Automatic Retrieving Data from Medical Equipment to Create Electronic Medical Records (EMRs) for an e-Hospital Model in Vietnam

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ABSTRACT

Applications of Information Technology (IT) in a healthcare management system, especially in Personal Health Records (PHRs) management has recently received a great attention in developing countries such as Vietnam [1,2]. The Vietnamese Government has implemented a special campaign to promote this process in hospitals. Several big hospitals have implemented electronic-based hospital systems, but have only concentrated on patient admission information, medical equipment management, and pharmaceutical and human resources. Besides, PHRs are rather simple, incomplete and involve much manual work [3]. Especially, many devices used in hospitals do not have digital outputs. Within our research, we have analyzed and built some methods that automatically retrieve data from medical devices and put them into EMRs. These data can be images, video, bio-parameters, waveforms, graphs, etc. This process is done by software that can be integrated into hospital information systems in Vietnam hospitals. Several modules have been tested in Khanh Luong hospital, Hanoi Vietnam.

Keywords: Electronic Medical Records (EMRs), e-Hospital, Computerized, Image, Video, Laboratory data, Waveform.

1. INTRODUCTION

Vietnam now has approximately 1000 hospitals that have over 500 beds. Most of them have computers and LAN connections. However, documentation systems and patient health records within hospitals are paper-based [4]. Besides, in recent years, many modern medical types of equipment have been acquired (imaging devices, laboratory equipment, multi-parameter patient monitors). That leads to the increase of patients as well as health records. The Ministry of Health has issued a policy that requires hospitals to implement electronic-based hospital models in Vietnam in the following years [5]. A few hospitals are using data management software but their databases are simple and incomplete. Complex data such as images, video, and waveforms are not automatically retrieved from medical devices to archiving devices. Numbers data are manually input to computers [3]. Therefore, an automatic retrieving process into patient health records will facilitate these problems, and meet requirements of electronic-based hospital models in Vietnam.

2. METHODS FOR AUTOMATICAL RETRIVING DATA

1) Images and video data retrieving

According to our survey, imaging and video devices mainly used in hospitals include ultrasound systems, CT Scanners, CRs, DRs, MRIs, video endoscopies, and microscopy systems. Images or videos that are produced by this equipment then are displayed on the screen accompanied with them. Results delivered to patient will be printed. Hence, in order to archive these data into computers, doctors have to scan all these images and save them into the computer database. If data are in video form, they have to save to disks, memory sticks and then to computers. That consumes quite a lot of time and increases errors due to manual work. To solve that problem, we need a process to retrieve data automatically from medical devices. Data will be stored in computers by software corresponding to patient health records. To store images or video from imaging devices, we follow the sequence shown in Figure 1:

Fig.1 - Acquisition data from imaging equipment

Solution: In fact, most imaging devices have video output that is an analog signal. So they require an A/D converter circuit before sending data to the computer. This process is implemented by using a Capture video card that is available in the Market. In Vietnam, there are many brand names of this card such as Aver, Gadmei, Pinnacle, Snazzi and Hauppauge with digital output support USB or PCI standard. Software installed in computers then receives and processes digital data. Depending on programming languages, we can choose data processing tools including Image and Video Processing ActiveX OCX of X360soft, Viscomsoft, and Brothersoft.

In our work, we used the Sanzzi Capture video I card and VideoCap SDK ActiveX 5.0 processing tool of Viscomsoft, the programming language is ASP.net, we have been developing software to retrieve and process image data from imaging devices. This software can be integrated into the database management system in the electronic-based hospital model to retrieve and store image and video data into personal health records [6].

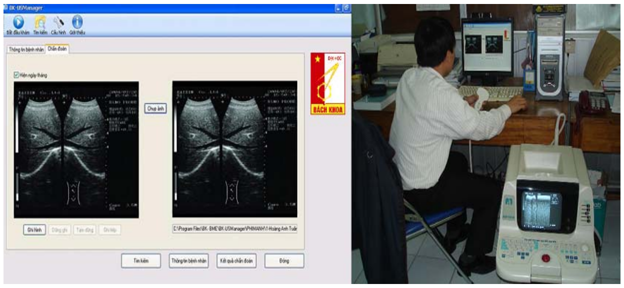

Fig.2 - Acquisition image data resulting from the software from the ultrasound machine, MEDELKOM *model SLE-101M*

