A MEDICAL INFORMATION CONCENTRATOR
Acquisition Biosignals Module for a Mobile Telemedicine System

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Abstract: This paper describes the development of medical information concentrator to be used for a telemedicine unit in a mobile telemedicine system. The concentrator contains of an interface array which function to obtain biosignals coming from several medical instruments, such as ECG monitor, NIBP device, etc. The number of medical instruments connected to the concentrator can vary, though there must be a swap between the user's requirement and the design complexity to optimize the design implementation. This concentrator provides connection of low-priced medical instruments which previously are incapable of directly link up to the necessary computer in a telemedicine unit. Hence, the cost for building a mobile telemedicine can be more economically. Comprehensively test of the concentrator has been conducted in a whole mobile telemedicine system. Results show recorded biosignals can be displayed by parts or collected beforehand as a medical record which may be sent to the doctor who stays alert in the hospital as the base unit.

1 INTRODUCTION

Community healthcare services in rural areas are often impeded by the scarcity in transportation infrastructure, inadequate service facilities, insufficient number of medical experts, and limited availability of communication means. To alleviate these problems, a mobile telemedicine system is believed to be an alternative solution (Martinez et.al., 2004) (Satyamurthy, 2007). Unfortunately, to extend the system will involve high-priced investment to procure medical devices and supporting equipments both hardware and software (Norris, 2002).

This paper presents the development of a medical information concentrator as a module to acquire various biosignals in the telemedicine unit of a mobile telemedicine system. The medical information concentrator is an interface array for various medical instruments used within a mobile telemedicine system, such as an ECG monitor, NIBP, and oxygen saturation SpO2. For each of medical instruments we have developed a dedicated interface, since the medical instrument selected are incapable of direct connectivity to the necessary computer, also each of the devices must be operated individually according to a previously decided set of procedures. So, we apply a multiprotocol interface within the concentrator.

In designing of the medical information concentrator, the compatibility between hardware and software is very important, and needs special consideration. To cope with this, the hardware-software co-design method is used on the design by considering the complexity that the system has.

This concentrator provides different medical instrument with relatively inexpensive may be applied for building a mobile telemedicine system. Therefore, it may reduce the venture to get hold of medical devices. The rest of the paper is organized as follows. In the section two, the method and the implementation of the medical information concentrator is explained. The test of the concentrator that has been integrated into a mobile telemedicine unit is also discussed in this section. Finnaly, section three is a summary of the paper, and it also presents the future works as the closing remark.

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2 METHOD AND IMPLEMENTATION

For monitoring a patient in a mobile telemedicine system we need the measurements of biosignals, including vital sign for instance ECG signal, blood pressure, etc. (Jung et al., 2005). In general to conduct the vital sign measurement, the mobile telemedicine system applies medical devices which already has a digital output for instance a continuous one channel ECG, plus another biosignals, viz. NIBP, SpO2, HR etc., in one package. Also, such kind of equipment is costly. Usually, user has no flexibility to choose a medical device that may suit her/his ability. In addition, since the devices are already in one compact package, it is difficult to be expanded.

The medical information concentrator offers a user to select and to use a low-cost individual medical device to be linked up with a mobile telemedicine system. The kind and the number of medical instruments to be connected to the system can be decided by the user according to her/his financial ability, and a clinical situation.

Figure 1 depicts the block diagram of the medical information concentrator. Each of medical instrument is served by a dedicated interface that is connected to the data buffer which stores measured biosignal to be processed and transmitted to the communication manager. The communication manager is a module to manage data transaction and communication within units in a mobile telemedicine system.

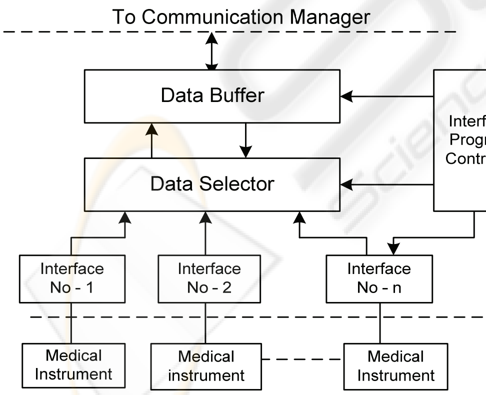

Figure 1: Block diagram of the medical informational concentrator.

Every instrument is operated and controlled by the interface program controller that is a specific software which has been developed during this research.

The number of medical instruments may be attached to the medical information concentrator is flexible, depends on the user's need to cover a certain clinical situation. Although, there must be a trade off between the user requirement and the design complexity to optimize the realization. It is suggested that the number of the medical instrument is less than 16. If the number of medical devices is bigger will degrade the performance of the whole system dramatically.

