Evaluation of Wireless Teleradiology System for Emergency Care with Mobile Network.

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Introduction

❖ Background

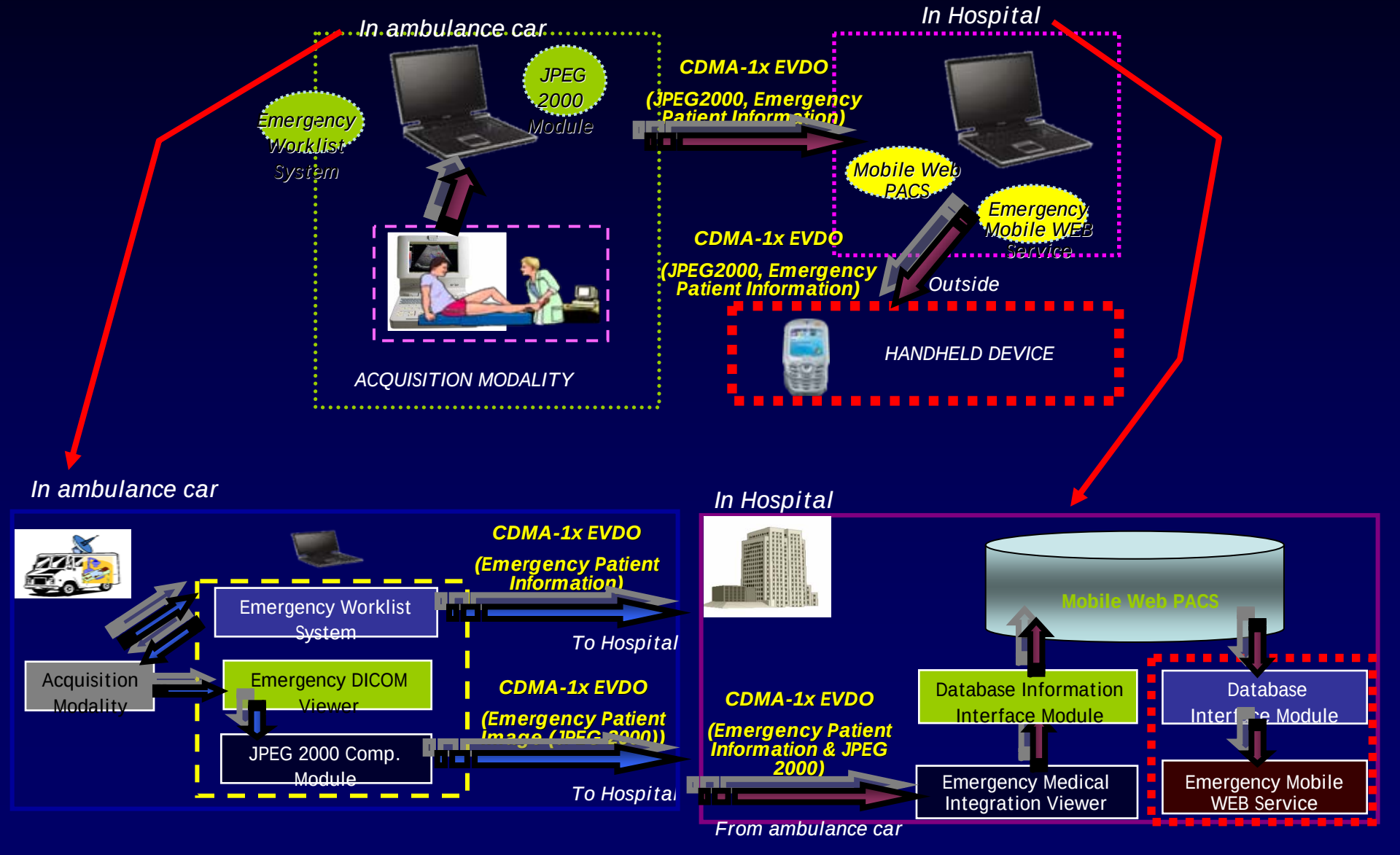
- Recently, study about Emergency Medical Information System is actively in progress to improve quality of Emergency Medical diagnosis.
- Study about Installation of Portable acquisition modality in ambulance car is also in progress.
- Although, the exact and rapid consultation from medical specialist is necessary to further treatment… especially for emergency surgery..
- If the specialist is in outside of hospital in that time, → Can not perform next treatment process!!
- If using wireless LAN based PDA, it is impossible to read the images where access point (AP) is not exist.
- Recently, the technique and infrastructure of commercial wireless network such as CDMA-1x EVDO have been dramatically promoted.

