CHAPTER-1

INTRODUCTION

1.1 Introduction

Compression algorithms have been developed for various applications at an international level. These algorithms have been tested and standardized by several organizations. The methods are alternatives to a certain extent, because they were developed with different aims and are tailored to specific applications. Overall, the range of available standardized video compression methods covers practically all applications. Some compression algorithms permit a degree of variation within the standard to meet technology constraints. The most common video compression methods use the statistical similarity of adjacent pixels. The image is converted to a frequency space block by block using the DCT (Discrete Cosine Transformation). In video coding, it is also possible to use the strong time correlation of consecutive frames – the objects shown are usually static or move in a more or less constant manner. If the difference between the images is calculated with motion estimation, it is only necessary to transfer the changes from frame to frame [WR-1].

Transforming a video sequence into a bit-stream is called coding or encoding. This is usually performed by an encoder inside or close to the camera. Transforming a bit-stream back to an image is called decoding. A decoder is needed each time the bit-stream has to be displayed. A device able to perform both functions is called a codec (coder/decoder) [WR-2]. Compression is a reversible conversion (encoding) of data that contains fewer bits. This allows a more efficient storage and transmission of the data. The inverse process is called decompression (decoding). Software and hardware that can encode and decode are called decoders.

The performance of a video codec is always a trade-off among the three variables: (i) Quality, (ii) Bit Rate, and (iii) Computational Cost.

Quality: This notion is inseparable from the fact that all video compression schemes are loss. This means that the cycle consisting in coding a video sequence into a compressed bit-stream, then decoding the bit-stream, yields a recovered uncompressed video sequence which is not strictly the same as the original one. There are information losses. Incidentally, there are lossless compression schemes, but their performance along the bit rate axis is poor, and they cannot be used for the vast majority of applications. An exception might be medical imaging for diagnosis purposes.

Bit Rate: Subjecting a video sequence to a particular encoder yields a compressed bit-stream which is progressively generated. The average production rate of bits is the bit rate. Bit rates for compressed video may range somewhere between 50 Kbits/s and 250 Mbits/s. The bit rate is strongly related to the compression performance of the coder, but it also depends on the size of the original images (SDTV, HDTV) and their frame rate. You can use it to compare encoders compressing images of identical size and rate [WR-3].

Computational Cost: Encoding and decoding images involve a large amount of real-time computation. Generally speaking, increased compression performance involves higher computational cost.

In the early days, general-purpose computers were inadequate, even for the relatively simple compression standards available then. With the ever increasing processing power of computing hardware (the famous Moore's law), it became possible to run sophisticated compression or decompression algorithms on low-cost PCs. However, it does not come as a free lunch. If you entrust your computer with such a high-priority task as real-time video coding or decoding, you will experience a performance reduction for all other software applications [WR-4].

The main function of video compression technologies is to reduce and remove redundant data (i.e. no motion and no change in scenery) in video so it can be effectively stored or sent over a network. Modern efficient compression techniques can achieve a significant reduction in file size without sacrificing video quality.

Video compression technologies are commonly known as codecs. They use an algorithm called an encoder that compresses data at the source (i.e. before storage or transmission). At the destination, they use another algorithm called a decoder to decode and decompress the data. Codecs are used in pairs and are not cross compatible. A video encoded using MPEG4 technology cannot be decoded using a H264 decoder [SG+2005].

- MPEG: Motion JPEG or M-JPEG is a video compression format based on the popular JPEG compression used for still images. It forms a video sequence and gives the impression of motion by combining several still JPEG images. MJPEG is a robust video compression format. Since each frame of video is independent, even if one is dropped, the rest of the video is unaffected. This robustness however also translates to higher bandwidth requirements and higher storage space used.

- MPEG4: MPEG4 compression technology in video surveillance refers to MPEG4 Visual. Unlike M-JPEG, MPEG4 is a licensed standard. DVRs, IP cameras and other surveillance products must pay a license fee for each channel of video that uses MPEG4 technology. In terms of compression, MPEG4 supports low bandwidth applications that require decent quality images. It uses video compression techniques to locate redundant data in video and reduce its size.

