Real - Time Applications of Video Compression in the Field of Medical Environments

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Abstract

We introduce DCNN and DRAE appraoches for compression of medical videos, in order to decrease file size and storage requirements, there is an increasing need for medical video compression nowadays. Using a lossy compression technique, a higher compression ratio can be attained, but information will be lost and possible diagnostic mistakes may follow. The requirement to store medical video in lossless format results from this. The aim of utilizing a lossless compression tool is to maximize compression because the traditional lossless compression technique yields a poor compression ratio. The temporal and spatial redundancy seen in video sequences can be successfully utilized by the proposed DCNN and DRAE encoding. This paper describes the lossless encoding mode and shows how a compression ratio greater than 2 (2:1) can be achieved.

Keywords:
Deep Convolutional Neural Networks, Deep Recurrent Auto Encoders, Video, Encoding, Decoding, Deep learning, medical field.

1. Introduction

The use of lossy compression tools results in the loss of information from the original medical video sequence and may result in diagnostic errors. This paper describes a method to increase the compression ratio of medical video sequence while satisfying the need for lossless encoding.

A pixel is the smallest controllable component of a picture in a medical imaging. The size of a medical image is increased because instead of using 8 bits to describe a pixel, high image resolution requires the usage of 16 bits. In order to enable effective data transmission, real-time teleconsultation, and simple storage, medical video compression is thus becoming increasingly important. High temporal and spatial redundancy can be seen in medical video sequences. This spatial and temporal redundancy is successfully taken advantage of by HEVC in order to increase compression ratio. Medical video sequences can be completely lossless encoded using HEVC. Normal predictions are still permitted in lossless encoding mode; therefore, the encoder will select the best inter or intra prediction and encode the video sequence.

The proposed approaches employ Intra prediction to take advantage of spatial redundancy and Inter prediction to take advantage of temporal dependencies. An entropy coding method called CABAC is employed in addition to intra- and inter-prediction to improve compression. A compression ratio larger than 2 can be easily reached using prediction and entropy coding techniques and lossless compression with transquant bypass mode activated. The study describes how to use HEVC to completely lossless compress a medical video sequence.

2. Related Work

A medical video analysis offers a platform for the dissemination of various findings in the medical industry. Modern developments in imaging are part of the rapidly evolving changes in healthcare. In the case of medical video processing, the impact of camera motion from a video stream results in incorrect diagnosis. Consequently, the video stream can produce a stabilized video thanks to video stabilization technology. Since compression transmits a lot of information while lowering file size, it is also extremely important in the fields of clinical and image analysis. Prior to compression, a video stabilization is carried out to further guarantee effectiveness in diagnosis. Peak signal-to-noise ratio and structural similarity measurements showed that the proposed methodology significantly improved video quality.

2.1 Image and Video compression:

Image compression aims to reduce image size for transmission and storage without sacrificing important image data. Images have certain redundant elements, such as space, time, structure, etc. These redundancies are used by image compression algorithms to achieve the best compression ratio. There are hundreds of compression algorithms for static images, which are divided into lossless encoding and lossy encoding techniques. The

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lossless JPEG and lossless JPEG 2000 compression methods are the most widely used in the medical picture community.

In 2001, DICOM began using JPEG and JPEG 2000. A file format for a series of JPEG and JPEG 2000 images is provided by Motion JPEG and Motion JPEG 2000. They're made to live beside MPEG. Inter-frame prediction coding, three-dimensional transformation coding, mode-based coding, and other compression methods for motion images fall under this category. The most widely used video compression technology, inter-frame prediction coding makes use of the strong connection between succeeding frames. MPEG-4 and H.264 are just two examples of worldwide standards that have adopted this method.

2.2 Image and Video compression:

Deep neural networks have enabled computer vision-based analytics to achieve practical accuracy, and as a result, many embedded platform applications now call for fast processing speed and low energy consumption. These applications require more compression than the standard state-of-the-art video codecs can provide. If it is possible to precisely describe the application context, top-down approach-based video compression techniques can be employed to obtain the necessary compression levels. For a variety of related applications that often use a shared set of features for analysis, hybrid approach-based compression strategies can be applied. As the number of early adopters grows daily, camera and video capturing technology is rapidly advancing. The basic problem with data transfers still exists, though. Thanks to these compression methods, the user or developer can select the appropriate form of compression for a certain application.

2.3 Medical Video compression:

Consider a picture that is 3840 by 2160 pixels in size and is a standard 16-bit medical X-ray image. This amounts to a about 16 MB file size (considering Luma component only). Increased disc capacity and image transmission time are the results of this. Hospitals are producing more digital video images than ever before, even though disc storage has been continually rising. The issue of sending the medical video sequence over the network exists even if there is infinite storage. In order to decrease file size and storage requirements, there is a rising need for medical video compression. Techniques for compressing medical video make use of the redundancy that is seen in video sequences.

2.4 Medical Imaging compression research:

According to research on medical imaging errors, there are often between 2% and 4% of imaging reports that contain inaccurate or misleading information [7]. The medical profession has been reluctant to employ lossy techniques because of the potential legal and regulatory concerns that could arise as a result of diagnostic errors. As a result, the present focus of digital imaging is to reduce diagnostic error. Redundancy in the image is often reduced using lossless medical data compression (Spatial redundancy). The literature has used a number of typical methods to carry out this redundancy reduction step. The Lempel-Ziv-Markov chain algorithm, Huffman coding, and DPCM are three popular methods of lossless encoding [1].

