MODIFIED INTER PREDICTION H.264 VIDEO ENCODING FOR MARITIME SURVEILLANCE

MOHD AZRAF BIN MOHD RAZIF

A thesis submitted in fulfilment of the
requirements for the award of the degree of
Master of Engineering (Electrical)

Faculty of Electrical Engineering
Universiti Teknologi Malaysia

NOVEMBER 2016

Specially dedicated to my lovely mom, Zainab bt Ismail, my family and friends.

ACKNOWLEDGEMENT

In the name of Allah, The Most Gracious and The Most Merciful. I am grateful that I have finally finished writing the thesis for my master in Electrical Electronic. The thesis is finished thanks to Almighty Allah and every single person that I have met while I was studying at UTM and for that I am forever grateful. Firstly I want to say thanks to my family, who are supporting me with every decision that I did while I was studying Especially my mother. She has been working hard to raised me. There are times where I doubt myself, but she always reminded me of what I can achieve and always pray for my sake. I believe, without her prayers, I will not be able to be where I am right now. Two brilliant persons who always inspire me are my supervisors. I am always going to be grateful to Assoc. Prof Mun'im, the person who chooses me as his student and shows me the true nature of researchers' work. Dr. Musa accepted to become my supervisor halfway through my second semester and guided me until the end of my study. He provided calm views on the problem that surfaces and give his advice on which direction the research is supposed to take. Not to forget all of my friends and personnel in Embedded System laboratory. May all of us graduate and achieves happiness in our lives.

ABSTRACT

Video compression has evolved since it is first being standardized. The most popular CODEC, H.264 can compress video effectively according to the quality that is required. This is due to the motion estimation (ME) process that has impressive features like variable block sizes varying from 4×4 to 16×16 and quarter pixel motion compensation. However, the disadvantage of H.264 is that, it is very complex and impractical for hardware implementation. Many efforts have been made to produce low complexity encoding by compromising on the bitrate and decoded quality. Two notable methods are Fast Search Mode and Early Termination. In Early Termination concept, the encoder does not have to perform ME on every macroblock for every block size. If certain criteria are reached, the process could be terminated and the Mode Decision could select the best block size much faster. This project proposes on using background subtraction to maximize the Early Termination process. When recording using static camera, the background remains the same for a long period of time where most macroblocks will produce minimum residual. Thus in this thesis, the ME process for the background macroblock is terminated much earlier using the maximum 16×16 macroblock size. The accuracy of the background segmentation for maritime surveillance video case study is 88.43% and the true foreground rate is at 41.74%. The proposed encoder manages to reduce 73.5% of the encoding time and 80.5% of the encoder complexity. The bitrate of the output is also reduced, in the range of 20%, compared to the H.264 baseline encoder. The results show that the proposed method achieves the objectives of improving the compression rate and the encoding time.

ABSTRAK

Teknologi pemampatan video telah berkembang sejak pertama kali ia dipiawaikan. CODEC yang paling popular, H.264 boleh mengurangkan saiz video dengan baik mengikut kualiti yang diperlukan. Ini adalah kerana proses Penganggaran Gerakan (ME) yang mempunyai ciri-ciri yang mengagumkan seperti saiz blok yang berbeza-beza dari 4×4 hingga 16×16 dan pemampasan gerakan sukuan piksel. Walau bagaimanapun, kelemahan H.264 adalah ianya sangat kompleks dan tidak praktikal untuk pelaksanaan perkakasan. Pelbagai usaha telah dibuat untuk menghasilkan pengekodan berkerumitan rendah dengan berkompromi pada kadar bit dan kualiti video yang dinyahkod. Dua kaedah yang terkenal adalah Mod Carian Pantas dan Penamatan Awal. Dalam konsep Penamatan Awal, pengekod tidak perlu mengira ME untuk setiap blok-makro untuk setiap saiz blok. Jika kriteria tertentu sudah tercapai, proses itu boleh ditamatkan dengan lebih awal dan Keputusan Mod boleh memilih saiz blok yang terbaik dengan lebih cepat. Projek ini mencadangkan penggunaan pengasingan latar belakang untuk memaksimumkan proses Penamatan Awal. Apabila merakam menggunakan kamera statik, latar belakang tidak berubah untuk tempoh masa yang panjang di mana kebanyakan blok-makro akan menghasilkan sisa minimum. Oleh itu dalam tesis ini, proses ME untuk blok-makro latar belakang ditamatkan lebih awal dengan menggunakan saiz maksimum iaitu blok-makro 16×16. Ketepatan segmentasi latar belakang untuk kajian kes video pengawasan maritim ialah 91% dan kadar latar depan yang sebenar ialah pada 79.33%. Pengekod yang dicadangkan berjaya mengurangkan 56% daripada masa pengekodan dan mengurangkan 68% daripada kekompleksan pengekod. Kadar bit keluaran juga dikurangkan dalam lingkungan 20%, berbanding dengan pengekod garis dasar H.264. Hasil kajian menunjukkan bahawa kaedah yang dicadangkan mencapai objektif untuk meningkatkan kadar mampatan dan masa pengekodan.