❖ Objective

- In this study, we designed a wireless mobile emergency patient information and imaging communication system using CDMA-1x EVDO service based personal digital assistant (PDA) phone for emergency care.
- And we evaluated the performance of this system which is a Wireless Teleradiology System for Emergency Care with Mobile Network

Materials and Methods

❖ System Layout



Materials and Methods

❖ System Layout

❖ Material

❖ Development Environment

Emergency Worklist System

- ❖ *Microsoft Visual C++ 6.0 (Microsoft, USA)*

JPEG2000 Compression Module & Emergency Info. Viewer :

- ❖ *Microsoft Visual C++ 6.0 (Microsoft, USA)*
- ❖ *Lead tool JPEG2000 SDK (Lead tool Corporation, USA)*

Mobile Web PACS:

- ❖ *Microsoft Access 2003 (Microsoft, USA)*

Mobile Web Service Module:

- ❖ *Microsoft Visual Studio .NET 2003 (Microsoft, USA)*
- ❖ *Embedded Visual C++ 4.0 (Microsoft, USA)*
- ❖ *Microsoft Window 2003 Server (Microsoft, USA)*

RW6100, LG Electronics, Korea

- *Intel Bulverde PXA270 520 MHz Processor*
- *Windows Mobile 2003 SE (Second Edition)*
- *128M Intel State Flash ROM*
- *240 x 320 pixels*

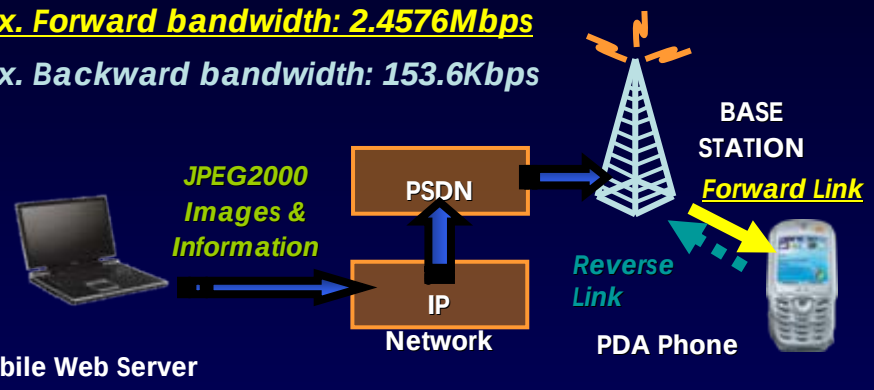
- *Support both Wireless local area network (WLAN) and CDMA 1x EVDO service*

Materials and Methods

❖ Forward Link vs. Reverse Link

CDMA2000 1x EVDO has asymmetric data rate structure.

- Max. Forward bandwidth: 2.4576Mbps
- Max. Backward bandwidth: 153.6Kbps



❖ System Evaluation

Transmission Time Measurement

- for evaluation about medical image application in the Mobile Network
- from emergency car and hospital
- from hospital and outside
- using X-Note Express LW20-EV3MK (CDMA -1x EVDO Support)

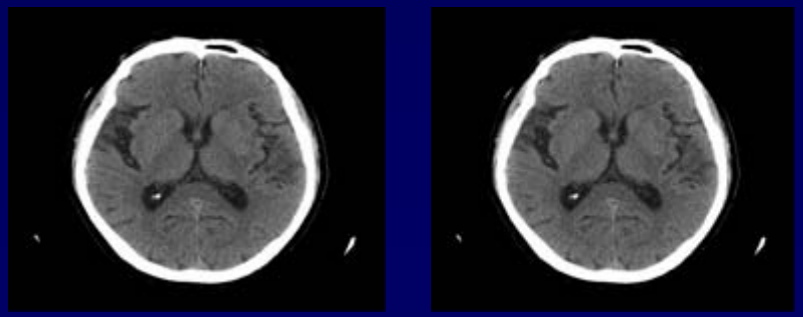
❖ System Evaluation

- Transmission time of JPEG 2000 image on the PDA phone was measured using our system outside hospital.
- PSNR measurement according to JPEG2000 Compression Ratio of Medical image Compression
- Evaluation of Medical Image Compression

❖ System Evaluation

PSNR (Peak Signal to Noise Rate)

- for evaluation image usability according to compression ratio using mathematical factor
- Using PSNR measurement function which is included in Aware Image Compression Factor Measurement System



Original image : JPEG2000 Image

Materials and Methods

❖ System Evaluation

Test Images were selected..

