

Study on Efficient Telemedicine System Design for Ambulance Emergency Situation

Young-Hyuk Kim, Il-Kwon Lim and Jae-Kwang Lee, *Member, KIMICS*

Abstract—Telemedicine system means a remote support system among 4 remote telemedicine services of u-Health. A currently available service in Korea is the one checking and maintaining patient's status and supporting in emergency through video communication between an ambulance transferring patients and hospital under HSDPA and WiBro environment with coding of MPEG-2 and MPEG-4. With that, this paper improves the stability of the current telemedicine system service of ambulance confirms the improvement compared to the old system by generating a system communicating by RTP/RTCP under coding process through H.264/AVC after converting RGB video to YUV in order to improve network efficiency.

Index Terms—u-Health, Emergency Monitoring, H.264/AVC.

I. INTRODUCTION

U-HEALTH, an abbreviation of ubiquitous health, is an integrated concept of Healthcare and Wellness. It can be defined as a service system or environment supplying health care services of prevention, diagnosis and post-management anytime and anywhere by combining medical industry and IT. U-Health is an ideal health care system to ensure human's healthy life by systematically connecting health care providers and beneficiaries [1].

U-Health divides telemedicine services roughly into telemedicine, remote monitoring, tele-consultation and remote support in terms of service types. Currently, the domestic medical law only allows remote support a patient can be supported by practitioners in a remote place through communication when the patient is unable to access medical service because of geological isolation or a harsh environment[2]. Therefore, this paper suggests real-time communication system based on videos, which applying H.264/AVC (Advanced Video Coding)[3] to telemedicine support situations of ambulance transferring emergency patients, where U-Health is currently utilized without breaching the medical law.

Telemedicine System used in an ambulance enables a doctor at a remote place to identify the patient status through video and supply remote support at emergency. This paper suggests a target system of stable telemedicine service efficiently and quickly transmitting videos under the currently available communication method HSDPA(High Speed Downlink Packet Access) and WiBro environment with limited and low transmission speed, by designing real-time video communication system using RTP(Real-Time Transport Protocol)/RTCP(Real-Time Transport Control Protocol) technology the most widely used tech in communication system converting the videos acquired in RGB to YUV and transmitting them after coding process through H.264/AVC.

II. RELATED STUDIES

We have seen a lot of active both domestic and overseas studies and researches regarding u-Health market on governmental and private levels.

A. u-Health Trend

1) U.S.

The U.S. government, which has been initiating policies supporting U-Health, established a telemedicine specialized organization, ATA(American Telemedicine Association) in 1993 and legislated a law for exchanging medical information, HIPPA(Health Insurance Portability and Accountability Act) in 1996 and federal telemedicine corporation, HIT(Health Information Technology) in 1997[4]. Private enterprises of ICT(Information & Communication Technology) have utilized them under partnership.

- 1.1) *Sprint*: has a strategy of GE Healthcare supplying equipment and Sprint supplying wireless network based on partnership with GE Healthcare.
- 1.2) *Verizon*: has Verizon Business and Wireless healthcare project teams among 3 projects, supported by marketing healthcare group.
- 1.3) *Deutsche Telecom*: supplies Home monitoring telemedicine service through partnership with Philips, a medical device specialized company.

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2) Japan

u-Health is referred as the same concept with telemedicine in Japan. Starting as CCTV and telephone wires in 1971 to provide medical care in back regions in Okayama-ken and being developed into remote support at disaster using communication satellite and ISDN in 1980s, telemedicine then expanded followed by MHLW(Ministry of Health, Labour and Welfare)'s regulation determining telemedicine using Info & communication equipment to conform with Doctors Act in Dec. 1997. The public's usage of telecommunication survey of MIAC(Ministry of Internal Affairs and Communications) in 2001 showed 43.2% of population used medical care through video screens.

3) Domestic trend

Domestic trend with perspective of seeing u-Health as a representative integral new industry and strong drive to facilitate u-Health, the government presented 'Medical Act Amendment' approving telemedicine in April and proposed a bill of 'Health Care Service Law' allowing preventive health care based on personal health status in May in order to improve legal and institutional systems which have so far limited u-Health market. In addition, SKTelecom consortium including Samsung Electronics and SNU(Seoul National Univ.) Hospital and LG consortium including LGTelecom and Gangnam Severance Hospital participated in 'Smart Care Pilot Project' organized by Ministry of Knowledge Economy[5]. Seoul city also introduced and invested in remote video emergency medical system as a 5 year project starting from 2006. The fire department of Pusan city has been already operating remote video first aid services as a part of U-119 emergency medical service since 2007 and Siheung city has dispatched ambulances applied with telemetry system in places patients of serious cases frequently transferred since Feb in 2010 while using HSDPA/WiBro for info transmission.

