Faculty of Electronics and Computer Engineering

VARIABLE BLOCK BASED MOTION ESTIMATION USING HEXAGON DIAMOND FULL SEARCH ALGORITHM (HDFSA) VIA BLOCK SUBTRACTION TECHNIQUE

Jitvinder Dev Singh a/l Hardev Singh

Master of Science in Electronic Engineering

2015

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JITVINDER DEV SINGH A/L HARDEV SINGH

A thesis submitted
in fulfilment of the requirements for the degree of Master of Science
in Electronic Engineering

Faculty of Electronics and Computer Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2015

DECLARATION

I declare that this thesis entitle "Variable Block Based Motion Estimation Using Hexagon Diamond Full Search Algorithm (HDFSA) Via Block Subtraction Technique" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ....

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APPROVAL

I hereby declare that I have read this report and in my opinion this report is sufficient in terms of scope and quality for the award of Master of Science in Electronic Engineering.

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Date	:	....

ABSTRACT

Motion estimation is a technique to reduce high information redundancy which exists between successive frames in a video sequences. There are many types of motion estimation method but the most used method is the block matching method which is the fixed block matching and the variable block matching. The fixed block matching uses the same block size throughout the motion estimation process while the variable block matching uses different block size. The variable block matching developed based on four stages which is the video and frame selection, threshold calculation, block size selection and search pattern. In the video and frame selection, pre-defined video which have different type of motion and size is used for the algorithm evaluation purpose. The threshold calculation is based on the video selected. Each video selected will have its own threshold which is used for the block size selection. There is three block size selection which is 16×16 pixels block size (uniform motion), 8×8 pixels block size (moderate motion) and 4×4 pixels block size (complex motion). In order to calculate the threshold and block size selection, the block subtraction technique is implemented. The concept of the block subtraction technique is based on the changes of pixels value between successive frames which represent the existence of motion. The next stage of algorithm development is the search pattern which is the hexagon diamond (16×16 and 8×8 pixels block size) and full search pattern (4×4 pixels block size). To evaluate the performance of the developed algorithm, the average PSNR value, average search point and average elapsed processing time is calculated. Overall, the developed algorithms have similar PSNR value and lower average search point compared to superior algorithms. The average elapsed processing time have increased due to the implementation of the block subtraction technique and the variable block matching. .

ABSTRAK

Anggaran pergerakan adalah satu teknik yang digunakan untuk mengurangkan pertindihan maklumat yang tinggi wujud di antara bingkai berturut-turut dalam urutan video. Terdapat pelbagai teknik anggaran pergerakan yang digunakan tetapi kaedah yang paling banyak digunakan ialah kaedah blok sepadan iaitu padanan blok tetap dan padanan blok berubah-ubah. Padanan blok tetap menggunakan saiz blok yang sama sepanjang proses anggaran gerakan manakala padanan blok berubah-ubah menggunakan saiz blok yang berbeza. Padanan blok berubah-ubah dibangunkan berdasarkan kepada empat peringkat iaitu pemilihan video dan bingkai, pengiraan ambang, pemilihan saiz blok dan corak carian. Dalam peringkat pemilihan video dan bingkai, video yang digunakan mempunyai berlainan jenis gerakan dan saiz untuk tujuan penilaian algoritma yang dibangunkan. Peringkat pengiraan ambang pula adalah berdasarkan kepada video yang dipilih. Setiap video yang dipilih akan mempunyai ambang sendiri yang digunakan untuk pemilihan saiz blok. Terdapat tiga saiz blok pemilihan iaitu 16 × 16 piksel saiz blok (gerakan seragam), 8 × 8 piksel saiz blok (pergerakan sederhana) dan 4 × 4 piksel saiz blok (pergerakan kompleks). Dalam usaha untuk mengira ambang dan pemilihan saiz blok, teknik blok penolakan dilaksanakan. Konsep teknik blok penolakan adalah berdasarkan perubahan nilai piksel antara bingkai berturut-turut yang mewakili kewujudan gerakan. Peringkat seterusnya pembangunan algoritma adalah corak carian yang mempunyai dua jenis corak carian yang digunakan iaitu "Hexagon Diamond Search" (16 × 16 piksel saiz blok dan 8 × 8 piksel saiz besar) dan "Full Search" (4 × 4 piksel saiz besar). Untuk menilai prestasi algoritma yang dibangunkan, nilai purata PSNR, purata titik carian dan purata masa pemprosesan berlalu dikira. Secara keseluruhan, ia menunjukkan bahawa algoritma yang dibangunkan mempunyai nilai PSNR yang sama dan purata titik carian yang lebih rendah berbanding dengan algoritma yang telah dibangunkan. Purata masa pemprosesan berlalu meningkat kerana pelaksanaan teknik penolakan blok dan padanan blok berubah-ubah.

