A Framework for Affordable Telemedicine Service

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Abstract— **Paraplegic patients require periodic assessments that often need to be performed by paraplegia specialists, but these specialists may not always be available at the patient location. In this paper, we propose a framework that enables medical institutions to provide a high quality of service to a large number of patients at their homes or nearest medical institutions. This framework allows patients in remote locations to access specific medical specialists from anywhere. Our proposed framework focuses on providing a robust high resolution video stream that allows for the physician to establish live communication with the patient and medical assistant at the remote location using smartphones. Medical assistants will collect vital signs such as temperature, pulse rate and blood pressure. High Efficiency Video Coding (HEVC/h.265 codec) used in this framework improves data compression over the popular h.264. HEVC enables specialists to reach patients at remote locations and to provide quality medical service. Through this scheme, physicians can exchange expertise with colleagues, patients can have access to remote specialists, and medical experts can treat more patients by reducing travel. Our solution provides a cost effective and time efficient approach in extending the reach of specialists.**

I. Introduction

Telemedicine provides a cost effective approach to continue a high or higher quality medical service between the physician, and the patient. A major driver in the Telemedicine industry is the shortage of medical specialists. However, the public prefers face to face healthcare interactions, this is prevalent throughout the industry, alternatively, real time interactive telemedicine demands very expensive infrastructure. Another cost effective approach of telemedicine with a store and forward transmission of user interactions suffers from the lack of standards and the low quality of service [5]. Further, the lack of interoperability among healthcare systems makes widespread connectivity difficult, impeding clinician access to real-time data for medical decision-making.

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Another important Telemedicine application field is home monitoring. The costs associated with waiting times, unnecessary hospitalizations and basic checkups can be reduced with a focus on higher quality video streaming. A high resolution at minimal bandwidth cost is required to provide high quality healthcare to the most remote regions. The transmission of vital information through wireless networks to treat patients for medical preventive care or emergencies whether at their homes or in a medical institution, provides an efficient way to reduce the time and cost of treatment.

In this paper we will present a healthcare information system that uses healthcare databases, medical records, the routing of images/text/video and sound at a higher compression rate than the h.264 standard so that healthcare can be offered in any network. Also, we describe the application of newly released High Efficiency Video Coding for a cost effective real time interaction between patients in remote locations and physicians. The rest of the paper highlights the architecture of the proposed real time interactive telemedicine care system. Finally, the paper concludes with the proposal of an adaptive bitrate streaming algorithm that reduces the bandwidth requirement even further and future work on its ergonomics.

II. System Architecture

The system consists of two separate modules, the patient module (patient-unit) located with the patient, and the specialist's module (specialist-unit) located at the specialist's site. The specialist might be using the system remotely either for an emergency service or to monitor the patient.

A. Patient-unit

The P-unit is responsible for collecting and transmitting patient statistics and real time video stream to the specialist's location. An optimal PSNR (Peak Signal to Noise Ratio) for voice and video quality must be obtained in order to obtain a high quality of service. Data transmissions focus on content from desktop and mobile devices.

B. Specialist-unit

The S-unit is responsible for the interchange of data, and routing information to other S-units (specialists) with the teleconferencing support among group of specialists for the specific treatment. Data transmissions include file, image and video transfers, and vital health statistics of patients. The characteristics of each of these data streams can differ greatly and each traffic stream has to be processed differently.