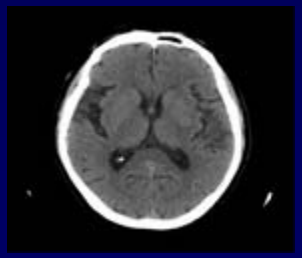
- For measurement of PSNR
- brain axial and sagital CT Images (512x512 -16bit)

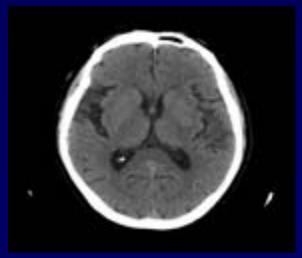
Compression Ratio was.. (for each image)

- 5:1, 10:1, 15:1, 20:1, 25:1, 30:1, 35:1, 40:1, 45:1, 50:1 and 100:1

Evaluation of Medical Image Compression

- using both DICOM image and JPEG2000 image (according to Compression Ratio)
- brain CT image (512x512, 16bit) – 12 case study(360 images)
- Desktop Environment vs UMPC, PDA Phone





Original image : JPEG2000 Image

❖ System Evaluation

Evaluation Method of Medical Image Compression

- Implementation Alberta Stroke Program Early CT Score (ASPECT) Test to evaluate medical image diagnosis possibility (Random)
- One radiologist
- Wilcoxon signed rank test – Statistic Process Method

Evaluation of Medical Image Compression

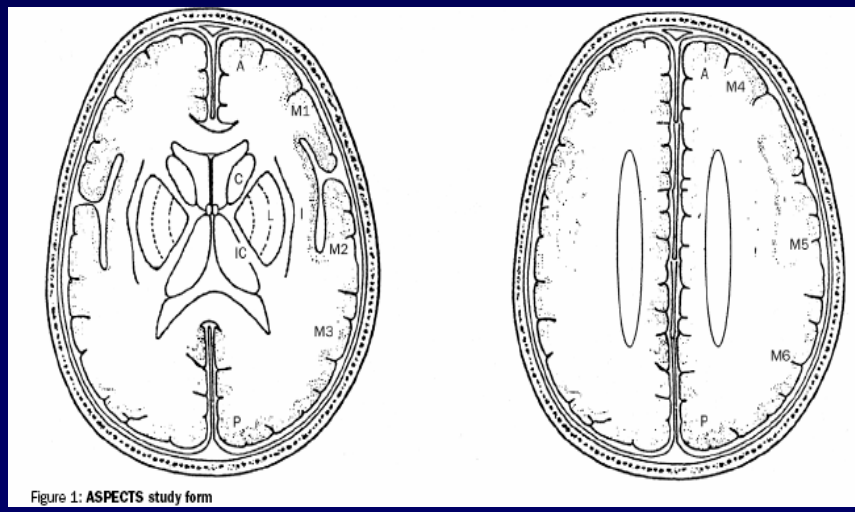
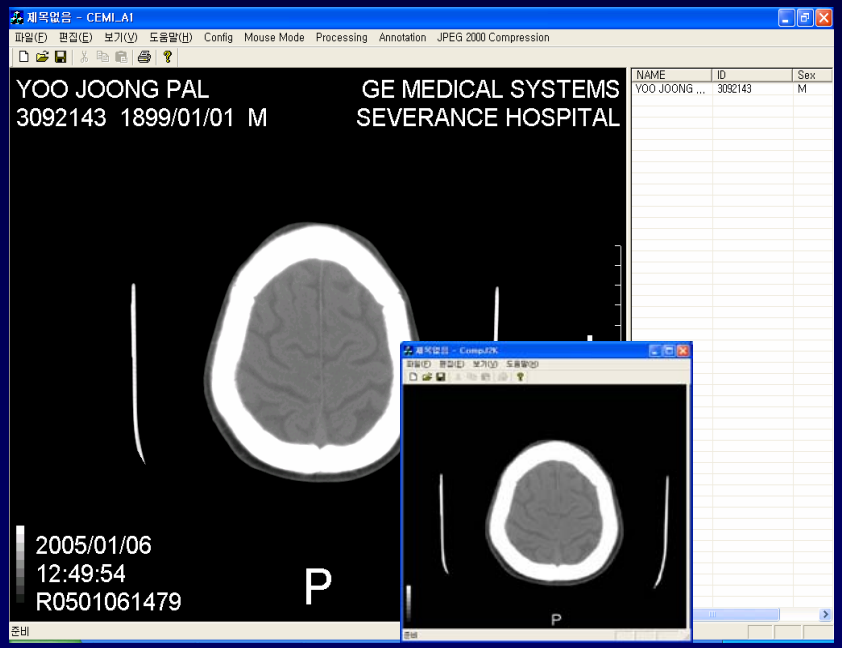