- H264: H264 also known as MPEG4 Part 10/AVC (Advanced video coding) is the latest MPEG standard for video encoding. As of 2010, it is the preferred video encoding standard since it can compress video significantly without compromising video quality. It provides up to 80% reduction in file size compared to M-JPEG and up to 50% reduction compared to MPEG4. H264 is jointly defined by two standardization groups, the ITU-T's Video Coding Experts Group from the telecommunications sector and the ISO/IEC Moving Picture Experts Group from the IT sector. Because of this backing, it is expected that H264 will surpass the other standards in terms of adoption [WR-5].

Most CCTV compression algorithms used in CCTV are lossy compressions, because such algorithms offer higher compression ratio (the ratio of the resulting video file size compared with the original file size). If the CCTV camera signals are digitized, then a digital stream with more than 150 Mbps will be interpreted, but such a stream contains a lot of redundant information. All image compression algorithms are divided in two groups namely: (i) lossless, and (ii) lossy. Most CCTV compression algorithms used in CCTV are lossy compressions, because such algorithms offer higher compression ratio (the ratio of the resulting video file size compared with the original file size). Video compression algorithms are divided in two groups: (i) Frame based compression (JPEG, Wavelet, JPEG 2000), and (ii) Stream based compression (MPEG-2, MPEG-4, H.264, MPEG-7). Usage of stream based compression algorithms enables greater savings on storage space and network bandwidth but as a trade-off these algorithms require higher computing performance. Four of the most common type of compressions widely used in CCTV are: (i) Motion JPEG, (ii) MPEG-4, (iii) H.264, and (iv) JPEG2000.

Motion JPEG is very popular compression format. MJPEG fits very well for video archives because of its frame based nature. MPEG4 can be 3 times more efficient in terms of compression ratio in comparison toMotion JPEG. But MPEG4 is a bad choice for systems with frame rate less than 5-6 frames per second. H.264 can be 50-100% more efficient in comparison toMPEG-4. The MPEG-4 and H.264 are ideal for CCTV systems with limited but stable bandwidth. JPEG2000 is similar to JPEG, but uses wavelet transform instead of discrete-cosine-transform (DCT) of JPEG. JPEG2000 offers a better image quality on higher compression levels. Another great advantage is a possibility to decompress lower resolution representation of the image. This feature is good for motion detection algorithms. However JPEG2000 compression needs way higher CPU performance, than JPEG [WR-6]. With the advent of IP Security Camera Systems and its increased popularity over Analogue CCTV Systems, it has now become inevitable for the Camera Manufacturers/System Integrators to focus more on the data compression to maintain the quality of image as well as save on transmission bandwidth and hard disc storage space. An application which requires live monitoring will need signal streams high quality image, whereas for recording purpose or even for viewing in Mobile from a remote location, different streams are required with different compression techniques. There are DVR’s in the market with even five separate streams for five different kinds of applications [WR 7-9].

At its most basic level, compression is performed when an input video stream is analyzed and information that is indiscernible to the viewer is discarded. Each event is then assigned a code commonly occurring events are assigned few bits and rare events will have codes more bits. These steps are commonly called signal analysis, quantization and variable length encoding respectively [HH+2014]. There are four methods for compression; Discrete Cosine Transform (DCT), Vector Quantization (VQ), Fractal Compression, and Discrete Wavelet Transform (DWT).

Discrete cosine transform is a lossy compression algorithm that samples an image at regular intervals, analyzes the frequency components present in the sample, and discards those frequencies which do not affect the image as the human eye perceives it. DCT is the basis of standards such as JPEG, MPEG and H.264 [LL+2013],[ZA+2014]. Vector quantization is a lossy compression that looks at an array of data, instead of individual values. It can then generalize what it sees, compressing redundant data, while at the same time retaining the desired object or data stream's original intent. Fractal compression is a form of VQ and is also a lossy compression. Compression is performed by locating self-similar sections of an image, then using a fractal algorithm to generate the sections. Like DCT, discrete wavelet transform mathematically transforms an image into frequency components. The process is performed on the entire image, which differs from the other methods (DCT) that work on smaller pieces of the desired data. The result is a hierarchical representation of an image, where each layer represents a frequency band [WR-9].

