Fast Implementation of Block Motion Estimation Algorithms in Video Encoders

N.R.Koduri[1], M.E.Dlodlo[1], G. De Jager[1] and K.L.Ferguson[2]
[1]Department of Electrical Engineering, University of Cape Town, Private Bag X3,Rondebosch, South Africa and
[2]CSIR, Meraka Institute, P.O Box 395, Pretoria 0001, South Africa
Email: {rohini.koduri, Mqhele.Dlodlo, gerhard.dejager}@uct.ac.za[1];kferguson@csir.co.za[2]

Abstract- This project will involve analysing some of the newer fast algorithms in comparison with an exhaustive full search algorithm for motion estimation in video encoders. It will investigate the issues of computational complexity and efficiency of each fast algorithm in relation to the quality of the decoded video frames.

Motion estimation and compensation forms a significant contributor in the video compression process. Motion estimation involves prediction of a video frame from other previously decoded frames. Block motion estimation algorithms adopt various search criteria and techniques for constructing optimal predictions of the frames. Many different fast block matching algorithms (BMA) have been proposed over time.

Combining each algorithm with the streaming SIMD extensions (SSE) is expected to increase processing speeds.

***Index*: Motion estimation, Block motion estimation algorithms, Fast algorithms, Streaming SIMD extensions**

I. INTRODUCTION

Video compression techniques are currently of great interest in meeting the pervasive demand of video applications in the context of limited bandwidth and storage resources. Introduction of international standards in video compression has ensured compatibility and wide-spread adoption amongst different video applications, H.264/AVC being the latest [1].

A Video sequence can be interpreted as a series of pictures referred to as ‘frames’, assuming non-interlaced sources. High correlation between the successive frames can be expected with high frame rate (measured in frames/second). The prevailing hybrid compression techniques exploit these redundancies between frames. Video compression adopts an approach where the current frame is predicted from past or near-future frames and is represented by *motion vector(s)* for each block in the frame. The *residual*, which is the difference between the prediction and the original frame, plus these motion vectors are transmitted as opposed to the transmission of the whole current frame independently coded.

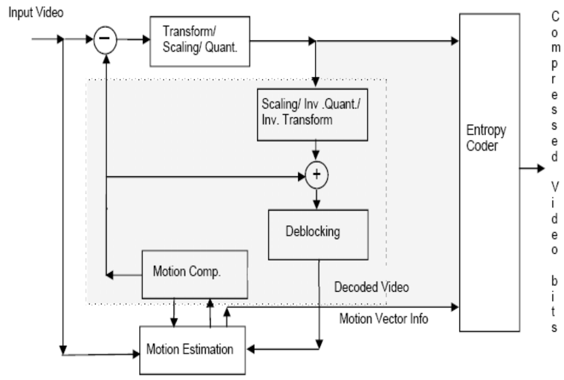

Figure 1: Block diagram of a video encoder [1]

Prediction of a frame involves *motion estimation* followed by *motion compensation*. The prediction process begins by dividing a frame into smaller blocks called *macroblocks* and analyzing previous or future frames (or both) to identify the best match for each block in the current frame. The displacement is stored as a *motion vector*. This is called *motion estimation*. The techniques for finding the best match are provided by *block motion estimation algorithms*. Applying the motion vectors to each macro block of the reference frame to synthesise the predicted frame is *motion compensation*.

II. BLOCK MOTION ESTIMATION ALGOROTHMS

Employing BMAs in motion estimation is a vital part in the process of building a prediction of the current frame. A macroblock basically, consists of a two dimensional set of pixels, typically in 16-by-16 blocks within the frame. Most estimation algorithms operate on the luminance component only and infer the colour component for compression.BMA aims to find a similar luminance block with equal energy from a window within a reference frame [2]. The project attempts to study the more widely accepted fast algorithms concentrating on their quality of output and processing complexities.

A. Exhaustive search or Full search motion estimation algorithm

The full search algorithm (FSA) compares each block of the current frame with every possible block position in the search region or window of the reference frame. The FSA is guaranteed to find a best match and is therefore, an optimum prediction of the frame but is computationally intensive. Typically, the search starts at the (0, 0) position and proceeds spirally outwards. The number of comparisons increases with the size of the search window.

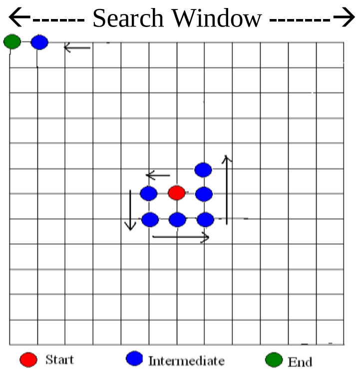

Figure 2: Full search algorithm [3].

B. Fast search algorithms

The FSA is unacceptably complex in software-based real-time applications. A fast search algorithm attempts to reduce the number of computations involved in the algorithm. The key idea in fast algorithms is to sub-sample the search points to avoid searching all possible locations [3].

III. STREAMING SIMD EXTENTIONS (SSE)

Modern general purpose processors define instruction set architectures (ISA) used for multimedia that allow some basic arithmetic operations to be performed simultaneously on multiple items in such a set. The mentioned architectures support single instruction multiple data (SIMD) parallel processing across multiple data elements. The MMX (Multimedia Extensions) technology, which was developed for image manipulation defines a simple and flexible SIMD execution model to handle 64-bit packed integers [4].

The SSE instruction set was introduced by Intel in Pentium III processors. These extensions are updates to MMX and expanded the scope of SIMD instructions where SIMD can further operate on packed data types. The SSE added new programming registers to MMX registers. SSE 4 is the latest version and major enhancements were in adding a dot product instruction, additional integer instructions, and more [5].

In the video coding context, advantage can be taken of the SIMD architectures in paralleling the block matching tasks in motion estimation computations.

IV. PROPOSED METHODOLOGY

The project proposes to use the C++ programming language to implement different fast algorithms and Microsoft Visual Studio 2008 has been chosen as a suitable IDE (Integrated development environment) to support the software development. Acknowledging that FSA successfully delivers the best prediction, the project involves the evaluation of published fast algorithms in comparison with FSA. From all the fast search algorithms, the interest of the project lies in Cross search, Diamond Search and Logarithmic Search [1], [6]. However, other algorithms might be considered and implemented if time permits.

The measurements of interest will include PSNR (Peak signal-to-noise ratio) for quality measurement and the processing time on a set of standard video sequences. The project will include incorporating the SSE instructions to enhance the processing speeds of selected fast algorithms. The project aims to present results that show an average improvement in processing time at an average PSNR cost compared to the full search algorithm.

V. CONCLUSION

This project is expected to render the most relevant motion estimation algorithm which is fast, accurate and robust for the software based real- time video applications thus, achieving satisfactory video quality with an acceptable processing time.

VI. ACKNOWLEDGEMENT

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BIOGRAPHY

NagaRohini Koduri obtained her B. Tech (Electronics and Communication Eng.) Degree from Periyar University, India in 2004.She is currently in the first year of her MSc (Elec Eng) degree from University of Cape Town. Her research is sponsored by the Council for Scientific and Industrial Research (CSIR)