Figure 1: ASPECTS study form

Results

❖ JPEG2000 Transmission Module

- Compress DICOM images from acquisition modality to JPEG2000 files and Send JPEG 2000 Image to the hospital

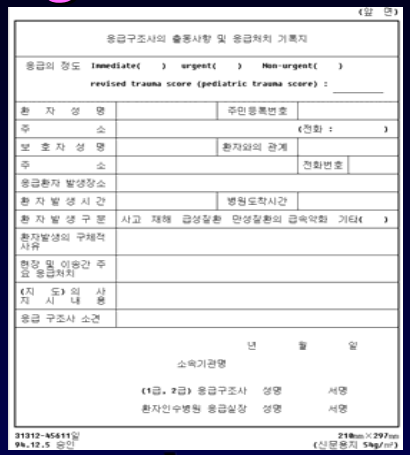


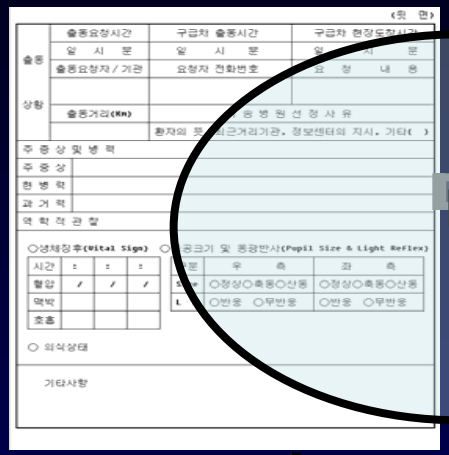
❖ Emergency Medical Integration Viewer

- View Emergency Patient Information and JPEG 2000 Image
- Storing Emergency Patient Information & JPEG 2000 image to Mobile Web PACS of the hospital

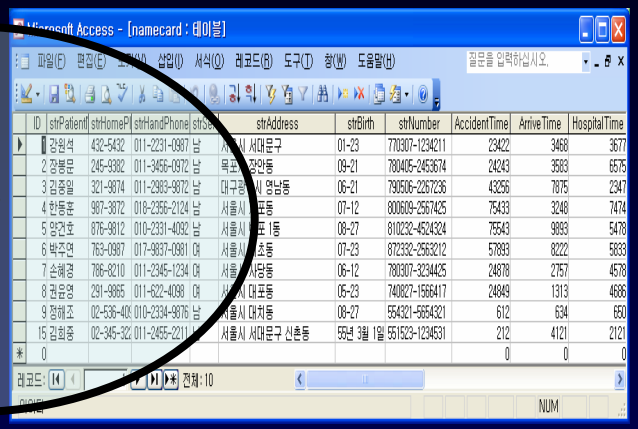
Results

❖ Design of Mobile Web PACS



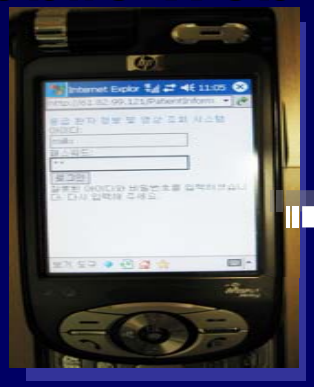


Structure of Emergency Patient Information



Design of Database using Access

❖ EM Mobile Web Service using PDA Phone



Login Process

EM Patient List

EM Patient Info.

Image View

Results

❖ PSNR (Peak Signal to Noise Ratio)

Ratio	PSNR	Ratio	PSNR
5:1	52.64±0.22	35:1	25.36±0.47
10:1	40.54±0.17	40:1	24.18±0.53
15:1	34.96±0.07	45:1	23.35±0.64
20:1	31.12±0.25	50:1	22.70±0.32
25:1	28.44±0.40	100:1	19.08±0.55
30:1	26.47±0.24		

❖ Evaluation of Medical Image Compression

	M1	M2	M3	M4	M5	M6	C	L	IC	I	Total
2556249	1	0	0	0	0	0	0	0	1	0	2
3021141	1	1	1	1	1	1	1	0	1	0	8
3092143	1	1	1	1	1	1	1	0	1	1	9
3756925	1	1	1	1	1	1	1	1	1	0	9
3784945	1	1	0	1	1	0	1	0	1	0	6
4124531	0	0	0	0	0	0	0	0	1	0	1
4157412	1	1	1	1	1	1	1	1	1	0	9
4172456	0	0	0	0	0	0	0	0	1	0	1
4189776	1	1	1	0	0	0	1	1	1	0	6
4243230	1	1	1	1	1	1	1	1	1	1	10
4243232	0	1	1	1	1	1	1	1	1	0	8
4262154	1	1	1	1	1	1	1	0	1	0	8

