A Novel Approach for Compressing Surveillance System Videos

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Abstract— *The surveillance systems are expected to record the videos in 24/7 and obviously it requires a huge storage space. Even though the hard disks are cheaper today, the number of CCTV cameras is also vertically increasing in order to boost up security. The video compression techniques is the only better option to reduce required the storage space; however, the existing video compression techniques are not adequate at all for the modern digital surveillance system monitoring as they require huge video streams. In this paper, a novel video compression technique is presented with a critical analysis of the experimental results.*

Keywords— Video Compression, CCTV, Surveillance System, Frame Compression

I. INTRODUCTION

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 [1].

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 compare with Motion 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 compare with MPEG-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 discreetest-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 [2].

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 [3-6].

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 [7]. 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 [8-12]. 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 [4].

This paper is organized as: Section I introduces the video compression and its needs, Section II reviews the available literature on compressing surveillance systems videos, Section III outlined the proposed algorithm for video compression with result analysis, and Section IV concludes the paper.

II. LITERATURE REVIEW: COMPRESSING SURVEILLANCE SYSTEMS VIDEOS

The CCTV industry continues to move towards digital devices, such as Digital Video Recorders (DVRs) and IP devices, technicians need to be familiar with the subject of Compression – the methods such as MPEG, Wavelet™, and similar. The volumes of data produced by digitizing CCTV image streams would swamp the available storage and communications systems. To overcome this, the process of compression is applied to the image stream, reducing the amount of information that needs to be transmitted and stored. In fact compression of the camera signal is not new - many people do not realize that all ‘analogue video’ has always been compressed. Similarly, there has long been a need for data compression in the computer industry. Specialist mathematicians have worked for many years on solving the basic problem of how to reduce the image size to produce the best compromise between image clarity, the data size of the image, and the amount of processing power it takes to run the compression method [3].

The compression formats used in CCTV vary by manufacturer and by product. But the four most commonly used compression formats are given below.

- H261: H261 is a digitization and compression scheme for analogue video. It is widely used in video conferencing and is aimed at providing digitized video at a bit rate of 64Kbps-1Mbps, which is the bandwidth range of public data networks. Compression rates as high as 2500:1 are achieved, but of course at the cost of quality. The format is good for high frame rates, showing movement, but the resolution of those frames is not high. This is not good if, say, person identification images are required. But if the application is a non-security application such as video-conferencing, the quality is likely to be adequate. Uniquely among the compression formats discussed here, H261 encoded signals can also be decoded or decompressed by reversing the process from a valid reference or I-Frame [13].
- Motion JPEG (M-JPEG): Motion JPEG (JPEG stands for Joint Photographic Experts Group) is an adaptation of the popular JPEG image compression for still digital photos. JPEG is a lossless compression technique, losing very little data in the image. Motion JPEG creates a video stream from a succession of JPEG-compressed still photos. Because it is based on these high quality lossless stills, it delivers a much higher quality image than H261. But at a cost – it requires a considerably greater transmission bandwidth and storage capacity compared to its H261 counterparts. An advantage of Motion JPEG is that, because it is based on still images, it can produce any of its frames as a single image for identification purposes.
- MPEG: MPEG (named after the Moving Pictures Experts Group) is purpose designed for moving pictures, rather than being based on still image compression. This means that each frame is defined as the previous frame plus changes, rather than a full frame. The advantage of this is that compression is more efficient – the same quality can be displayed from less data. However, the method has problems when there is extensive motion between one frame and the next – there is a danger that the image gets ‘blocky’ and vague, losing some definition in the areas of the frame where the movement occurs. There is not one MPEG standard but several, changing over time, of which only the first two are relevant at present.. MPEG -1 was designed to output 15 frames per second video from limited bandwidth sources, such as CD-ROMs. MPEG-2, designed for high bandwidth applications such as High Definition TV (HDTV), delivers 30 frames per second video at full CCIR 601 resolution but requires special high speed hardware for compression and playback – PCs cannot handle this.
- Wavelet Compression: Like Motion-JPEG, Wavelet™ compression delivers high-quality moving images by starting with still images, applying a compression method to them, and putting them together to form moving pictures. It compresses images by removing all obvious redundancy and using only the areas that can be perceived by the human eye. Wavelet™ is up to four times more effective in reducing the volume of data than JPEG and M-JPEG. Wavelet™ is also seen as

offering superior development potential to current MPEG compression, giving a greater amount of compression with equivalent quality. It transforms the whole image and not just blocks of the image, so as the compression rates increase, the image degrades gracefully, rather than into the 'blocky' artifacts seen with some other compression methods. Wavelet™ applications can have their preferred level of compression selected by the user – higher or lower.