Since all instruments have unique characteristics according to its measured biosignal feature, therefore the medical information concentrator is developed in a modular way both hardware and software. Each interface is designed specifically that includes the data transfer rate, the format of the file, and the assembler programming.

2.1 Design Implementation

In this research, the design of the medical interface concentrator has been implemented to serve four medical instruments, i.e. ECG monitor 12 leads, NIBP, temperature, SpO2, and FHR monitor. The block diagram of realized concentrator is shown in Figure 2.

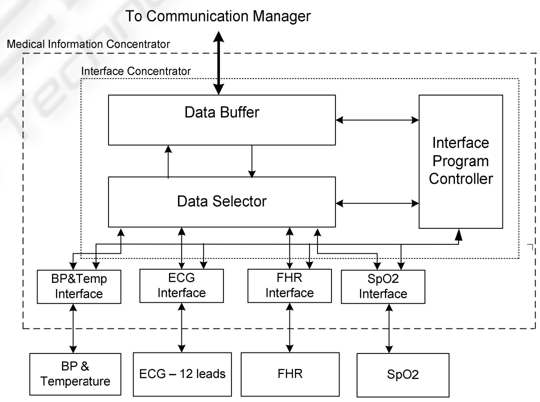

Figure 2: A realized medical information concentrator block diagram.

Functionally, the medical information concentrator can be divided into two sections, i.e. interface array section, and the interface concentrator section. The number of interface within the interface array section depends on the number of medical devices will be related to the system. In the interface concentrator, the software is developed using plug-in concept, to solve the problem of flexible functionality in many applications (Stapic et.al., 2008).

Every instrument is supported by one interface which is microcontroller based. Hence, the medical information concentrator consists of four interfaces, viz. ECG interface, BP and temperature interface, SpO2 interface, and FHR interface.

2.1.1 ECG Interface

The ECG interface is specialized design for ECG 12 leads Cardimax 2111. As the core of the interface is a microcontroller PIC16F87A from Microchip. The interface has specification as following:

- Input: serial data format;
- Clock data transfer: 500 KHz;
- Output: 8-bit parallel data format;
- Data transfer rate: 500 Kbit/second;
- Power supply: 5.3 volts.

2.1.2 BP and Temperature Interface

The BP interface is designed to a universal interface that means the interface can be connected to any digital blood pressure without regarding the product manufacture (Sutjiredjeki and Soegijoko, 2006). The microcontroller PIC16F87A from Microchip is still used as the core of the interface. The temperature interface is designed to be integrated with the BP interface by using A/D converter within the microcontroller. The specification of the interface is as following:

- Programmable;
- Range of measurement: (0 – 280) mmHg;
- Accuracy: ± 3 mmHg;
- Power supply: 5 volts.

2.1.3 SpO2 Interface

The core of SpO2 interface is a microcontroller ATMega8 from ATMEL. It is specialized design for common oximeter, and the interface has specification as following:

- Range of measurement: (0 – 100)%;
- Resolution: 8 bit;
- Output: 8-bit parallel data format.

2.1.4 FHR Interface

To simplify the design, we used a sound card as the FHR interface. The interface connects an inexpensive FHR doppler monitor to a PC. The range of measurement is for typical ultrasonic frequency of 2 Mhz.

2.1.5 Biosignals Display on the Concentrator

To prevent a conflict between the various medical instruments which may cause a reading error, each time only one instrument is allowed to detect a biosignal according to its function.

The measured vital signs can be displayed by parts or collected and presented as a medical record which can be sent to the doctor in the hospital or health centre. An example of displays on the medical information concentrator is showed in Figure 3. This figure describes the result of BP measurement, temperature, and oxygen saturation SpO2. In addition, the patient's data demographic is also included in the medical record.

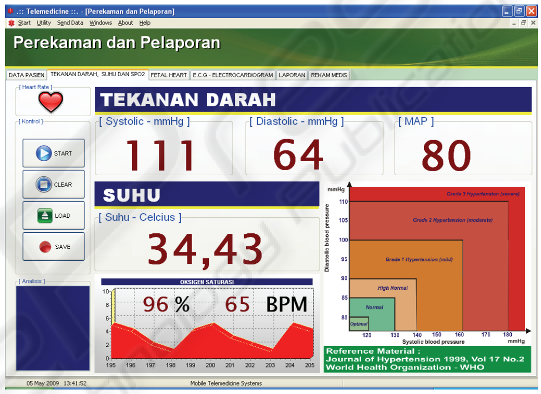

Figure 3: Example of measured vital signs display on the medical information concentrator.

If the biosignals are aimed to display partly or individually, it can be done as illustrated in Figure 4.