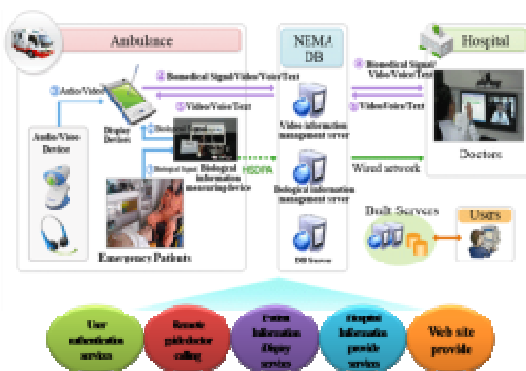


Fig.1. Concept Diagram of Remote Video First Aid Services in Pusan city



Fig.2. Concept Diagram of Telemetry in Siheung city

B. Real-time video communication system

1) RTP/RTCP: video communication systems generally use RTP and RTCP based on UDP (User Datagram Protocol) to transmit real-time data.

1.1) RTP Packet: RTP Packet contains media and basic info on media and the packet includes marker bit, sequence number and timestamp[6].

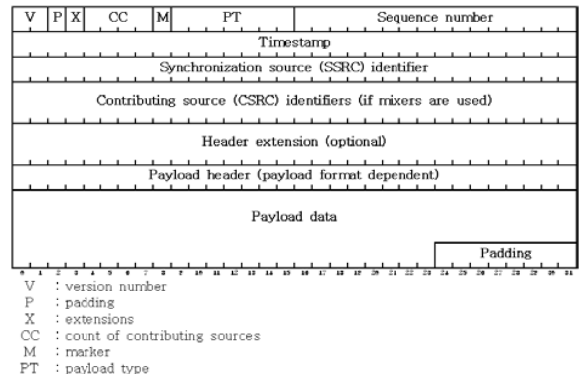


Fig.3. Structure of RTP Packet

1.2) RTCP Packet: RTCP Packet is divided into 5 elements: RR (Receiver Report), SR (Sender Report), SDES (Source Description Message), APP (Application Specific RTCP) and BYE (Bye Message). SR and RR packets are related to transceiver, SR is distinguished from RR, having 20 bytes of sender info section[7].