ACKNOWLEDGEMENT

First of all I would like to thank the Almighty God for being always being there guiding me and blessing me towards the completion of thesis.

My sincere appreciation and gratitude are dedicated to my honorable supervisor and co-supervisor, **Dr. Lim Kim Chuan** and **Engr. Ranjit Singh Sarban Singh** for guiding me through the whole process in completing this project. My gratitude also goes to my friends which gave a lot of ideas which enable me to complete this project.

I also would like to give my special thanks to my parents who gave me support in financial and also moral support. They have helped me a lot and I would not achieve a great success without them

Once again, I would like to give a million thanks to all.

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LIST OF SYMBOLS

log	-	Logarithm
dB	-	Decibel
λ	-	Lambda
$\sum$	-	Summation

LIST OF ABBREVIATIONS

AVC	-	Advance Video Coding
BMA	-	Block Matching Algorithm
BMP	-	Bitmap Image File
BMME	-	Block Based Motion Estimation
BDM	-	Block Distortion Measure
DS	-	Diamond Search
DFT	-	Discrete Fourier Transform
FS	-	Full Search
FSS	-	Four Step Search
FSBM	-	Fixed Size Block Matching
FFBMA	-	Fast Fixed Block Matching Algorithms
FME	-	Fractional Motion Estimation
FMV	-	Fractional Motion Vector
GIF	-	Graphics Interchange Format
HEXBS	-	Hexagon Based Search
HEXDS	-	Hexagon Diamond Search
ITU-T	-	International Telecommunication Union – Telecommunication Standardization Sector
ISO	-	International Organization for Standardization

IEC	-	International Electrotechnical Commission
IME	-	Integer Motion Estimation
IMV	-	Integer Motion Vector
JPEG	-	Joint Photographic Expert Group
JVT		Joint Video Team
LDSP	-	Large Diamond Search Pattern
LHBSP	-	Large Hexagon Based Search Pattern
MV	-	Motion Vector
MSE	-	Mean Squared Error
MAD	-	Mean Absolute Difference
MAE	-	Mean Absolute Error
MPEG	-	Moving Picture Experts Group
MVP	-	Motion Vector Predictor
NTSS	-	New Three Step Search
PSNR	-	Peak Signal to Noise Ratio
PNG	-	Portable Network Graphics
RDO	-	Rate-Distortion Optimization
SAD	-	Sum of Absolute Differences
SDSP	-	Small Diamond Search Pattern
SHBSP	-	Small Hexagon Diamond Search Pattern
SATD	-	Sum of Absolute Transformed Difference
TSS	-	Three Step Search
TIFF	-	Tagged Image File Format
VBMA	-	Variable Block Matching Algorithm
VCEG	-	Video Coding Expert Group

3DRS - 3D Recursive Search

LIST OF PUBLICATIONS

Journals:

[1] Jitvinder, S.H.D.S., Ranjit, S.S.S., Lim, K.C., Salim, M.D., and Salim, A.J., 2011. A Theoretical Study of Fast Motion Estimation Search Algorithms. *International Journal of Latest Trends in Computing,* 2(1), E-ISSN:2045-5364, pp. 207-211.

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[1] Jitvinder, S.H.D.S., Ranjit, S.S.S., Lim, K.C., and Salim, A.J. Image Pixel Comparison Using Block Based Positioning Subtraction Technique for Motion Estimation, *Proceeding of the 2011 5th Asia Modelling Symposium*, Kuala Lumpur, Malaysia, 26 - 27 May 2011, IEEE Computer Society Publisher.

[2] Ranjit, S.S.S., Jitvinder, H.S.D.S, Lim, K.C., and Salim, A.J. Motion Analysis for Real-Time Surveillance Video via Block Pixel Analysis Technique, *Proceeding of the 2011 International Conference on Signal, Image Processing and Applications,* IPCSIT vol. 2.

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CHAPTER 1

INTRODUCTION

This chapter briefly explain about the motion estimation using the block-matching technique. The problem statement, objectives, scope of work, methodology and contribution of this research are presented subsequently. The outline of this thesis is presented at the end of this chapter.

1.1 Introduction

In a video series, high intensity of temporal redundancy is exist in between successive frames. Due to these circumstances, video compression is achieved by reducing the temporal redundancy for data storage and transfer of the video series (Shenolikar and Narote, 2009b). In order to achieve it, motion estimation plays an important role in video compression due to the ability to exploit and reduce the temporal redundancy that is exists between the video frames (Jing and Chau, 2004). Motion estimation extracts information from the video series in order to find the motion vector coordinate which is the new coordinate of the similar pixels of the previous frame in the current frame (Phadtare, 2007).