III. PROPOSED ALGORITHM FOR VIDEO COMPRESSION AND RESULT ANALYSIS

Different applications have different priorities regarding clarity of the image, data volumes, and processing power – for example identification evidence has a different picture quality requirement compared to monitoring the length of a queue. Different sorts of compression are described as lossless or lossy. In general, the less compression the better the playback and recorded image, so naturally in that sense lossless is always better than lossy; however, less compression means more data to be transmitted and stored, and thus incurs higher system costs. Compression reduces the signal in three ways. The first is by various mathematical tricks that are lossless to the image, and can be reversed at the time of display so that the full image is viewed. The second is to remove parts of the signal that are redundant to human viewing of the image. The third method is to start to visibly reduce image quality – definition, frames per second, and color range – and it is this type of compression that is called lossy.

In the proposed algorithm for video compression, each surveillance system video is decomposed into time-interval segments. Then, each segment will be split into multiple frames. Each frame will be compared with its previous and its next frame and if the difference is within the configured threshold, then the frame will be discarded. After this frame discarding process, each frame is compressed using image compression techniques to have high compression ratio [14, 16].

H.264 is the next-generation video compression technology in the MPEG-4 standard, also known as MPEG-4 Part 10. H264 can match the best possible MPEG-2 quality at up to half the data rate. H264 also delivers excellent video quality across the entire bandwidth spectrum: from 3G to HD and everything in between (from 40 Kbps to upwards of 10 Mbps). The H.264 is an open, licensed compression format that supports the most effective video compression techniques available today. It is the result of a joint venture by the ISO/IEC Moving Picture Experts Group (MPEG) and the ITU-T Video Coding Experts Group. An H.264 encoder can diminish the size of a video file by greater than 80% more than with the Motion JPEG format and up to 50% more than with the MPEG-4 Part 2 standard, without compromising image quality [15].

This translates to much less storage space and bandwidth being needed for a video file, saving users money while achieving higher video quality. H.264 will most assuredly find the quickest acceptance in applications where there is demand for high frame rates and better resolution, such as the video surveillance industry. This is where the advantages of decreased bandwidth and storage needs will bring the biggest savings [17-18]. H.264 has made huge advances in video compression and is expected to be the video standard of choice in the coming years. It offers techniques that allow better compression efficiency due to more accurate prediction capabilities, as well as increased tolerance of errors. It also yields new possibilities for creating enhanced video encoders that permit higher quality video, more frames per second and better resolutions at higher bit rates or lower bit rates at the same quality video. An assortment of techniques can be used to compress video data, both within an individual video frame and among a progression of frames. Within an image frame, data can be reduced by removing unnecessary information, which will have negative consequences on the image resolution. In a series of frames, video data can be reduced by such methods as difference coding, which most video compression standards use, including H.264. Difference coding means that only the pixels of each frame that have changed with respect to a previous reference frame are coded. This way the amount of pixel values that are coded and transmitted is condensed. A progressive intra prediction method for encoding reference frames is introduced with H.264 [19-20]. The obtained experimental results are given pictorially as line chart in Fig. 1-4.