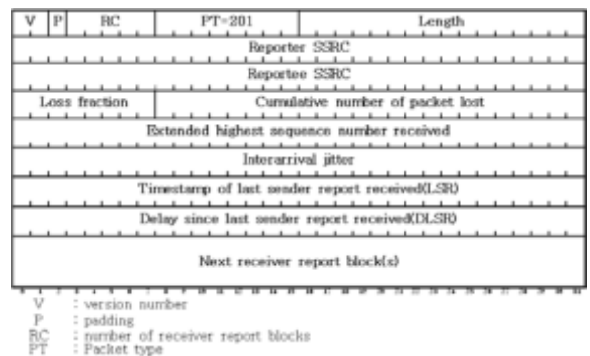


Fig.4. Structure of RTCP RR Packet

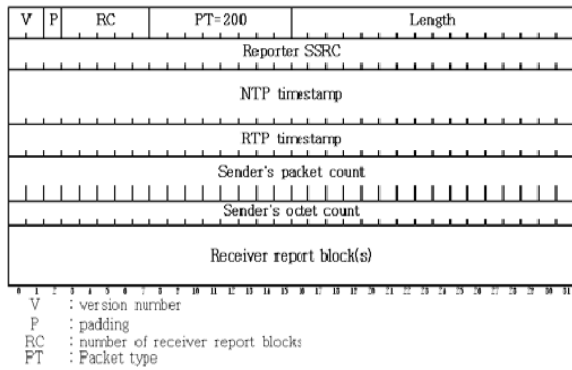


Fig.5. Structure of RTCP SR Packet

III. TELEMEDICINE SYSTEM DESIGN

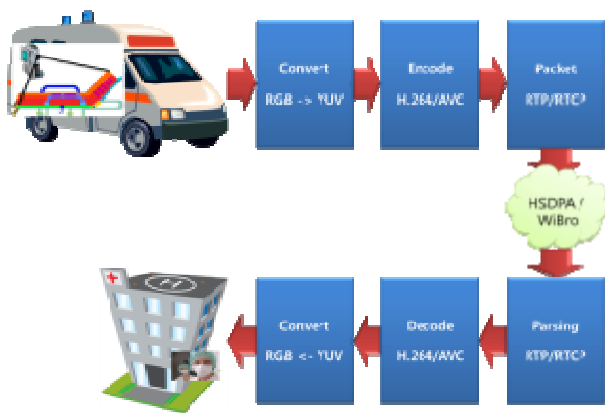


Fig.6. Overall Telemedicine System Operation Processes

A. How to Acquire Videos

Image sensors such as CCD(Charge Coupled Device) or CIS(CMOS Image Sensor) have a structure acquiring not all the elements but only one element of elements R, G and B for one pixel. R, G and B sampling patterns on image sensor surface are called as Bayer pattern, we sampled element G in the ratio of two to one compared to elements R and B since element G is most sensitive to human vision due to its largest frequency range[8]. Fig. 7 illustrates the color filter array on image sensor surface by Bayer pattern[9].

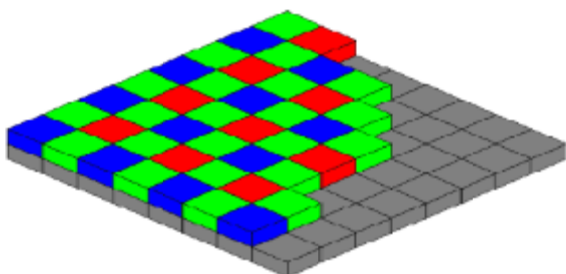


Fig. 7. Bayer array architecture on the image sensor surface

ISP(Image Signal Processor) is a term generally referring to the hardware which converts and outputs image data of Bayer pattern to YUV data necessary for JPEG/MPEG. Thus, ISP primarily includes the color interpolation process restoring other color component in need from insufficient color component-, the process of converting this to YUV color system, color correction process converting the color distribution of image sensor to color distribution of human perception and gamma correction process compensating nonlinearity of image sensor or display device. Fig. 8.illustrates the block diagram of simplified ISP[10],[11].

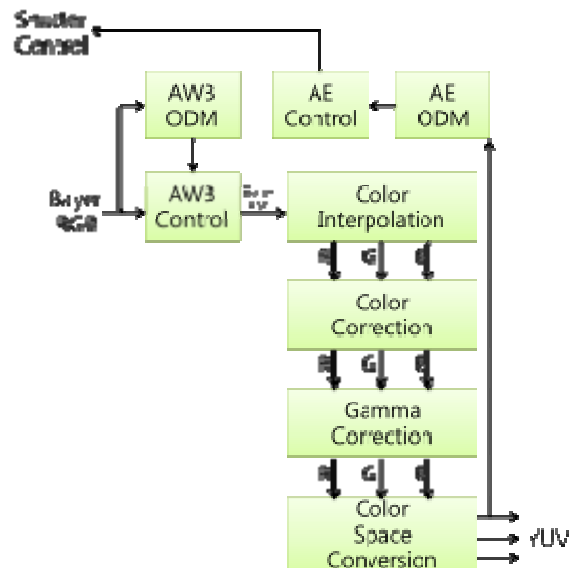


Fig. 8. Conventional ISP architecture

The image acquired by web-cam basically has the RGB format. Thus, this system goes through the conversion[12] process to YUV(4:2:2) format, instead of using 24frames/sec image for efficient compression due to the following reasons. In case of YUV, color info and lightness info are differentiated in three channels to express the color of one pixel with Y channel(LumaComponent) representing the color's light and shade and U·V channel(Chrominance Components) being a color model simultaneously determining the color. 3 hues are evenly applied in RGB format while YUV compresses during sub-sampling or quantization process. Since human eye is not sensitive to color info, compression rate can be increased without having humans aware of much difference in picture quality.