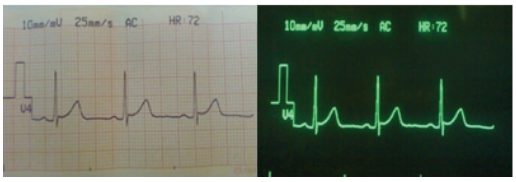

Figure 4: Recorded ECG biosignal from lead V4.

2.2 Test Results

The medical information concentrator is integrated into a mobile telemedicine unit of a mobile telemedicine system. Figure 5 depicts the block diagram of the mobile telemedicine unit. This unit is located at a patient's site, and comprises of the following:

- Medical instruments: ECG, NIBP, SpO2, FHR, and thermometer;
- Medical information concentrator;
- Data processing unit;

- Communication manager module;
- Communication devices: GSM/GPRS and CDMA.

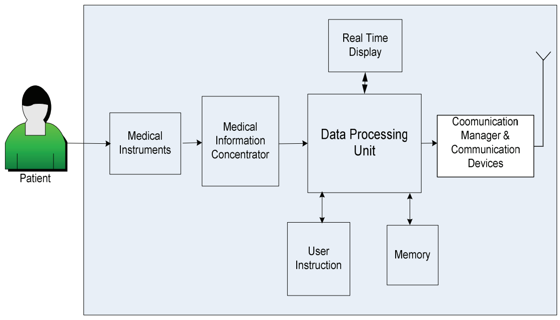

Figure 5: A mobile telemedicine unit block diagram.

The mobile telemedicine unit is realized in the form of a portable telemedicine unit which can be easily carried and placed in an ambulance or a remote community healthcare centre (Sutjiredjeki et.al., 2008). The unit is equipped with a Core 2 Duo CPU, 1 GB memory, and 120 GB hard disk. All components are placed in a water-proof case which also protects it from impact and vibration as shown in Figure 6.

By having the medical information concentrator inside, the portable telemedicine unit is able to acquire a number of vital signs coming from various inexpensive medical devices which formerly have no links up to the computer. These signals are directed into the computer via a standard RS232.

In the computer, the measured biosignals are processed to find the parameter values and displayed. Figures 7 describes the recorded biosignals using the medical information concentrator that has been realized.

As illustrated in Figure 7, all the measured vital signs, i.e. 12 leads ECG, NIBP (systolic and diastolic values), SpO2, HR, temperature, and patient's data can be exhibited at once.

Figure 6: A portable telemedicine unit.

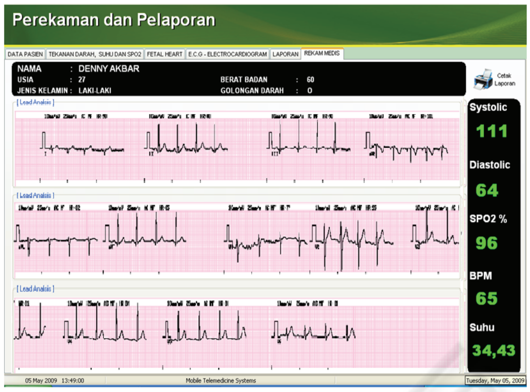

Figure 7: Recorded biosignals as a result of the medical information concentrator.

Currently, the mobile telemedicine system included the medical information concentrator is operated at local general hospital, RSUD Syamsudin in Sukabumi, West Java. The system is applied for recording and reporting patient's medical record, and teleconsultation. The portable telemedicine unit is placed in a moving ambulance. The recorded biosignals from the ambulance is transmitted via multi communication links, viz. GSM/GPRS and CDMA to the base unit which is located in the hospital. In addition, the tests also have been conducted in three community health centres in Sukabumi, i.e. Parungkuda, Cikembar, and Surade. Most of times, the system is used for teleconsultation in particular.

Based on the user evaluation, the acquired biosignals from the medical information concentrator are clear, and they can be applied for supporting patient's diagnose. Specially, for health centres in a rural area the mobile telemedicine system has been very demanding to improve healthcare services.

3 CLOSING REMARKS

The development of a medical information concentrator has been presented. The concentrator is applied to acquire biosignals coming from several medical devices that works individually. By providing the concentrator in the mobile telemedicine unit leads to low-priced medical instruments may be connected into a mobile telemedicine system. As a result, the cost of investment on medical instruments for building a mobile telemedicine system may be reduced.

At present each one of medical instruments is provided with one dedicated interface by using individual microcontroller. For future works, the interface array need to be redesigned and implemented in a single board in order to further reduce the size and the cost. Plug and play approach should also be considered to improve flexible functionality of the concentrator, so the system may be up-gradeable.

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