There are two foremost techniques used for motion estimation which is the pixel recursive algorithms and the Block Matching Algorithm (BMA) (Dhahri *et. al.*, 2009). The pixel recursive algorithm technique estimates motion based on pixel to pixel basis while the BMA perform on block by block basis (Dhahri *et. al.*, 2009). The motion estimation technique use the widely adopted block matching technique due to its simplicity; less computational complexity and practical approach in determining the motion vector coordinate (Tao *et. al.*, 2008). The block matching technique has been adopted and implemented into the international video coding standard, such as MPEG-1, MPEG-2, H.261, H.263 and H.264 (Tu *et. al.*, 2005). The block matching technique employs different types of superior search pattern which have been developed to determine the best matched blocks. The superior search patterns which have been developed are the Full Search (FS) (Paramkusam and Reddy, 2011), Three Step Search (TSS) (Koga *et. al.*, 1981), New Three Step Search (NTSS) (Li *et. al.*, 1994), Four Step Search (FSS) (Po and Ma, 1996), Diamond Search (DS) (Zhu and Ma, 2000), Hexagon Based Search (HEXBS) (Zhu *et. al.*, 2002) and Hexagon Diamond Search (HEXDS) (Ranjit *et. al.*, 2009). Each of the superior search patterns employs different type of search strategies to determine and capture motion vector coordinate.

The idea of block matching technique is, each frame is divided into non-overlapping small square shape blocks size 16 × 16 pixels (Ahmad *et. al.*, 2006).The small square shape blocks of 16 × 16 pixels in the current frame is then compared with the small square shape blocks of 16 × 16 pixels in the previous frame to search for the matching motion vector coordinate (Ezhilarasan and Thambidurai, 2008).

In this thesis, a new variable block size motion vector estimation technique algorithm is presented. The aim of this algorithm is to find the optimum motion vector with minimal number of search points along the algorithm search process. The performance of this algorithm is compared to other superior algorithms in terms of average Peak Signal to Noise Ratio (PSNR), average search point and average elapsed processing time.

1.2 Problem Statement

In video transmission especially for low bit rate video, predictive coding is used to predict the content of frames in the next sequences. Generally, the changes of objects from one frame to another frame are minimal which allows prediction of next frame from previous frames. In order to get the predicted frames, motion estimation plays an important role in measuring and producing that frames.

Conventional motion estimation algorithms use Fixed Sized Block Matching (FSBM) which is employed by international standards such as the MPEG-1, MPEG-2, H.261 and H.263 (Tu *et. al.*, 2003). FSBM divides frames of video into non-intersection fixed square blocks of equal size 16 × 16 pixels, 8 × 8 pixels or 4 × 4 pixels. Each of the blocks in the frame undergoes a search to find the best matching block in the reference frame. The displacement of the block is denoted with a vector known as motion vector (MV) (Gohokar and Gohokar, 2011).

In FSBM, flexibility is a setback whereby the block size being used is constant which does not take account the size characteristic of the object (Chang *et. al.*, 1998). Each of the objects in a frame is processed in the equal block size. FSBM also have a disadvantage in selection of the block size. Small block size selection also introduces noise interference (Gohokar and Gohokar, 2011) and increases the transmission rate due to the increase of the

MV which need to be encoded (Verma and Pandit, 2008). Increasing the block size leads to inaccuracy of obtaining the best match block for the prediction frame which leads to poor video compression (Gohokar and Gohokar, 2011).

In the year 2010, Ranjit Singh Sarban Singh completed master research entitled Hexagon Diamond Search for Motion Estimation: Implementation and Performance (Ranjit, 2010). The master research used FSBM for the Hexagon-Diamond search pattern. In order to expand the research done by Ranjit Singh Sarban Singh, variable block based motion estimation is proposed to detect motion according to the size and complexity using the Hexagon-Diamond search pattern to overcome setback from the FSBM.

1.3 Objective

Motion estimation has become an important tool for video compression. Although many algorithms have been proposed and developed to reduce the search points, computational complexity and increase the compression quality, though it still do not achieve the optimal results.

Thus, the objective of the research is to develop a new variable block-based motion estimation technique.

1.4 Contribution

In this research, a variable block based Hexagon-Diamond search pattern is developed based on previous master research done by Ranjit Singh Sarban Singh in the year 2010(Ranjit,