Real-Time Mobile Telemedicine using Scalable Video Coding for Neonatal Heart Disease

Kotaro Oyama[1], Shoichi Chida[1], Takashi Sawai[1], Akio Ikai[1],
Yuichi Fujino[2], Hiroshi Fujii[1], Motohiro Takagi[3]

Iwate Medical University, Iwate [1]
Future University Hakodate, Hokkaido [2]
NTT Cyber Space Laboratories, Tokyo [3]

Background

- An efficient system of real-time telemedicine needs to be applicable to a variety of devices and networks that consulting medical providers utilize.

- Scalable video coding (SVC) enables a video stream to be broken into multiple resolutions, quality levels and frame rates, and to be flexibly conformed to device capabilities and network conditions.

Scalable Video Coding Principles

Purpose

- To evaluate applicability of H.264/SVC to neonatal tele-echocardiography

- To devise a system of real-time mobile telemedicine using SVC for underserved regions in East Japan


Methods (1) : System & Encoding

- We built the H.264/SVC real-time tele-echocardiography system which composed of SVC encoder, extractor and decoder and the image evaluation system.
- Echocardiograms of newborns with critical congenital heart disease with resolutions of 640 x 448 and frame rates of 30 fps were encoded into two layers for scalability with resolutions of 640 x 448 and 320 x 224.
- Four sets of bit-rate were tested; no compression, 2 Mbps, 1 Mbps and 0.5 Mbps.

H.264/SVC Real-Time Tele-Echocardiography System

Coding and Transmission of Echocardiograms of Newborns with Critical Congenital Heart Disease
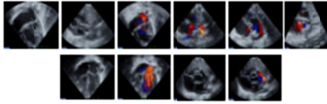
A ten-second video sequence was made from two-best echo-cardiography images of critical congenital heart disease; hypoplastic left heart syndrome and pulmonary atresia with intact ventricular septum.

Video sequences were coded by VPN system and randomly transmitted to decoders in three device/network conditions; local area network (LAN)/PC, wide area network (WAN)/PC and WAN/mobile.

Video Coding Protocol

Network/Device	LAN/PC	WAN/PC	WAN/Mobile
Image Resolution	640 x 448	640 x 448	640 x 448
Frame Rate black and white, color (fps)	39, 29	39, 27	39, 16
Spatial Scalability	2 layers (640 x 448, 320 x 224)		
Compression	0.5, 1, 2 Mbps, no compression	0.5, 1, 2 Mbps	1 Mbps
No. of Frames black and white, color	390, 290	440, 319	429, 176

LAN: Local Area Network; WAN: Wide Area Network

## Methods (2) : Evaluation of Images

Transmitted image quality was assessed systematically according to the international standard as recommended in ITU-T P.910.

A panel of 15 blinded experienced pediatric cardiologists subjectively assessed images and scored continuously between 0 and 1.0.

Zero is unsuitable for diagnosis
1.0 is compatible with normal studies

---

Physician Evaluation of Transmitted Images
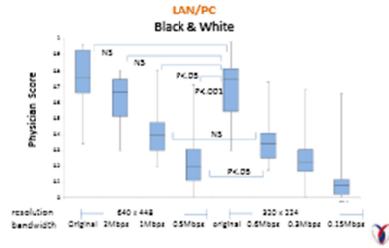
LAN/PC
Black & White

Physician Evaluation of Transmitted Images

LAN/PC
Color

Physician Evaluation of Transmitted Images

WAN/PC
Black & White

Physician Evaluation of Transmitted Images
WAN/PC Color

Physician Evaluation of Transmitted Images
WAN/PC vs WAN/Mobile
Black & White

Physician Evaluation of Transmitted Images
WAN/PC vs WAN/Mobile
Color
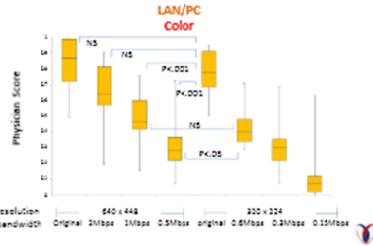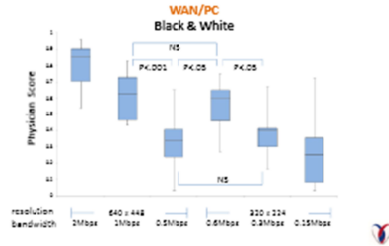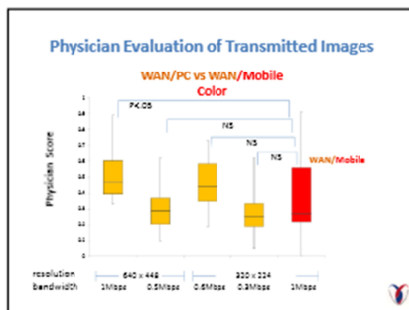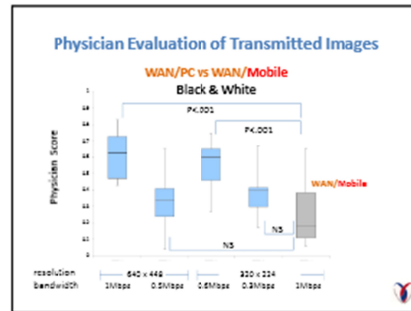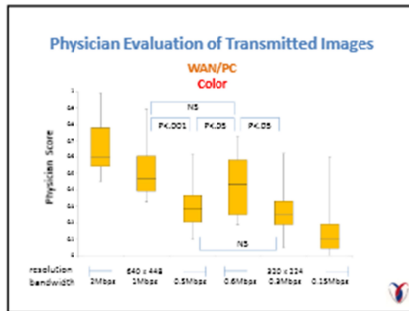
Results (1)

