OP 2000 and MedSeC: Implementating a Medical Video Server Using a Data-secured DICOM Interface

G. Bellaire[1], D. Steines[1], G. Graschew[1], A. Thiel[2], J. Bernarding[2], T. Tolxdorff[2], P. M. Schlag[1]

[1]Surgical Research Unit OP 2000, Robert Rössle Klinik am Max-Delbrück-Centrum für Molekulare Medizin, Universitätsklinikum Charité, Medizinische Fakultät der Humboldt Universität zu Berlin, Germany
[2]Department of Medical Informatics, University Hospital Benjamin Franklin, Free University of Berlin, Germany

Objective

To enhance documentation and data-secured second-opinion facilities by integrating medical video sequences (endoscopic, laparoscopic and computer generated) into DICOM.

Introduction

We present preliminary results toward developing a video server that integrates security mechanisms and digital mono- and stereoscopic video sequences (DSVS) into the DICOM standard.

The use of public networks such as the Internet for transmitting patient-specific data must comply with local legislation on data security and integrity. The typical heterogeneous hardware and software infrastructure within a hospital requires a standardized data exchange format and a protocol like that provided by the DICOM standard in radiology. Unfortunately, DICOM does not yet include inherent data security concepts. The goal of the MedSec project is to evaluate the secure high-speed transfer of very large amounts of data within LAN/WAN networks linking project partners using DICOM 3.0 [2].

Key issues of the video server are intelligent and standardized access using a database, the DICOM protocol for data security demands, and video compression. For the compression of stereoscopic video sequences in particular, we exploit redundant information to significantly reduce data and to facilitate image management.

A proposal to extend DICOM for diagnostic video

Our concept for a video server combining a commercial database (INFORMIX Dynamic Server) with the Mallinckrodt CTN DICOM server [3] will open new perspectives for medical documentation. The offline second opinion procedure for diagnosis can be simplified by secure Internet access. To optimize patient documentation and diagnosis, adequate clip size (storage space, access time, medical expressiveness) has to be determined. The parameters determining clip size are clip length, image resolution, frame rate and compression scheme. Because stereoscopic video is especially in demand for surgery, one of our goals is to integrate DSVS into the server concept.

The DICOM information model mainly consists of abstract data objects describing real-world objects (called information object definitions – IOD) and services applied to different IODs. The combination of a certain IOD and a particular service is called a service object pair class (SOP class). An IOD consists of different information entities (IE) with one or several modules. These modules are made up of attributes that describe properties of the object and are listed in the different groups of the DICOM data dictionary.

In order to be able to exchange video objects with the Mallinckrodt CTN DICOM software, we developed a new video IE and a video IOD, consisting of the IEs ‘patient’, ‘study’, ‘series’, and ‘equipment’ as defined in part 3 of the DICOM standard. The former is composed of the general image, value of interest (VOI) LUT, multi-frame, and SOP common modules (see part 3 of the DICOM standard) and privately defined video pixel and sample frame modules. The video pixel module is derived from the DICOM image pixel module, extended by the attributes shown in table 1. The sample frame module consists of a sequence of key frames which are automatically derived from the video sequence. Possible criteria for this extraction of key frames can be frame number (first, middle, last frame) or content-based features such as motion vectors, focus, and illumination.

The CTN software was modified in several places. A new DICOM attribute group for those attributes not yet included in the DICOM standard was introduced into the data dictionary together with the attributes themselves. A new video storage SOP class had to be registered with the CTN software using a provisional ‘unique identifier’. The list of information entities was updated with the video IOD including the new video pixel module.

Attribute	**Explanation / possible values**
Photometric Interpretation	RGB, RGBA, MONOCHROME1/2, YUV444, YUV422, YUV420
Stereo Frames	yes / no
Format	M-JPEG; MPEG1/2, STEREOCOMPRESSION
Frame Rate	Number of frames per second
Number of Frames	As in multi-frame module (Part 3 DICOM standard)

Table 1: Description of new attributes in the video pixel module

Integration of Stereoscopic Video

The left/right frames of a stereoscopic image pair contain similar image areas. The known camera geometry (epipolar lines) permits efficient coding using disparity predictability. The disparity denotes the relative offset between corresponding points in a stereoscopic image pair. In a *s*tandard *c*amera *c*onfiguration (SCC, parallel epipolar lines and complanar image planes), the disparity search can be performed in a single horizontal image line.