2.5 Encoding for DPCM:

The transformation known as Differential Pulse Code Modulation (DPCM) makes images more compressible. Predicting the following pixel value entails scanning the image. The next pixels' value can be predicted in a variety of ways. The anticipated value is calculated as the average of the leftmost and highest pixel. The residual image is the collection of discrepancies between each pixel's expected value and actual value. Compared to the original image, the residual distribution is more tightly packed. The minimal code word length is determined by the lower entropy as a result [2].

2.6 The Huffman coding:

Due to its simplicity and efficiency, the Huffman coding technology is a widely used method for data compression. It requires the coding of the data's statistical distribution. The Huffman coding method is detailed in more depth below. image's residual histogram Sort the histogram and combine the two lowest value bins until only one is left to create a coding tree. Codify the residual image, then save the coded values and coding tree [2].Algorithm of the Lempel-Ziv-Markov chain:

2.7 The Lempel-Ziv-Markov chain algorithm (LZMA):

which was first implemented in the 7z format of the 7-Zip archive, is used to produce lossless data compression. This approach, which employs dictionary compression, has a high compression ratio and a fast decompression rate comparable to that of other widely used lossless compression algorithms.

As they are all designed for image compression and not lossless video compression, DPCM encoding, Huffman encoding, and the Lempel-Ziv-Markov chain algorithm only take advantage of spatial dependency, not temporal dependency. In contrast, HEVC is a video compression standard that takes advantage of both spatial and temporal redundancies and performs entropy coding on the residual data to achieve higher compression ratios [12].

3. Proposed Methodology:

The ISO/IEC Moving Picture Experts Group and the ITU-T Video Coding Experts Group are preparing DCNN and DRAE as the newest video coding standard. When it's important to reduce data's storage or transmission bandwidth while preserving archival quality, lossless compression can be helpful. Since these applications cannot tolerate any distortion in the reconstructed images, many applications, including medical imaging, the preservation of artwork, image archiving, remote sensing, and image analysis, call for the adoption of lossless compression. Since the HEVC standard requires the video sequence to be in

YUV format, which is different from camera capture format, an internal conversion from RGB to YUV format is necessary to encode the picture sequence for camera recorded format.

RGB to YUV Conversion:
True Color, a 24-bit color space, is what results from the traditional 8-bit color representation. It is typically not possible to reverse the mapping between the RGB and YUV color spaces due to the restriction of rounding to the component bit depth. For instance, using Rec.709, only 24% of 24-bit RGB triplets can be precisely recovered from conversion to 8-bit YUV and back to 8-bit RGB. Most RGB triplets are wrong by 1 due to clipping. However, increasing bit depth can enhance the color representation's brightness and density over the full color spectrum.

3.1. The proposed lossless mode in general:

The fundamental method for lossless video coding involves skipping the quantization and transform stages in the encoder and decoder. All in-loop filtering processes, including the deblocking filter and SAO, are disregarded when the lossless mode is used. In-loop filtering operations won't improve the quality of the images or the efficiency of the coding because there is no distortion present in the reconstructed frame in the lossless mode. Figure 1 below depicts the general organization of the HEVC lossless mode. The bypass is represented by the dashed lines, and all bypass operations are active in the HEVC lossless mode [6].

3.2 Intra Prediction:

Intra prediction is used to exploit the spatial dependency in the image. HEVC specifies 33 angular predictions and two non-directional predictions (DC, Planar). The DC intra prediction mode generates a mean value by averaging reference samples and can be used for flat surfaces. The planar prediction mode in HEVC supports all block sizes defined in HEVC. The intra prediction modes use data from neighboring prediction blocks that have been previously decoded from within the same picture.

3.3 Interdiction:

The temporal dependency in the video sequence is taken advantage of via inter prediction. The motion vectors are computed with quarter-sample precision, and the fractional-sample positions are interpolated using 7-tap or 8-tap filters. Several examples of reference images are used. Both uni-predictive and bi-predictive coding are possible depending on whether one or two motion vectors are communicated for each prediction block. Weighted prediction is the process of applying a scaling and offset operation to the prediction signal.

4. Experimental Setup:

We encoded two streams in RExt mode with transquant bypass mode turned on so the encoding is lossless in order to test the lossless compression techniques and effectiveness of the proposed approaches encoding. Extended precision flag is enabled, LCU size is set to 64, and maximum coding unit depth is set to 4 in order to obtain a high compression ratio.

5. Conclusion:

In this study, we introduce DCNN and DRAE, a format for compressing 3-D medical data sets and films. According to experimental findings, the proposed approaches outperform MPEG-4 when it comes to medical video compression in terms of both PSNR increase and bit rate reduction. This suggests that DCNN and DRAE is a better candidate for medical video applications because it is more efficient than MPEG-4. Additionally, a perceptual mode decision algorithm that updates the Lagrange multiplier in accordance with the perceptual characteristics of video contents is proposed. Our suggested rate control system performs better for medical video compression than H.264 rate control, according to experimental findings. Our suggested rate control system performs better for medical video compression than H.264 rate control, according to experimental findings.

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