- In WAN/PC condition, SVC images with resolutions of 640 x 448 required a bit rate of more than 1 Mbps to get average score of 0.5 or more.
- At bit rates less than 1 Mbps, scores for images with resolutions of 320 x 224 were significantly higher than values for 640 x 448 images.

Results (2)

- Score for images in WAN/mobile condition at 1 Mbps was not different from score for images in WAN/PC, 640 x 448 and 0.5Mbps.
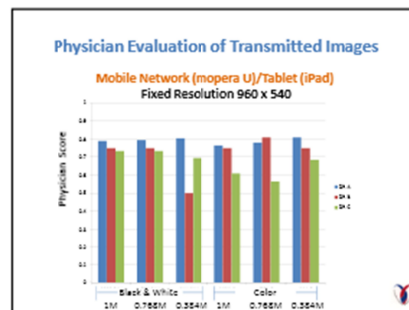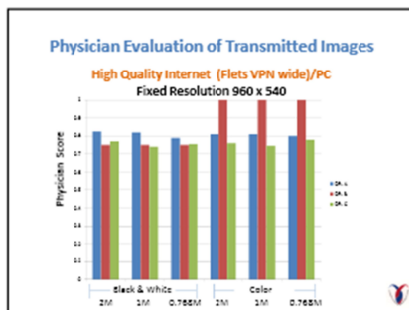

Application of Tele-Echocardiography using SVC (Vidyo Inc.) in VPN and LTE environment
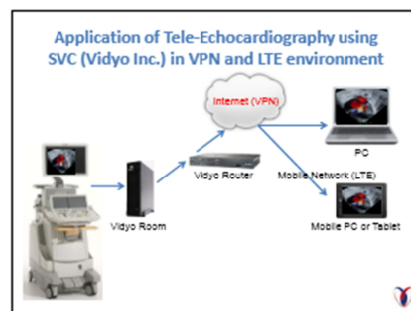
Application of Tele-Echocardiography using SVC (Vidyo Inc.) in VPN and LTE environment

Conventional Cording   Scalable Cording

Assessment of Transmitted Image Quality

Hachinohe Red Cross H.

Three most experienced echocardiologists evaluated transmitted images.

95 km

Iwate Medical University

Physician Evaluation of Transmitted Images

High Quality Internet (Flets VPN wide)/PC
Fixed Resolution 960 x 540

Physician Score

Black & White   Color
2M   1M   0.768M   1M   1M   0.768M

Physician Evaluation of Transmitted Images

Mobile Network (mopera U)/Tablet (iPad)
Fixed Resolution 960 x 540

Physician Score

Black & White   Color
1M   0.768M   0.384M   1M   0.768M   0.384M

Application of Tele-Echocardiography using SVC (Vidyo Inc.) in VPN and LTE environment

Results

- On mobile devices, sufficient physician score of neonatal echo-cardiograms was obtained with 960 x 540 and 30 fps at 0.384 and 0.768 Mbps.

Discussion(1)

- In tele-echocardiography, transmission bandwidth is a limiting factor for real-time wireless streaming.
- At limited bit rates less than 1 Mbps, expert physician scores for images with lower resolutions are significantly better than the values for images with higher resolutions.
- The system of real-time mobile telemedicine using H.264/SVC in VPN and LTE environment gives sufficient physician scoring of neonatal echo-cardiograms with 960 x 540 and 30 fps at bit rates less than 1 Mbps on mobile devices.

Discussion(2)

- Real-time mobile telemedicine using scalable video coding for neonatal heart disease allows real-time interaction between participating medical staffs.
- This system is applicable to other fields of medicine and health care including fetal cardiology and adult cardiology, etc.
- It also enables us to communicate with health providers abroad.

- The real-time telemedicine should be covered by health insurance system.

Conclusion

- The real-time video streaming system using H.264/SVC is feasible for neonatal tele-cardiology in the unreliable wireless and mobile network.

Acknowledgment

Thank you very much for your kind attention