The ASPECT test result of original image

❖ Transmission Time

Ratio	File Size	Theoretical Trans. Time (s)	Actual Trans. Time (s)
Original	543kB	1.78s (at 2.4Mbps)	5.43±1.22s
5:1	36.4kB	0.11s (at 2.4Mbps)	1.93±0.22s
10:1	24.1kB	0.08s (at 2.4Mbps)	0.65±0.07s
30:1	12.9kB	0.04s (at 2.4Mbps)	0.44±0.03s
40:1	9.87kB	0.03s (at 2.4Mbps)	0.22±0.02s
50:1	7.59kB	0.02s (at 2.4Mbps)	0.19±0.02s
100:1	4.45kB	0.01s (at 2.4Mbps)	0.14±0.02s

The result of average transmission time of various compression ratios from hospital to PDA Phone – brain CT image (attempt number = 30)

❖ Transmission Time

Ratio	File Size	Theoretical Trans. Time (s)	Actual Trans. Time (s)
Original	543kB	28.1s (at 154Kbps)	39.11±6.11s
5:1	36.4kB	1.93s (at 154Kbps)	5.21±0.09s
10:1	24.1kB	1.54s (at 154Kbps)	3.89±0.03s
30:1	12.9kB	0.97s (at 154Kbps)	2.26±0.04s
40:1	9.87kB	0.73s (at 154Kbps)	2.13±0.03s
50:1	7.59kB	0.42s (at 154Kbps)	1.98±0.03s
100:1	4.45kB	0.33s (at 154Kbps)	1.88±0.02s

The result of average transmission time of various compression ratios from ambulance car to hospital – brain CT image (attempt number = 30)

Results

❖ Evaluation of Medical Image Compression

	M1	M2	M3	M4	M5	M6	C	L	IC	I	Total
2556249	1	0	0	0	0	0	0	0	1	0	2
3021141	1	1	1	1	1	1	1	0	1	0	8
3092143	1	1	1	1	1	1	1	0	1	0	8
3756925	1	1	1	1	1	1	1	1	1	0	9
3784945	1	1	0	1	0	0	1	0	1	0	5
4124531	0	0	0	0	0	0	0	0	1	0	1
4157412	1	1	1	1	1	1	1	1	1	0	9
4172456	0	0	0	0	0	0	0	0	1	0	1
4189776	1	1	1	0	0	0	1	1	1	0	6
4243230	1	1	1	1	1	1	1	1	1	1	10
4243232	0	0	1	1	1	1	1	1	1	0	7
4262154	1	1	1	1	1	1	1	0	1	0	8

The ASPECT test result of 5:1 compression image

❖ Evaluation of Medical Image Compression

	M1	M2	M3	M4	M5	M6	C	L	IC	I	Total
2556249	1	0	0	0	0	0	0	0	1	0	2
3021141	1	1	1	1	1	1	1	0	1	0	8
3092143	1	1	1	1	1	1	1	0	1	0	8
3756925	1	1	1	1	1	1	1	1	1	0	9
3784945	1	1	0	1	0	0	1	0	1	0	5
4124531	0	0	0	0	0	0	0	0	1	0	1
4157412	1	1	1	1	1	1	1	1	1	0	9
4172456	0	0	0	0	0	0	0	0	1	0	1
4189776	1	1	1	0	0	0	1	1	1	0	6
4243230	1	1	1	1	1	1	1	1	1	1	10
4243232	0	0	1	1	1	1	1	1	1	0	7
4262154	1	1	1	1	1	1	1	0	1	0	8

The ASPECT test result of 10:1 compression image

Discussion

- *In this study, we evaluated two items using wireless mobile imaging communication system. First, when we refer to JPEG 2000 images using a PDA phone, display time is measured. Second, PSNR values are measured by peak signal-to-noise ratio (PSNR) measurement function in order to compare image quality between the original image and the JPEG 2000 compressed image. In order to evaluate two items, various brain CT images (530KB, 512x512, 16bit) are used. And, PSNR values are measured in proportion to the increase of the JPEG 2000 compression ratio.*
- *The compression of 10:1 is a clinically reasonable maximum compression ratio for emergency care according PSNR measurement in this study. Also, JPEG2000 images of 10:1 compression ratio are transmitted approximately 0.65s from hospital to PDA Phone for moving using CDMA-1X EVDO.*

Conclusion

- *The results of this study are expected to play an interface role between the mobile emergency medical system and ubiquitous healthcare.*

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