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Korotkoff sound signals recording and analyzing system

By

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Abstract:

The aim of this study is to help to improve new diagnosis methods for cardiovascular disease by designing software and a hardware which realizes the recording of Korotkoff sounds produced during the measurement of blood pressure and basic analysis process. Korotkoff sounds have been traditionally used to measure blood pressure noninvasively by employing the auscultatory method. The recording system developing in this study can be used to produce a large database by recording some important information such as weight, age, and disease name in addition to Korotkoff sounds. Basic analysis processes like filtering and finding frequency component of recorded data is accomplished by means of the designed software. Thus, the necessity of using different software for analyzing and recording data has been eliminated for Korotkoff sounds research.

Keywords:

Korotkoff sounds, recording system

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1. Introduction:

The most common method for blood pressure measurement is auscultation. In this method, blood pressure measurement is performed by listening Korotkoff sounds that occur in brachial artery. When a pressure, bigger than systolic blood pressure, is applied to brachial artery by cuff, artery collapses, blood flow in artery stops and any sounds is not listened on artery. When cuff pressure applied on artery is decreased with a speed lower than blood pressure variation in brachial artery, Korotkoff sounds can be listened in brachial artery. When cuff pressure reach to systolic blood pressure, Korotkoff sounds start and continue when cuff pressure reach to diastolic blood pressure [1-5]. Together with increasing mortality because of cardiovascular diseases in developing country, improving preventive and diagnostic new methods for cardiovascular diseases have have come into prominence. As a result of this, Korotkoff sounds and its relationship with other medical information of body have been started to research to find out new diagnosis methods[6-9].
In this study, realized Korotkoff sounds recording system consist of two parts that are hardware and software. The hardware is constituted of sensors, electronic circuits to obtain analog information and I/O card to convert analog signals to digital. The software is used for displaying of analog information converted to electrical signal via hardware, filtering analog signals, finding frequency component of analog signals and recording analog signals and information of subject measured Korotkoff sounds.

2. The Hardware of Korotkoff Sound Signals Recording System:

The block diagram of the hardware of Korotkoff sound signal recording system is shown in Figure 2.1. In Figure 2.1, pressure sensor is used to obtain cuff pressure. Air pressure in cuff is converted to electrical signal in direct proportion to cuff pressure value. Differential amplifier is used for amplifying electrical signal obtained from pressure sensor in milivolt. The microphone converts sounds to electrical signals in brachial artery. Sound signals obtained from microphone are amplified by a high gain preamplifier circuit. The other amplifier block is used for amplifying Korotkoff sound signals on preamplifier output to adapt signal level to I/O card input. Pump and pump driver block are used to inflate the cuff placed around the arm. In figure 2.1, I/O card is used for converting analog signals that obtained from microphone and pressure sensor into digital signals and driveling pump. The I/O card in recording system has a D/A converter output and 16 channel A/D inputs. The A/D and D/A converter on the I/O card have 12 bit resolution.