2) Laboratory data retrieving

Laboratory data in most hospitals in Vietnam are mainly: hematology, biochemistry, microbiology, immunology, cell and urine analysis and electrolyte data. These devices are supplied by Sysmex, Siemens, Abbott, Nihon Kohden, Hitachi, Roche, Hemacell, Mindray and Boule [3]. As we researched, all these devices make use of RS-232 – compatible digital output. Laboratory equipment, hence, can easily connect to computers that support RS-232. After processing laboratory samples, results will be displayed on the monitor. These data are concurrently sent to the RS-232 port. Therefore, we need a software algorithm to automatically receive each message after being sent to the RS-232 port. The message is then interpreted to extract useful information to put into patient health records. This algorithm and analysis message is as in Figure 3 [7]:

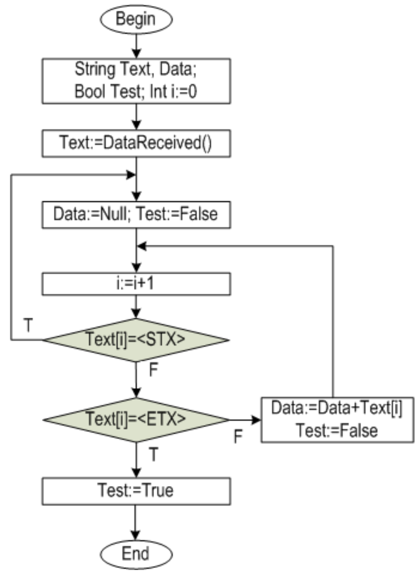

Fig.3 - Analysis message's structure algorithm from laboratory equipment

However, to identify fields in message we need to know the output format of each message from laboratory equipment. This is because different suppliers have different definitions for their output messages. Fortunately, we can find this information in Technical documents (normally in the Service manual) that comes with the equipment. The structure of the message that is sent to the RS-232 port of the Sysmex-KX21 hematology analyzer machine follows. This message includes 306 characters for each result. The initial character is STX, followed by data character DATA and ETX is the end character. Characters in DATA are divided into smaller fields that correspond with lab results. Each field has fixed length and is separated by character 0D. Field order in DATA is illustrated in table 1:

Table 1 - Definition fields' structure in the message of Sysmex-KX21

Field Name	Meaning	Filed Length (Character)
Field 1: STX($02)	Massage Start	1
Field 2: R($52)	R Character	1
Field 3: zz]	No of Test	3
Field 4:YYYYYYYYYYYYYYYY]	Code of Test	17
Field 5:YYYYYYYYYYYYYYYYYYYYY]	Doer	31
Field 6:zz/zz/zz-zzhzzmzznzzs#]	Date	21
Field 7:zzzzz-RN]	WBC	9
Field 8:zzzzz-RN]	LYM#	9
Field 9:zzzzz-RN]	LYM%	9
Field 10:zzzzz-RN]	MON#	9
Field 11:zzzzz-RN]	MON%	9
Field 12:zzzzz-RN]	GRA#	9
Field 13:zzzzz-RN]	GRA%	9
Field 14:zzzzz-RN]	NEU#	9

Field 15:zzzzz-RN]	NEU%	9
Field 16:zzzzz-RN]	EOS#	9
Field 17:zzzzz-RN]	EOS%	9
Field 18:zzzzz-RN]	BAS#	9
Field 19:zzzzz-RN]	BAS%	9
Field 20:zzzzz-RN]	ALY#	9
Field 21:zzzzz-RN]	ALY%	9
Field 22:zzzzz-RN]	LIC#	9
Field 23:zzzzz-RN]	LIC%	9
Field 24:zzzzz-RN]	NULL	9
Field 25:zzzzz-RN]	NULL	9
Field 26:zzzzz-RN]	NULL	9
Field 27:zzzzz-RN]	NULL	9
Field 28:zzzzz-RN]	RBC	9
Field 29:zzzzz-RN]	HGB	9
Field 30:zzzzz-RN]	HCT	9
Field 31:zzzzz-RN]	MCV	9
Field 32:zzzzz-RN]	MCH	9
Field 33:zzzzz-RN]	MCHC	9
Field 34:zzzzz-RN]	RDW	9
Field 35: zzzzz-RN]	NULL	9
Field 36: zzzzz-RN]	PLT	9
Field 37: zzzzz-RN]	MPV	9
Field 38: zzzzz-RN]	PCT	9
Field 39: zzzzz-RN]	PDW	9
Field 40:ABCDEFGHIJKLMNOPQRSTU]	5 WBC Memory Flag	22
Field 41:LMMGGG]	LMG Memory Flag	7
Field 42:PSM]	PLT Memory Flag	4
Field 43:CRC	Check Code	1
Field 44: ETX ($03)	Massage End	1

Note: "-" is space, which is $20 in ACSII coding system. "]" indicates the carriage return that separates fields, which $0D; zzzzz is a numbers field with 0 in the left hand side, for example 03.55. For fields having no results, they will present as __.__. Y is a character that has codes from $20 to $7F [8].