1.2 Motivation

Data Compression shrinks down a file so that it takes up less space. This is desirable for data storage and data communication. Storage space on disks is expensive so a file which occupies less disk space is "cheaper" than an uncompressed file. Smaller files are also desirable for data communication, because the smaller a file the faster it can be transferred. A compressed file appears to increase the speed of data transfer over an uncompressed file. Video compression is the last step before uploading your file online. As the name implies, compressing video reduces its file size. This is very important, because smaller files upload faster, save bandwidth and storage costs, and load quicker when played back. However, if video is compressed too much, the file can lose its detail, resolution, clarity, and much more. Thus the conducted research is aimed to reduce the cost of saving large scale files in the high speed capacity disc.

1.3 Definition of the Problem

The high bit rates that result from the various types of digital video make their transmission through their intended channels very difficult. Even entertainment video with modest frame rates and dimensions would require bandwidth and storage space far in excess of that available from CD-ROM. Thus delivering consumer quality video on compact disc would be impossible. This is analogous to an envelope being too large to fit into a letterbox. Similarly the data transfer rate required by a video telephony system is far greater than the bandwidth available over the plain old telephone system (POTS). Even if high bandwidth technology (e.g. fibre-optic cable) was in place, the per-byte-cost of transmission would have to be very low before it would be feasible to use it for the staggering amounts of data required by HDTV. Finally, even if the storage and transportation problems of digital video were overcome, the processing power needed to manage such volumes of data would make the receiver hardware very expensive. Although significant gains in storage, transmission, and processor technology have been achieved in recent years, it is primarily the reduction of the amount of data that needs to be stored, transmitted, and processed that has made widespread use of digital video a possibility. This reduction of bandwidth has been made possible by advances in compression technology. Advances in compression technologies aimed to minimize the storage space required for storing videos. Video compression technologies are about reducing and removing redundant video data so that a digital video file can be effectively sent over a network and stored on computer disks. With efficient compression techniques, a significant reduction in file size can be achieved with little or no adverse effect on the visual quality. The video quality, however, can be affected if the file size is further lowered by raising the compression level for a given compression technique.

1.4 Objective and Scope of Research Work

The objective of the research is stated as below.

Design of efficient compression techniques as a novel and enhancing the existing industry proven video compression techniques for compressing large-scale surveillance system videos that includes CCTV footages and medical clinical videos.

1.4.1 Scope of Research Work

The scope of the research includes,

(i) Analyzing the compression needs of surveillance system and clinical medicine videos.

(ii) Finding the existing gaps in the available video compression solutions

(iii) Development of algorithms for boosting up compression ratio.

(iv) Real-time capture and interpretations of large-scale videos.

(v) Implementation of the proposed algorithms.

(vi) Testing with real-time environment with large-scale CCTC footages and ECG medical videos.

(vii) Interpretation of results and enhancement of the proposed compression solution.

1.4.2 Limitations

(i) Only applicable for large-scale videos of running length greater than 24 hours.

(ii) The proposed solutions are not suitable for short videos such as movies and frequent frame variation videos.

(iii) The proposed algorithms are based on lossy compression so that the decompressed videos cannot result in video quality of source video.

1.5 Research Methodology

Existing Compression Techniques for Large Scale Videos are studied and analyzed critically. New Proposed techniques are created. The proposed algorithms are implemented using Java technologies and tested for the standard large scale videos.

1.6 Original Contributions

The following are the original contributions of this research.

Contribution 1: Efficient proven compression techniques are designed for compressing large-scale surveillance systems and clinical medicine videos.

Contribution 2: The algorithms of the existing proven video compression techniques in the industry are critically analyzed with their pros and cons.

Contribution 3: The conducted research is aimed for development of compression solution for large-scale and extra large-scale videos. Special batching and task scheduling approaches are introduced.

Contribution 4: For Proof-of-Concept (PoC), the proposed algorithms are implemented using Java technologies and tested using real-time surveillance systems in educational and medical sector (large scale educational institution and hospital).

1.7 Thesis Organization

The thesis is well organized into six chapters as listed below:

- Chapter I : Introduces the research topic in a broader view
- Chapter II: Reviews the available literature in terms of academic and industrial perspective
- Chapter III: Broadens the research topic and the techniques related to video compression
- Chapter IV: Illustrates the proposed video compression technique for compressing large-

scale surveillance videos with the constructed algorithms

- Chapter V: Critically analysis the observed results of the proof of concept(PoC) of the implementation of the proposed videos compression technique along with the comparison of the existing relevant techniques.
- Chapter VI: Concludes the thesis with the potentials for future research.