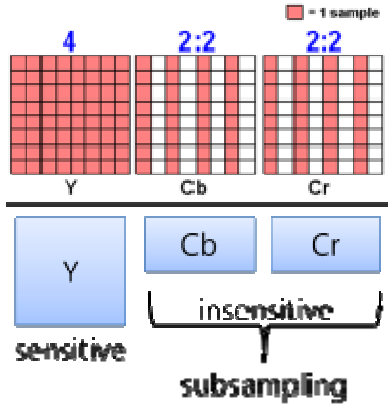


Fig. 9. YUV(YCbCr) character

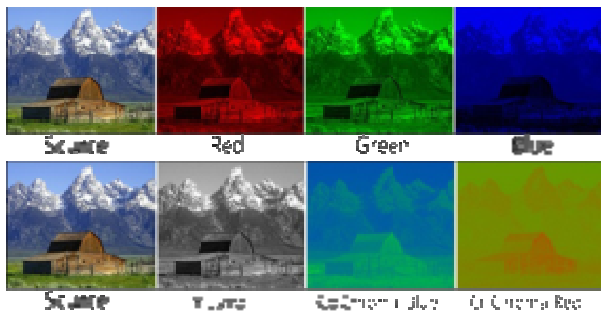


Fig. 10. RGB and YUV(YCbCr)

Thus, YUV(4:2:2) format can provide approx. 33% better efficiency in image transmission resulting in higher transmission speed at network; therefore, it is used as a conversion process for faster image transmission under low transmission speed of an ambulance TSS in combination of HSDPA and WiBro. Pre-processing from acquiring image to converting files used OpenCV(Opensource Computer Vision) Library function.

- RGB -> YUV Conversion Formula

$$\begin{bmatrix} Y \\ Cb \\ Cr \end{bmatrix} = \begin{bmatrix} 0.299 & 0.587 & 0.114 \\ -0.16874 & -0.3313 & 0.500 \\ 0.500 & -0.4187 & -0.0813 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} + \begin{bmatrix} 0 \\ 128 \\ 128 \end{bmatrix}$$



Fig. 11. Pre-processing[14]

B. Video Coding

H.264/AVC coding technology is used for video coding. H.264/AVC tech, the Standard co-developed and released by JVT (Joint Video Team) co-established by ISO/IEC and ITU-T, is the video coding standard with the best

compression function ever among video compression technologies. H.264/AVC tech uses the similar basic compression flow from H.263[13] and MPEG-2[14] to MPEG-4[15] video, yet changes a great deal of detailed algorithm[16]. There is H.264/SVC(Scalable Video Coding) with more efficient operation in terms of H.264/AVC network channel capacity. Note that, however, SVC requires higher Bit-rate than AVC when ensuring the same quality and has overhead of 10~30%[17]. Thus, under the current network environment, SVC is less efficient than AVC[18]. Therefore, we excluded some functions such as complicated object coding-which is implemented in MPEG-4 and scalability and applied H.264/AVC with high compression rate, enhanced time delay which can be applied to multiple services, network-friendliness, and error endurance. H.264/AVC has 2~3 times greater coding efficiency than MPEG-2 and more than 1.5~2 times than MPEG-4. MPEG-2 is widely used for digital broadcast MPEG-4 for image transmission for cell phones and H.264/AVC for mobile communication terminal applications such as DMB which requires higher compression rates[19].

IV. IMPLEMENTATION & EXPERIMENT

Fig. 12.shows the screen where a real system is implemented based on our design. In addition to the image defined above, we built interface related to patient’s cardiac to transmit more accurate status of patient and this experiment demonstrated values hypothetically defined in advance.

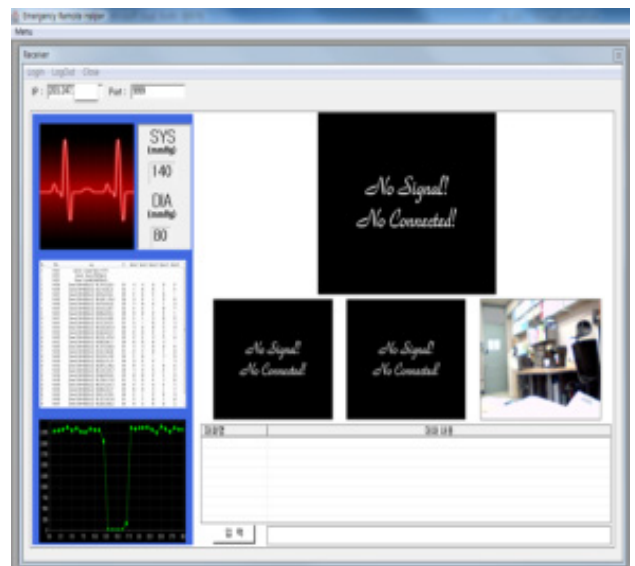


Fig. 12. Telemedicine System Interface

We created an experiment environment shown as in TABLE I to compare it with the old system.

