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Application of Error-resilient Transmission of Sleep Apnea Patient Video with Sound over Mobile Network

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Abstract:

Mobile video-audio transmission systems have delivered patient video with relevant snoring sound to quantify the severity of the sleep apnea patient over wireless networks, but few have optimized video-audio transmission in combination with transmission protocol over error-prone environments using wireless links. In this paper, the performance of the MPEG (Motion Picture Expert Group)-4 error resilient tools with UDP(User Datagram Protocol) protocol were evaluated over a wireless network to suggest the optimum combination of MPEG-4 error resilient tools and UDP packet size suitable for real-time transmission of video-audio transmission over error-prone mobile networks. Through experimentation, it was found that the packet size should correspond to IP(Internet Protocol) datagram size minus UDP and IP header for optimal video-audio quality. Also, for error resilient tool selection, the combination of resynchronization marker and data partitioning showed the best performance.

Key-Words: - sleep apnea, video, audio, mobile

I. INTRODUCTION

Advances in mobile communication technology have enabled the access of patient video-audio information without the limitations of time or location. Mobile technology can offer continuous, uninterrupted, and instant service to ultrasound application domain. However, the current bandwidth of the mobile network is not sufficient to transfer patient video data requiring high throughput. Besides the bandwidth of the mobile network, the high error rates due to multipath fading should be taken into consideration to sustain, video transmission in mobile transmission systems [1].

MPEG-4 has been successfully applied to many types of mobile applications [2]. Some pioneering telemedicine applications of MPEG-4 can give insight into the compression efficiency for patient video streaming over the limited bandwidth of the mobile network [3,4]. However, the error resilient tools of the MPEG-4 standard, which are important for error-prone mobile applications, have rarely been researched, particularly for use in mobile transmission applications. In addition to compression, an efficient data transmission protocol should also be considered for real-time video streaming. Between the two well-known network protocols, TCP(Transmission Control Protocol) and UDP(User Datagram Protocol), UDP is much more suitable for real-time streaming because it uses simple datagrams with no congestion control [5]. Nevertheless, little research has been conducted to comprehensively validate the efficacy of the MPEG-4 error resilient tools in combination with the UDP protocol when applied to a mobile video-audio system.

II. ERROR RESILIENCE IN MPEG-4

MPEG-4 [2] provides error resilient tools to enable robust transmission of compressed ultrasound video over error-prone mobile networks, which are subject to Rayleigh fading and burst errors as a result of multipath propagation [6]. MPEG-4 employs four types of error resilient tools to enable resynchronization, error detection, data recovery, and error concealment: resynchronization markers (RMs), data partitioning (DP), reversible variable length coding (RVLC), and header extension code (HEC).

III. EXPERIMENTATION

3.1. Data Transmission Format

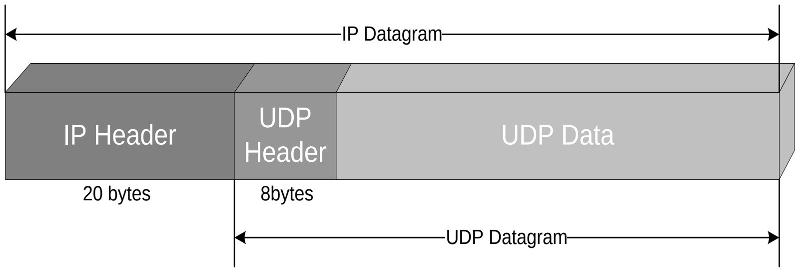


Fig. 1. Encapsulation of a UDP datagram within an IP packet

An MPEG-4 bit stream composed of a series of video packets is encapsulated into an IP datagram using the UDP protocol. As shown in (Fig. 1), an IP datagram consists of UDP data corresponding to the fragmented MPEG-4 bit stream data, 8 bytes of UDP header and 20 bytes of IP header. A total of 28 bytes of overhead is created by the attached headers [5]. Particularly, the UDP protocol drops the whole UDP datagram when corruption of the UDP datagram is detected by the checksum field within the UDP header.