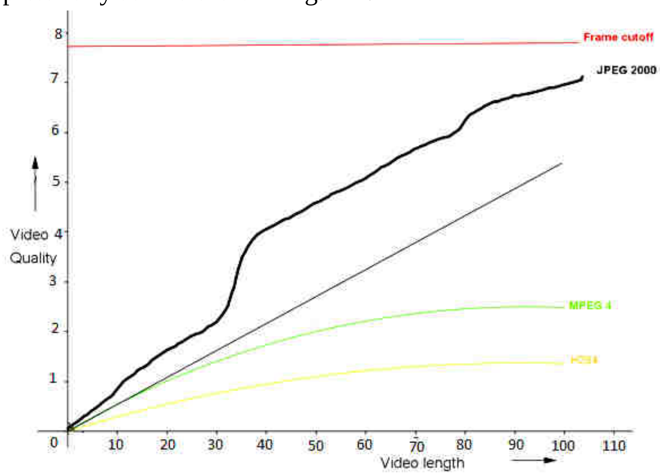

Fig. 1: Video Quality vs Video Length

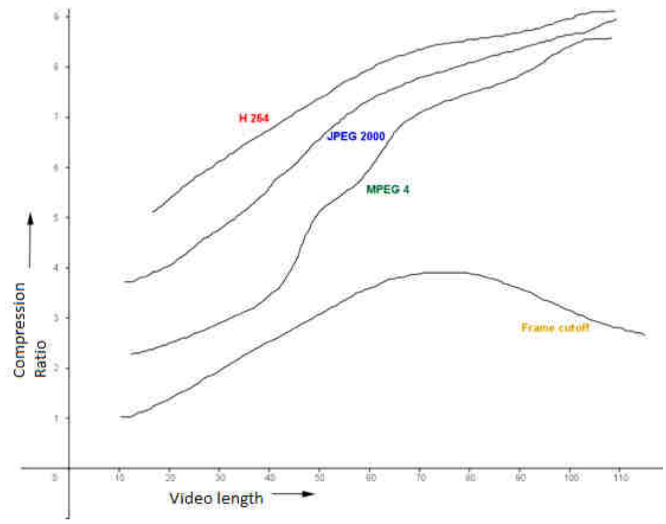

Fig. 2: Compression Ratio vs Video Length

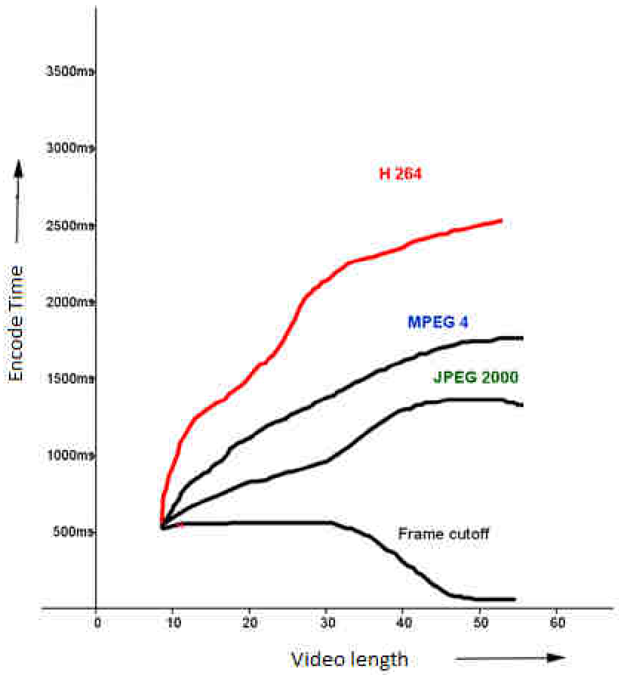

Fig. 3: Encode Time vs Video Length

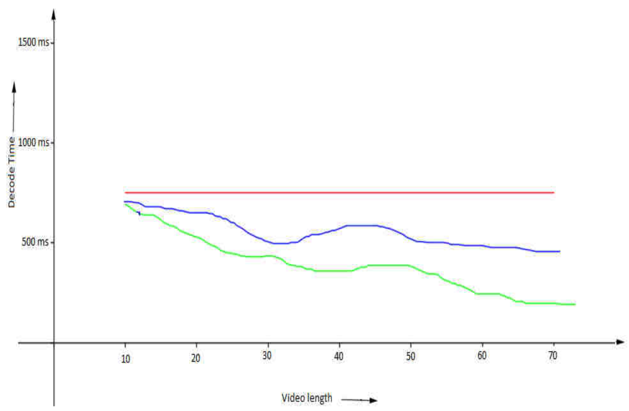

Fig. 4: Decode Time vs Video Length

IV. CONCLUSION

As most of the surveillance cameras are expected to run 24/7, there'll be a huge amount of video data that needs to be recorded. The obvious question is how to handle the storage of the data. Uncompressed video of course gives the best possible quality. However, when it comes to CCTV video, content rather than quality takes preference. Nobody wants to sacrifice a sizeable amount of disk space for the sake of visual quality. H.264 is the latest and most widely used video recording standard; it is used not only in CCTV systems but also in all areas of digital recording. It provides you with better picture quality compared with older standards and it provides smaller file size compared with older compressing methods. In this paper, a novel video compression technique for compressing surveillance videos is given and the obtained results are critically analyzed.

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