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LIST OF ABBREVIATIONS

3SS	-	Three step search
4SS	-	Four Step Search
AIS	-	Automatic Identification System
ASO	-	Arbitrary Slice Ordering
B-MB	-	Bi-directional prediction macroblock
CAVLC	-	Context Adaptive for Variable Length Coding
CABAC	-	Context Adaptive Binary Arithmetic Coding
CCTV	-	Closed circuit television
CODEC	-	Encoder Decoder
CB	-	Chrominance Blue
Cr	-	Chrominance Red
DCT	-	Discrete Cosine Transform
DS	-	Diamond Search
EEZ	-	Exclusive Economic Zone
E3SS	-	Efficient Three Step Search
FMO	-	Flexible Macroblock Order
GOP	-	Group of Picture
HEVC	-	High Efficiency Video Coding
HD	-	High definition video
IP	-	Internet protocol
I	-	Intra
ISO/IEC	-	International Organization for Standardization/International Electrotechnical Commission
ITU-T	-	ITU Telecommunication Standardization Sector
I MB	-	Intra macroblock
IDR	-	Instantaneous Decoding Refresh

JVT	-	Joint Video Team
JPEG	-	Joint Photographic Experts Group
MB	-	Macroblock
MoG	-	Mixture of Gaussian
MJPEG	-	Motion Joint Photographic Experts Group
MPEG	-	Motion Picture Expert Group
MPEG1	-	Motion Picture Expert Group Phase 1
MPEG2	-	Motion Picture Expert Group Phase 2
MxPEG	-	Mobotix video compression
MV	-	Motion vector
ME	-	Motion Estimation
MVFAST	-	Motion Vector Field Adaptive Search Technique
MVC	-	Multiview Video Coding
MSE	-	Mean Square Error
NAL	-	Network Abstraction layer
N3SS	-	New Three Step Search
PTZ	-	Pan/tilt /zoom
PMB	-	Prediction macroblock
P	-	Predictive
PPS	-	Picture Parameter Set
QCIF	-	Quarter Common Intermediate Format video
QP	-	Quantization Parameter
ROI	-	Region of interest
SI	-	Switching I
SP	-	Switching P
SPS	-	Sequence Parameter Set
SAD	-	Sum of absolute differences
SSD	-	Sum of Squared differences
SVC	-	Scalable Video Coding
VGA	-	Video graphic array video
VCL	-	Variable Length Coding

LIST OF SYMBOLS

λ	-	Lagrangian multiplier
QP_{bg}	-	Quantization Parameter for background
QP_{fg}	-	Quantization Parameter for foreground
$Ref(x,y)$	-	Reference frame
$I(x,y)$	-	Current frame
$I_{diff}(x,y)$	-	Difference value at pixel (x,y)
$(I_{sum}(m,n))$	-	Total difference in macroblock (m,n)
$BF(m,n)$	-	Background/foreground segmentation
T_1	-	Pixel level threshold
T_2	-	Macroblock level threshold
J	-	Lagrangian cost function
R	-	Motion vector bits

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CHAPTER 1

INTRODUCTION

1.1 Background

In an act to monitor the behaviour or activities that took place in a certain area, surveillance camera or CCTV is widely used whether at the museums, schools, and banks. For a group of security operators, there are limitations to what they monitor and it is a loophole for a security system and it can bring harm to whatever they wanted to protect. This is why surveillance camera is needed. Its usage is proven to be very helpful even for the enforcer to determine crime scene and traffic monitoring. Surveillance camera also can be used to monitor events that include honourable guests without interrupting the flow of the events. Besides, in a situation like in a bank safe, it is safer to lock the safe with a surveillance camera implemented inside and outside of the safe than having a guard inside the safe.

For navy, maritime surveillance video is an important tool to monitor the nation vast ocean from any threat such as pirates, militant groups, smuggling narcotics, marine pollution and illegal immigrant [1]. Malaysia maritime area is 598,450 km^2 which is almost twice the size of our land area after the declaration by Exclusive Economic Zone (EEZ) and it is divided by the South China Sea, Malacca Straits Sea, and the Sulu Sea. Malaysia's beach length is 4,490 km with 1,737 km in

Peninsular and 2,755 km in Sabah and Sarawak. The overall area that needs to be monitored by marine navy is about 160,000 square feet [2]. Obviously, they cannot only rely upon navy periodically patrolling the sea. Besides, Malaysia is surrounded by ocean and the latest case involving invasion in Lahad Datu means that most threats experienced came from the sea. Even the invasion during Japanese time came from the sea. Thus, it is important for Malaysian maritime to be monitored.

