNR), number of search point required and computational complexity.

CHAPTER 2

LITERATURE REVIEW

2.1 MOTION ESTIMATION [1][2][3]

ME is a process to estimate the current frame from reference frame(s). The basic premise of ME is that in most cases, consecutive video frames will be similar except for changes induced by objects moving within the frames. ME can be done using the block matching technique which exploit different search patterns and search strategies for finding the optimum motion vector for particular ME which reduced the number of search points. It efficiently removes the temporal redundancy between successive frames. Block-based ME is the most practical approach to obtain motion compensated prediction frames. It divides frames into equally sized rectangular blocks and finds out the displacement of the best-matched block from previous frame as the motion vector to the block in the current frame within a search window.

2.2 BLOCK MATCHING ALGORITHM [4]

In the fast BMAs, a search pattern with different shape and size has significant impact on the efficiency and effectiveness of the search results. BMA are based on the matching of macroblocks (MB) between two ME subnetwork images. Block distortions (or block-matching errors) form an error surface over the search window, and the global minimum point corresponds to the motion vector where the best matching (or the least error) incurs. There are various cost functions, of which the most popular and less computationally expensive is Mean Absolute Difference (MAD) given by (2.1). Another cost function is Mean Squared Error (MSE) given by (2.2).

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

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

The block-matching algorithm compares two l6 x 16 blocks of memory by accumulating either a Sum of Absolute Error (SAE), which gives similar performance of using MSE, but with much lesser computations. Suppose the block size is N x N. The SAE or distortion, D of a block located at (x, y) in current frame, F_t matched against the block with a displacement (u, v) from (x, y) in previous frame F_{t-1} is defined as

$$D = SAE_{(x,y)}(u, v)$$

$$= \sum_{i=0}^{N-1} \sum_{j=0}^{N-1} \left| F_t(x+i, y+j) - F_{t-1}(x+i+u, y+j+v) \right|$$

Where $F_t(. , .)$ and $F_{t-1} (. , .)$ denote the pixel value in current and previous frame , respectively, while (x , y) represents the coordinates of the upper left comer pixel of the current block, and (u , v) is the displacement relative to current block located at (x, y). The basic operations of computing SAE are absolute (|.|) and addition (±) operations, and require about (3N2 - 1) operations per Block Distortion Measure (BDM)

2.3 THREE STEP SEARCH ALGORITHM [5]

TSS algorithm is one of the first non full search algorithm which use three steps. It is mainly used for real time video compression with low bit rate video application such as video conferencing and videophone. Figure 2.1 illustrates an example of TSS algorithm. The search starts with a step size equal to or slightly larger than half of the maximum search range. In each step, nine search points are compared. They consist of the central point of the square search and eight search points located on the search area boundaries as shown in Figure 2.1. The step size is reduced by half after each step, and the search ends with the step size of one pixel. This search proceeds by moving the search area center to the best matching point in the previous step. We need three search steps for a maximum search range between 8 and 15 pixels.

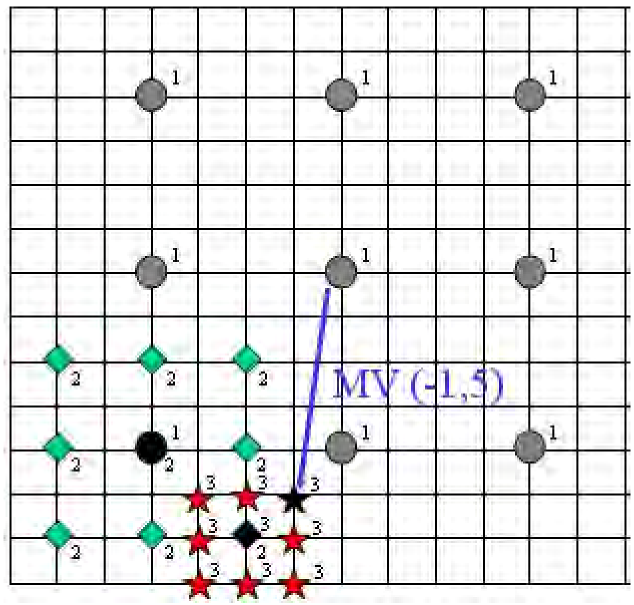

Figure 2.1: TSS Algorithm [4]

2.4 HEXAGON BASED SEARCH ALGORITHM [6]

HEXBS algorithm uses the hexagonal pattern; with the designed hexagonal pattern, we develop the search procedure is developed as follows. In the first step, the large hexagonal pattern with 7 check points is used for search. If the optimum is found at the center, the search switches to the shrunk hexagonal pattern including 4 check points for the focused inner search. Otherwise, the search continues around the point with Minimum Block Distortion (MBD) using the same large hexagonal pattern. Note that while the large hexagonal pattern moves along the direction of decreasing distortion, only 3 new non-overlapped check points will be evaluated as candidates each time.

Step 1: The large hexagon with 7 search points is centered at (0,0), the center of a predefined search window in the motion field. If the minimum MBD point is found at the center of the hexagon, proceed to Step 3; otherwise, proceed to Step 2.