From this analysis of message structure, the software interface that has been built by our research team, will automatically receive data from laboratory equipment Sysmex-KX2. Figure 4 shows the interface of this software to display original content of messages from equipment and display laboratory results after analyzing fields within a message [9].

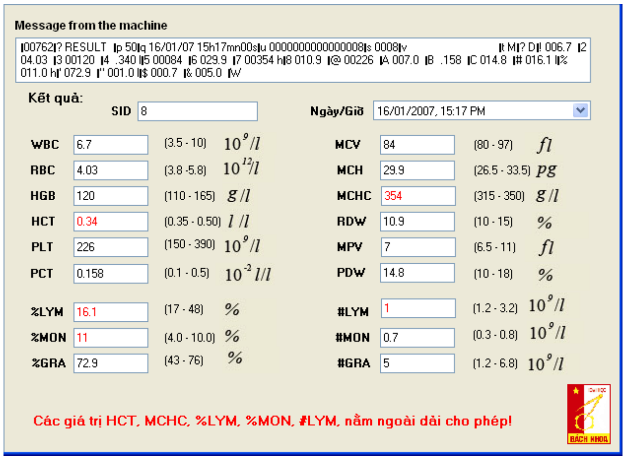

Fig.4 - Automated acquisition laboratory data software from hematology analyzer machine, Sysmex-KX21 model

3) Retrieving waveform data

Measuring and monitoring patient vital parameters has been increasingly important and useful in order to assist doctors and nurses in patient care. Typical waveform data are ECG, EEG, EMG, RESP, SpO2 and IBP. Besides, related parameters including HR, PR, NIBP, TEMP, and EtCO2 are also helpful in diagnosis and therapy. ECG, EEG, EMG, Patient Monitor, NIBP, and SpO2 are widespread – used devices that produce waveforms. However, as in laboratory equipment, Measuring and monitoring devices are now supplied by various companies [3]. A common characteristic among these devices is that they all have output that supports RS-232. Therefore, they can directly connect to the COM port in computers. In laboratory equipment, data format is structured into messages. Because measuring devices produce real-time data, data will be sent to RS-232 continuously. Therefore, each supplier specifies their own protocol in their equipment to send data to output ports. To receive data automatically from equipment, we first need to identify the data frame of sent data. They are normally illustrated in the Service Manual of equipment [10,11]. Tables 2-4 show examples of definition of data frames that are sent to RS232 ports of MMED6000DP-S6 patient monitoring (MMEDCHOICE company) [12].

Table 2 - Transmission Data Protocol (12 bytes)

Pack head		Reserved	Identification	Identified by the STATUS1		
0x55	0xAA	STATUS0	STATUS1	DATA		
ECG wave sample point value				Reserved	Respiration wave	Check sum
ECGW3	ECGW2	ECGW1	ECGW0	SATW	RESPW	SUM

0X55, 0XAA is data pack head, SUM is check sum,
SUM =
(STATUS0+STATUS1+DATA+ECGW3+ECGW2+ ECGW1+ECGW0+SATW+RESPW)/256
The other bytes are explained following.
STATUS0: reserved

STATUS1: is pulse voice indication and identification. Before the next DATA byte, the STATUS1 byte is sent as identification. As a result the corresponding value can be filtered out of the data flow. The different identification represents the corresponding data.

Table 3 - STATUS1 Structure (1 byte)

STATUS1		BIT7 = 1		ECG beep flag
		BIT6 = x		Reserved
		BIT5 = x		Reserved
		BIT4 = 1		The following byte DATA values exceed 255. E.g if BIT4=0 the DATA value is 30, the real value is 30, if BIT4=1, the DATA value is still 30, but the real value is 30+256=286.
BIT3	***BIT2***	***BIT1***	***BIT0***	***The following byte DATA means***
0	0	0	0	ECGS
0	0	0	1	STAS
0	0	1	0	NIBPS
0	0	1	1	Heart rate (0-255)
0	1	0	0	Pulse rate (0-254) from SpO2
0	1	0	1	Pulse rate (0-254) from NIBP
0	1	1	0	ST
0	1	1	1	% SpO2 (0-99%)
1	0	0	0	Cuff pressure value/2 (mmHg)
1	0	0	1	Systolic 0-255 (mmHg)
1	0	1	0	Diastolic 0-255 (mmHg)
1	0	1	1	Mean arterial 0-255 (mmHg)
1	1	0	0	Respiration rate (0-99)
1	1	0	1	Temperature 1 (T1)