TABLE I
EXPERIMENT ENVIRONMENT

Device	Configuration
Server	CPU : Quadcore 2.4GHz RAM : 4GB Network : UpLink : 3Mbps DownLink : 5Mbps
Client	CPU : Dualcore 2.4GHz RAM : 1GB Network : UpLink : 384Kbps DownLink : 2Mbps

The communication environment was fixed at 384Kbps, the uploading speed of HSDPA. The result values obtained through MPEG-4 coding image transmission of RGB method and H.264/AVC image transmission of YUV method are shown in TABLE II.

TABLE II
EXPERIMENT RESULT

	Configuration
Old system	Interval Transfer Bandwidth
	0-14sec 47.4KBytes 388Kbits/sec
	1-2sec 47.4KBytes 388Kbits/sec
	2-3sec 45.9Kbytes376Kbits/sec
	3-4sec 47.4Kbytes388Kbits/sec
	4-5sec 47.4Kbytes388Kbits/sec
	5-6sec 45.9Kbytes376Kbits/sec
	6-7sec 47.4Kbytes388Kbits/sec
	7-8sec 47.4Kbytes388Kbits/sec
	8-9sec 45.9Kbytes376Kbits/sec
	9-10sec 47.4Kbytes388Kbits/sec
	0-10sec 471 Kbytes 384 Kbits/sec
	2.013 ms, Sent 328 datagrams
Improved system	Interval TransferBandwidth
	0-1sec 47.4 Kbytes388 Kbits/sec
	1-2sec 47.4 KBytes388 Kbits/sec
	2-3sec 45.9 KBytes376 Kbits/sec
	3-4sec 47.4 KBytes388 Kbits/sec
	4-5sec 47.4 KBytes388 Kbits/sec
	5-6sec 45.9 KBytes376 Kbits/sec
	6-7sec 47.4 KBytes388 Kbits/sec
	7-8sec 47.4 KBytes388 Kbits/sec
	8-9sec 45.9 KBytes376 Kbits/sec
	9-10sec 47.4 Kbytes 388 Kbits/sec
	0-10sec 471 KBytes384 Kbits/sec
	1.250 ms, Sent 328 datagrams

The results showed that our improved system has 62% of improvement compared to the old system.

Finally, we used DSIS (Double-stimulus impairment scale) method to identify any difference in picture quality awareness from old RGB and YUV when our designed image was shown to a receiver. DSIS, a subjective assessment of picture quality, is used to assess quality degradation caused by any picture impairments occurred in a new system or transmission process [20].Configured

assessment as the survey is shown in TABLE IIIfor image quality.

TABLE III
SCORE CHART OF DSIS

Content	Score	Your Check
Very difficult to recognize	1	
Difficult to recognize	2	
A bit difficult to recognize	3	
Regardless their difference, no difficulty in recognition	4	
Do not feel any differences	5	

The result of 10 participants in DSIS survey is shown in Fig. 13.

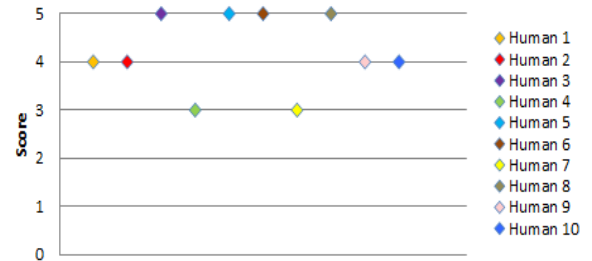


Fig. 13. DSIS research result

IV. CONCLUSIONS

This paper studied, among U-Health services, the telemedicine system in an ambulance when transferring emergency patients, which does not breach domestic Medical Laws. Our study confirmed that telemedicine system enhanced image channel efficiency by converting picture taped through camera in an ambulance in RGB format to YUVnetwork friendly H.264/AVC coding with higher compression rate compared to old MPEG-4 made telemedicine system more stable under the applied communication tech, that is HSDPA/WiBro environment and furthermore, subjective assessment showed no difference in picture quality even after changing formats.

We believe that faster wireless communication application would be required since most mobile telemedicine system currently applied and in use in Korea use HSDPA andWiBro. Thus, we suggest that further studies on whether mobile telemedicine servicecan be applied using Wi-Fi, which are rapidly growing in domestic Telco's and more studies on appropriateness of H.264/SVC under Wi-Fi, which is dozens of times faster than HSDPA/WiBro.

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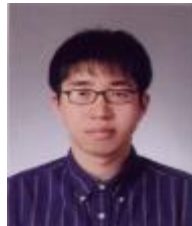
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