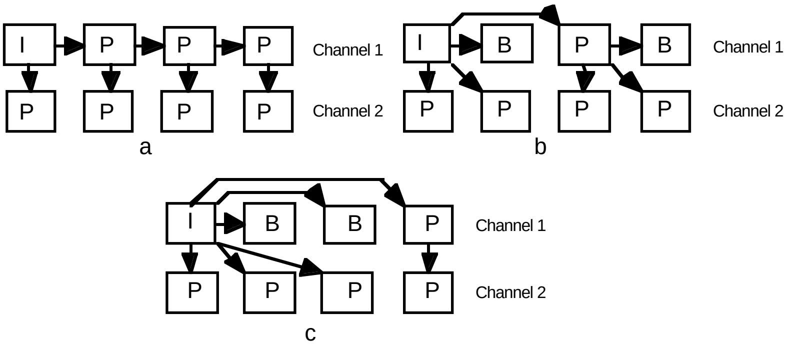

Figure 1: Coding sequence depending on channel 1 frame order;
a) IPPPP... b) IBPBPBPBPB c) IBBPBBPBBP

Taking channel (CA) 1 as the main CA and encoding it using MPEG-2, the frames of CA 2 can be compressed as p-frames referencing the nearest preceding I- or P-frame of CA 1. The predetermined order of P- and B-frames in the first CA results in the sequences shown in Figure 1.

Two DSVS compression algorithms used in our approach were tested and verified as methods to define standards for DSVS in surgical applications. Image sources include stereoscopic laparoscope, stereoscopic surgical microscope, stereoscopic camera, and artificial stereoscopic sequences.

		Transmission rates (kB/s)		
Algorithm	max. PDU size (KBytes)	File 1 300.6 kB	File 2 5494.8 kB	File 3 35156.9 kB
RC4-MD5	8	507	830	829
	16	448	840	856
	32	409	813	868
DES-CBC-MD5	8	431	754	777
	16	397	799	854
DES-CBC3-MD5	8	268	352	357
	16	278	385	393
No encryption	8	507	790	831
	16	457	801	832
	32	450	783	832

Table 2: Transmission rates depending on file size, encryption algorithm and transmission unit (PDU) size over MAN network.

Results

In order to prove functionality and to determine the influence of encryption and decryption processes on transmission times, we carried out some experiments in which DICOM video objects of varying sizes were transmitted from an SGI Onyx system (1 200 Mhz R4400 CPU) to a DEC Alpha (175Mhz CPU) over a metropolitan area network. Various encryption methods and transmission unit (PDU) sizes were tested. Results are shown in table 1. With larger file sizes the average transmission rate increases due to the reduced overhead of parameter negotiation. The RC4-MD5 encryption method apparently is not a bottleneck in this network. The DES encryptions, however, slow down transmission rates.

The encoding time and the size of the compressed stereoscopic video data were measured on the Onyx (1 CPU) and compared with the separate compression of each CA in the conventional way [1]. Additionally the algorithm of [4] was compared. Results for the microscope (Leica WILD M680 stereoscopic surgical microscope - 2 x 3” CCD camera KC233, Ikegami) sequence and for captures from the stereoscopic room camera (Ikegami LH33, 2 x 6’’ CCD) are similar. Both algorithms show that making use of redundancy in stereo image pairs can reduce encoding time up to 60%. To receive better results in compression ratio, color and intensity variations in image acquisition should be compensated.

Discussion and Conclusion

The extension of DICOM to integrate medical video for documentation and second opinion will optimize patient diagnosis and therapy. In a short time common PC hardware will be powerful enough to display high-quality video from harddisk. Using DICOM as standard, the building of viewer software for radiological and video data can take advantage of similar demands in these application fields. PACS technology for video can also benefit from the wide experiences with radiological systems.

Acknowledgements

MedSec is funded by the Fed. Ministry of Science, Research and Technology. The database integration is part of the INFORMIX research grant program.

References

1. Bellaire G., Steines D., Graschew G., Thiel A., Bernarding J., Tolxdorff T., Schlag P. M., OP 2 and MedSeC: A Concept to Extend the DICOM Standard to Include Digital Stereoscopic Video Sequences, Proc. of the BVM 98, Lehmann & al ed., pp. 234-238, 1998
2. Bellaire G., Hasenbrink F., Graschew G., Göbel M., Schlag P.M., The OP2000 Medical Augmented Immersive Environment, Proc. of Collaborative Virtual Environments (CVE), 33-40, Manch. UK, 1998
3. CTN, DICOM Software Document., ftp://ftp.erl.wust1.edu/pub/dicom/software/ctn/doc
4. Tzovaras D, Grammalidis N, Strintzis MG: Object-Based Coding of Stereo Image Sequences using Joint 3-D Motion/Disparity Compensation, IEEE Trans. Video Technology 7(2), 1997

Corresponding Author:

Dr. G. Bellaire
Surgical Research Unit OP 2000
Robert-Rössle-Klinik, Charité,
Max-Delbrueck-Center für Molekulare Medizin,
13125 Berlin, GERMANY

tel.: +49-30-94171634
fax.: +49-30-94063405
email: bellaire@rrk-berlin.de
Lindenberger Weg 80
url: http://www.rrk-berlin.de/op2000/