3.2. Experimentation

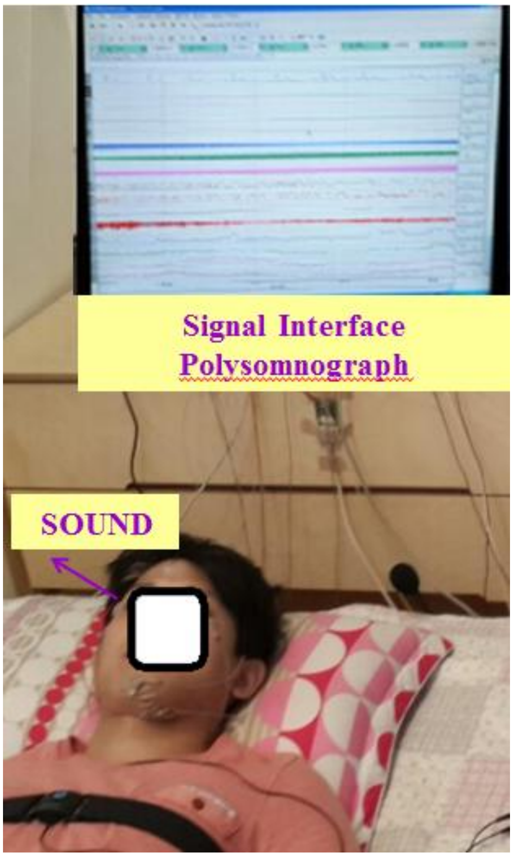


Fig. 2. A typical image extracted from a patient video with audio and signals interface for experimentation

Measurements were taken for 7 days at the Seoul metropolitan area. As shown in (Fig. 2), 30 seconds of captured video-audio were repeatedly used for each measurement. The output bit rate of the MPEG-4 encoder (spatial resolution of 320x240, frame rate of 4 frames/sec, and key-frame period of 2 sec) was set to 80 Kbps, considering a measured mean bit rate of 100 kbps for the reverse link [7] and an MPEG-4 decoder buffer margin of 20 kbps for network jitter compensation. Because of the interrelation between the error resilient tools (for example, RVLC should only be used in conjunction with DP), and the header's relative importance compared to other streaming data, three different combinations of error resilient tools were considered, all utilizing HEC: RM only, RM with DP, and RM with both DP and RVLC. At the MPEG-4 decoder, an error concealment technique was employed before evaluating video quality. In particular, when the frame drop occurred due to a burst error, the dropped frame was replaced by the previous frame. The MPEG-4 simple profile with error resilient tools was implemented by mpegable Video SDK (Dicas Co., Germany) [8].

IV. RESULT

In order to analyze the error effect of the wireless networks with respect to different IP datagram sizes (corresponding to UDP datagram sizes), the IP datagram size was varied between 200 and 5000 bytes. As shown in (Fig. 3), the DLR increased as IP datagram size increased, because UDP discards the entire datagram regardless of the amount of corruption when an error is detected within. As the size of the IP datagram increased, the percentage of UDP data increased relative to the headers (with a fixed size of 28 bytes), Thus, PSNR increased as the size of the IP datagrams increased.

When the compressed bit stream is not contaminated by error (before transmission) as shown in (Fig. 4a), the highest PSNR can be obtained without using any error resilient tools. Moreover, the PSNR decreases as more MPEG-4 error resilient tools are employed. (The use of headers is unavoidable if any error resilient tool is employed.) Thus, for fixed-size bits, the bits allocated for a patient video can be decreased if the bits allocated for headers are increased. Particularly, the abrupt change in PSNR for the case using RM with both DP and RVLC is due to fact that the prefix for RVLC requires additional space compared to RM and DP.

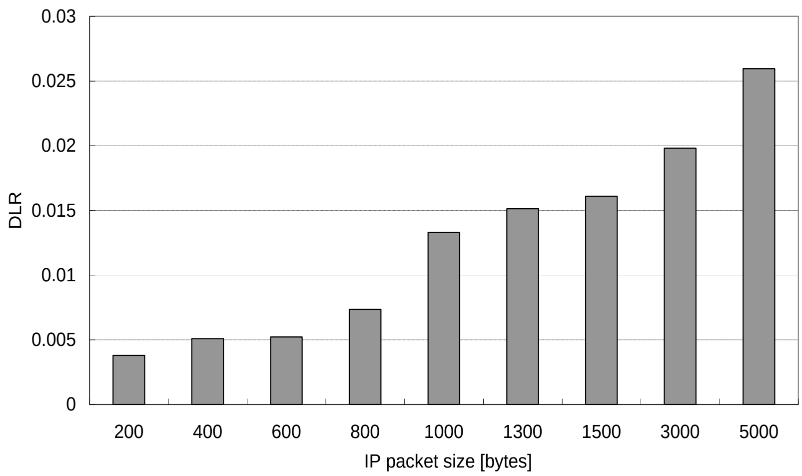
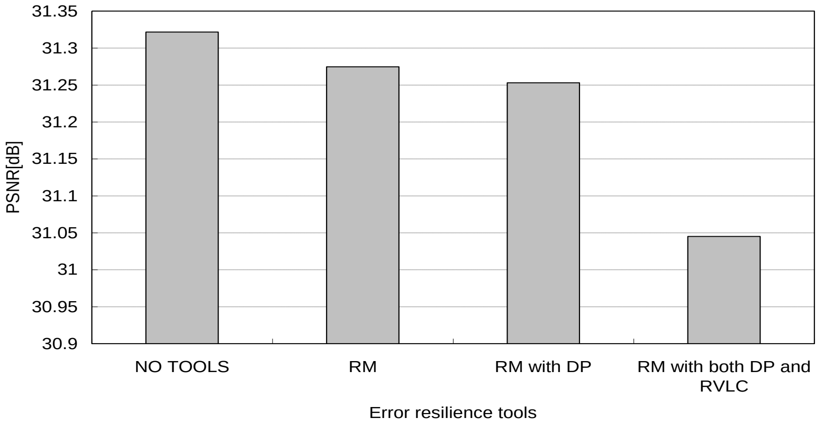