Surveillance camera usually records a video for a long time. Even with video compression, large data storage is needed. Video compression is a series of processes specialized in compacting digital video to a smaller number of bits in another format that is suitable for storage or transmission. Compression is achieved by removing the redundancy of the video data and it can be reduced without affecting overall video qualities. Video cameras have a few different types; whether it is stationary or pan/tilt/zoom (PTZ). For maritime surveillance, a stationary camera is usually preferred as it needs to monitor any activities in its territories without missing any blind spot. It would not cover a lot of areas compared to PTZ but the video is more reliable and it would reduce the blind spots.

1.2 Problem Statement

For static surveillance maritime video, the recording normally captured small movements, and sometimes there is zero motion. The main focus of maritime surveillance is the ships that are passing through the area, either airborne or aquatic. The areas involving the ships are regarded as the region of interest (ROI). While using state of the art H.264 CODEC would produce a good compression rate. There is an aspect of static maritime surveillance video that can be exploited to obtain low bitrate video. Maritime surveillance videos are meant to record any movement, for example, boats in the sea area. It records all activities in full resolution, with regard to type of camera used. However, most of the times the recorded video is mainly the ocean and the sky, with boats only passing through only at certain times. When there is a ship passing through, it moves slowly. This shows that it is impractical to encode the video using the standard encoder. Thus in the videos, the boat is supposed to be the only region that needs to be recorded with full resolution, aside from recording the whole area with full resolution.

Maritime surveillance videos are placed at the various locations and its data usually need to be sent to the main data server through the network. Many efforts have been made to use low bandwidth communication channel as it is cheaper and less affected by noise. However simultaneous transmission of video data could not be transmitted over a low bandwidth communication channel. Currently, maritime surveillance cameras are using a wireless network to send video’s feed to the main server. Wireless network bandwidth is limited. Thus, only a small number of cameras video’s feed can be sent to the server at one time.

Standard H.264 is the state of the art video compression, able to compress data effectively with a high quality. This is due to its motion estimation (ME) process that managed to reduce the temporal redundancy efficiently. However, it comes at a cost of a very high computation. More than half of the encoders’ computations are consumed by ME process [3]. With the advance in technology focusing on smaller, low powered portable devices such as smartphones and tablets, there is a need to produce a low complexity video coding.

1.3 Objectives

1. To identify the low moving ships as the region of interest (ROI) in a maritime surveillance video using background subtraction method.
2. To improve H.264 baseline encoder computation complexity and bitrate for the maritime surveillance video application based on the identified ROI.

1.4 Project Scope

The project aims are to improve the compression rate and reduce the complexity of the encoder without badly influencing the quality of the ROI. The research area is on video compression, particularly on H.264 codec. There are different profiles of H.264, such as baseline, main, high and extended. Baseline profile is used as it has the entire basic feature and the profile has the lowest complexity among the profiles. Another version of video codec namely H.265 also known as High Efficiency Video Coding (HEVC) has been released by the time the project started [4]. However, the research still used H.264 due to its compression ability and the number of literatures been written using the codec. All modification is performed on the encoder. The modifications are only done on the encoder, while keeping the syntax unchanged. Maintaining the syntax allowing the video encoded to be played on any H.264 decoder.

The proposed method is implemented on a software version of H.264 encoder. The encoding process is not real-time. The encoding time of the proposed method can be compared to the original software version of the encoder.

1.5 Significance of the Research

The research is intended for maritime surveillance application. As stated in the introduction, Malaysia has vast ocean areas which need protection. One of the main economic sectors is the imports and exports that mostly operated using the maritime ports. A lot of surveillance cameras are installed and it requires high storage capacity. By having a low bitrate maritime encoder, less storage are used for the videos. Some surveillance cameras are transmitting the videos using wireless connection instead of storing the video. The transmission use low data bandwidth to transfer low bitrate video. Consequently, the overall budgets for maritime surveillance are reduced, allowing an increase in the number of surveillance cameras installed. Higher number of surveillance camera can assist the enforcer to safeguard the port.

The research also aims to produce a low complexity encoder. Reduction in complexity would lead to reduction of encoding time. Faster encoding time can allow the video to be viewed instantly in real-time. Besides that, low complexity encoder uses lower power.

1.6 Thesis Organization

The thesis is divided into five chapters starting with Chapter 1 as introduction. Chapter 2 is the literature review that discusses the basic regarding video compression and works that are related to the research. Chapter 3 is focusing on the methodology that is proposed to be implemented to the encoder. The chapter is divided into three sub-section, introduction, external process and internal settings. Chapter 4 is the results and discussion. This chapter is also divided into external process and internal settings, similar to Chapter 3. Lastly chapter 5 is the conclusion of the thesis.

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