1	1	1	0	Respiration wave gain
1	1	1	1	Temperature 2 (T2)

Table 4 - DATA Structure (1 byte)

ECGS	The state of ECG: BIT7=1 means lead off BIT7=0 means normal BIT6 BIT5 mode selection 00: diagnosis mode, bandwidth = 0.05-100Hz 01: monitor mode, bandwidth = 0.5-75Hz 10: operation mode, bandwidth = 0.5-25Hz
STAS	The state of SpO2: BIT7=1 means probe off BIT7=0 means normal BIT6=0 reserved BIT5=1 means drop in SpO2 BIT4=1 means searching too long BIT3-BIT0 Real time Bar Graph, in the range of 0 to 8, < 3 means weak signal
NIBPS	The state of NIBP: BIT7=1 means repeat measurement BIT5, BIT6 reserved BIT3=1 means manual BIT3=0 means automatic BIT4=1 means gas circuit is jam, 0 means normal BIT2,BIT1 mode selection 00: adult mode; 01: pediatric mode; 10: neonate mode BIT0=1 means measuring or calculating 0 means not measured or finished
ST	ST value (show as complementally code in the binary system) E.g. –80 means –0.8mV, 80 means 0.8mV
T1	Channel 1temperature value (0-255) The value should divide by 10 then add 20 and then the result is the temperature value E.g. 235 (235/10)+20 = 43.5^{o}C
T2	Channel 2 temperature value (0-255) same as T1

From the interpretation of this data frame, we have built RS-232 compatible software on computers to automatically receive and process parameters. These parameters include ECG, SpO2 and RESP waveforms. Numbers parameters are HR, PR, NIBP, TEMP, %SpO2 and #RESP. Data are then stored in a way that corresponds to the data frame structure we analyzed above. Data from the patient database system will be retrieved and displayed to support diagnostic and therapy procedures through our designed software. Numbers and waveform results are illustrated in figure 5 [10]:

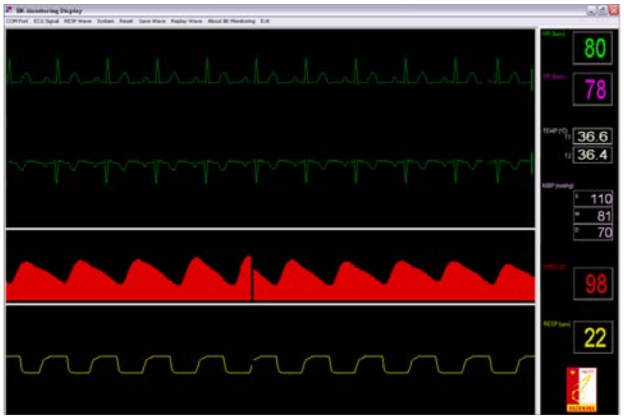

Fig.5 - Automated acquisition and display data software from multi-parameters patient monitor MMEDCHOICE, MMED6000DP-S6 model

3. CONCLUSIONS

Software modules that automatically retrieve data from medical equipment include images, waveforms, video, lab parameters; number data has been built with the above method. These modules can be integrated into information management systems in electronic-based hospitals that have been implemented in Vietnam recently. By automatically receiving data from medical equipment, patient health records will be filled completely (including images, video and waveform data), manual work will be reduced (eliminate film scan and papers) and hence, errors from manually input parameters of clinicians will be reduced (input laboratory results and vital parameters). With more complete and precise health records, the electronic-based hospital model is increasingly useful to assist doctors in diagnostic and therapy procedures.

For retrieving images, video data, this method can be implemented for all medical devices as they all have similar video output. However, for laboratory parameters, waveform, numbers, to retrieve data automatically requires an understanding of the output data framework. This information is normally supplied by suppliers in Manual Services.

Some of our software modules have been implemented in Khanh Luong hospital Hanoi by our research team. They receive many good comments from doctors as it helps them archive patient records more completely, precisely and facilitates them in the diagnostic and therapy process.

Fig.6 - Testing and implementation acquisition ultrasound data modules to create EMR in Khanh Luong hospital

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