Fig. 3. Datagram Loss Rate(DLR) in terms of IP datagram size after mobile transmission

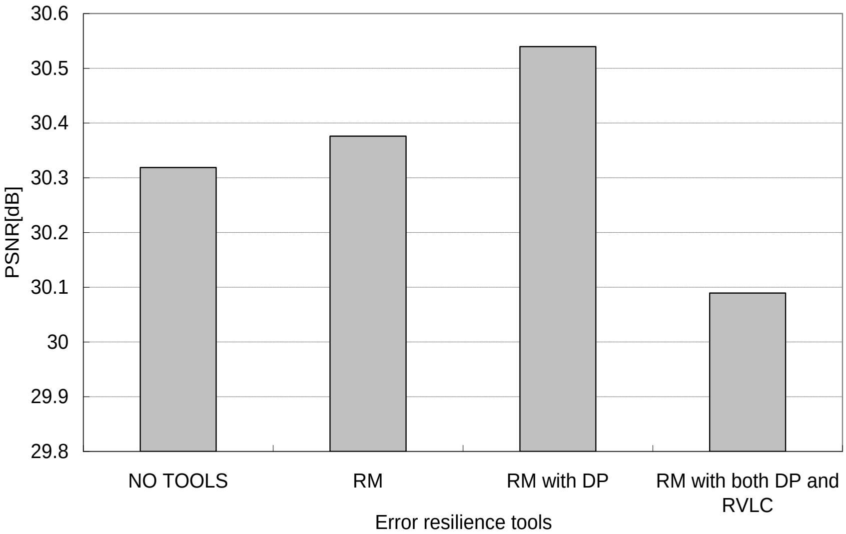
When the compressed bit stream is contaminated by error because of bit stream transmission over the cellular network, as shown in (Fig. 4b), RM with DP shows the highest PSNR. Since the PSNRs for RM only and for RM with DP are higher than that for case of no error resilient tools, MPEG-4 compression with error resilient tools (except RVLC) is more suitable for mobile applications than without error resilient tools. Particularly, lower coding efficiency with added prefix and complicated decoding logic for RVLC resulted in the worst PSNR performance, as shown in the case using RM with both DP and RVLC.

V. CONCLUSION

The selection of an appropriate error resilient video compression method might be a primary concern in designing a mobile video-audio transmission system running over a mobile network with limited bandwidth. Among the many standard video compression methods available, MPEG-4 can be regarded as one of the most appropriate for compressing video data for transmission over a mobile network, because MPEG-4 offers high compression at a low bit rate and useful error-resilient tools [6]. In addition to the compression method, a transmission protocol, either TCP or UDP, should also be taken into consideration when transmitting a compressed bit stream over an IP-based mobile network [9]. For real-time video-audio transmission over an error-prone mobile network, the conditions required to select the transmission protocol are the capability for real-time streaming and tolerance to frame loss [10].



(a)



(b)

Fig. 4. PSNR with respect to different combinations of error resilient tools a) before mobile transmission b) after mobile transmission

TCP is unsuitable because the retransmission mechanism it uses to guarantee reliable transmissions violates the real-time streaming condition. Hand-offs and burst errors often mistakenly trigger TCP's retransmission mechanism, which can unpredictably increase the transmission delays. Contrary to TCP, UDP is appropriate for error prone mobile networks because it is a relatively "unreliable" protocol. It employs simple datagrams with no retransmission control. When an error occurs, UDP simply drops the frame [11]. Hence, MPEG-4, when used in combination with the UDP protocol, can be successfully applied to transmit ultrasound video data in real time over error-prone mobile networks with limited bandwidth.

In this paper, the performance of the MPEG (Motion Picture Expert Group)-4 error resilient tools with UDP(User Datagram Protocol) protocol were evaluated over a wireless network to suggest the optimum combination of MPEG-4 error resilient tools and UDP packet size suitable for real-time transmission of video-audio transmission over error-prone mobile networks. Through experimentation, it was found that the packet size should correspond to IP(Internet Protocol) datagram size minus UDP and IP header for optimal video-audio quality. Also, for error resilient tool selection, the combination of resynchronization marker and data partitioning showed the best performance.

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