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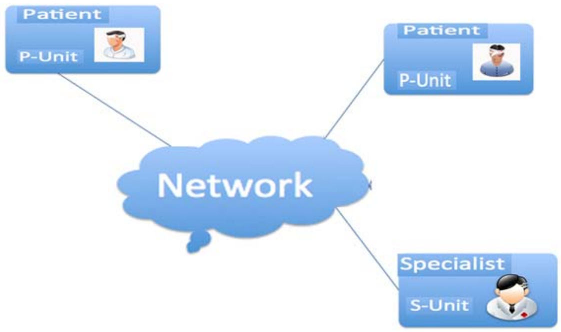

Figure 1. Overview of the System Architecture

III. Video Encoding

High Efficiency Video Coding (HEVC) has shown a major breakthrough with regards to compression efficiency. However, it comes with additional computational complexity cost. Experimental results show that HEVC can offer consistent performance gains over a wide range of bitrates [2]. A simulation was performed using Ericson's SVP 5500 H.265 Encoder and the H.264/MPEG-4 AVC compression standard where we made a comparison of results of some previous standards in the scenario of lossless image coding and noticed an improvement of up to 50% bitrate reduction. In this paper we will aim to increase the bitrate reduction by focusing on a specific region of interest on the frames.

A. Improvements over H.264

HEVC aims at doubling the compression ratio of H.264/AVC high profile with comparable image quality. It is targeted at the next-generation HDTV displays and can support display resolution from QVGA (320x240) up to (1920x1080) and 4320p(7680x4320). One of HEVC's various improvements over H.264 lies in the intra prediction performance, with more prediction modes for luma and chroma components for large range of block sizes (up to 64×64). Unlike h.264, the shape of its coding unit is not restricted to a square they are expressed in a recursive quadtree representation adapted to the picture, this provides a high degree of adaptability for both temporal and spatial prediction. At the same time, a leaf merging mechanism is included in order to prevent excessive partitioning of a picture into prediction blocks and to reduce the amount of bits for signaling the prediction signal [3].

B. Compression Challenges

Images captured by any camera can have a resolution of up to 8k and resolutions up to 8192×4320 pixel and are compressed using the HEVC compression algorithm; the resulting data set is approximately compressed twice as its predecessor H.264 at the expense of significantly higher computational complexity, compared to H.264/AVC, because of the added complexity to the encoder, the current H.265/HEVC draft contains several proposals aiming at reducing the processing time either through parallelism or efficient coding mechanisms [4].

D. Proposed Algorithm

In order to guarantee a clear channel of communication between users we propose an algorithm to dynamically adapt the bit-rate of the stream to varying network conditions. There are various approaches to adaptive streaming. We focus on a full duplex channel over http where the media file is subdivided into large segments over a number of intervals, where several segments will be sent in each interval. For each interval of time the first segment is transmitted at multiple bit-rates and the receiver is to identify the optimal bit-rate and acknowledge that bit-rate to the sender. Subsequently, the remaining segments for that interval are transmitted at the designated bit-rate. Our algorithm focuses on isolating a region of interest on the frame (normally the central region of the frame) and lowering the resolution of peripheral regions as depicted in Figure 2.

Normal Resolution Reduced Resolution

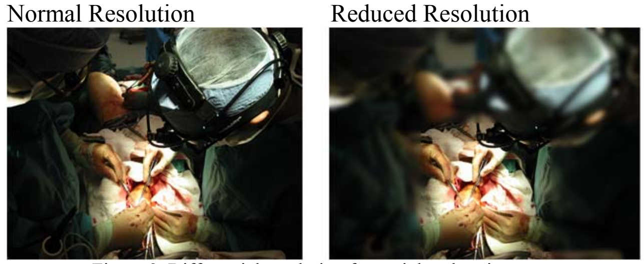
Figure 2. Differential resolution for peripheral regions.

IV. Conclusion & Future Work

The widespread availability of healthcare can improve the quality of service at understaffed rural or remote areas. This framework provides medical experts the ability to provide patients with immediate response that can help treat diseases on time and cost effectively. We will continue to test our algorithm that partially lowers the resolution and decreases/increases the size of a video stream. A secure transmission on video is required for emergency procedures, or any form of treatment where a visual feedback is required, our approach aims to further decrease the required bandwidth to secure a transmission between patient and physician. Further research and PSNR analysis are required for the quality of service and ergonomics for the integration of the adaptive bitrate stream algorithm in the framework.

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