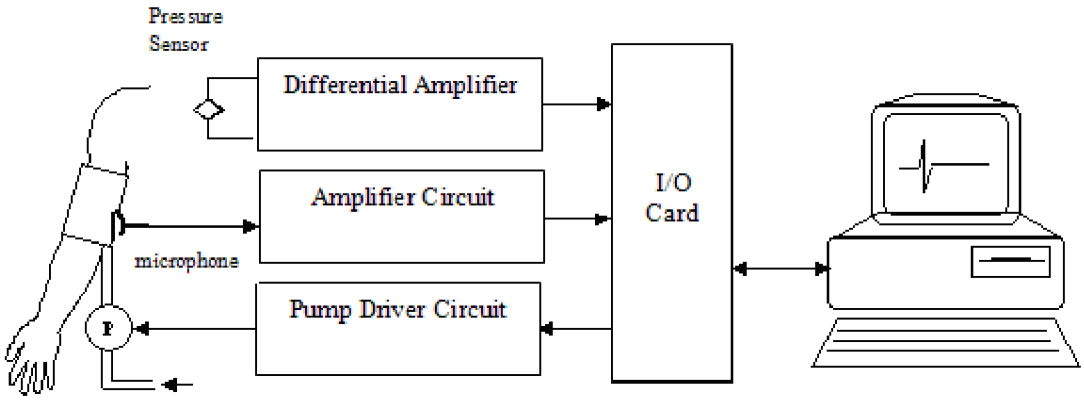

Figure (2.1): *Block Diagram of Korotkoff Sound Signals Recording System*

3. The Software of Korotkoff Sound Signals Recording System:

Recording systems used for Korotkoff sounds research have not specialized for Korotkoff sounds until now. It is general purpose data acquisition systems and they record only Korotkoff sounds. In addition to the recording of Korotkoff sounds, realized recording system generate large database by recording addition information about subject like age, weight, disease name etc. Also analyzing of Korotkoff Sounds has been achieved with prepared software. Flow diagram of recording steps of Korotkoff sound signals is shown in figure 3.1. To measure Korotkoff sounds firstly cuff pressure should be increased. For this aim, the software send information to pomp driver block via D/A converter output of I/O card. After pomp start to inflate cuff, signal of pressure sensor is observed via analog to digital converter of I/O card. When cuff pressure (Pc) reaches the pressure value entering by user (Pu), pomp is stopped. After then cuff pressure automatically is started to deflate by mechanical apparatus on the pump. At the same time, obtained Korotkoff sounds and cuff pressure signals are converted to digital signals by A/D converter of I/O card and recorded in computer. The recording of signals are continued, until cuff pressure reach 40 mmHg. When recording of Korotkoff sound and cuff pressure signals finish, recorded Korotkoff sounds and cuff pressure signals versus time are displayed graphically by the software. Graphical user interface (GUI) of the software is shown in Figure 3.2. GUI is prepared like classical windows program and easy to use. Main window in Figure 2 include subtitle that is “File”, “Edit”, “Transform”, “Record Information” and “About”. “File” and “Edit” subtitles is used for standard function of program like open, save, cut and paste. In addition to these subtitles, Transform subtitle is used to filter and find spectral component of recorded Korotkoff sounds. “Record Information” subtitle is used to show name, surname, age etc. of the person recorded Korotkoff sounds.

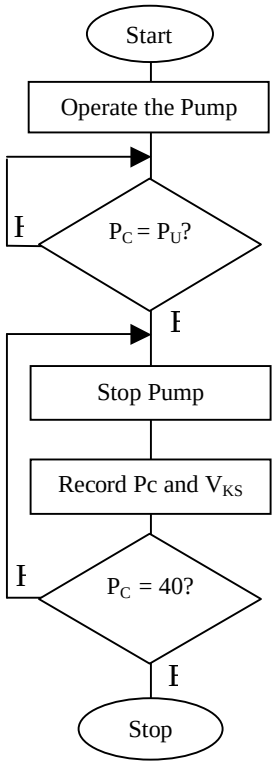

Figure (3.1): *Flow Diagram of Korotkoff Sound Signals Recording*

In figure 3.2, one of the curves shows Korotkoff sound signals versus time and the other curve shows cuff pressure signals versus time. Amplitude of Korotkoff sound and cuff pressure signals respectively in Volt and mmHg are shown on the right side of the window in the figure. Nominal amplitude and time value of the curves are displayed on the upper side of the window by clicking on a point of the curves. Also maximum, minimum, mean value, total sample number and sample frequency of recorded signals are shown on the upper side of the window.

While saving obtained data to the hard disk of computer, name, surname, age, weight, height, sex and disease name of subject are inquired by a new window and saved on hard disk. This window is shown in figure 3.3.

Also, the software helps the user locate the microphone on arm and wrap up the cuff around his/her arm by displaying some photographs. In this way, users can record their own Korotkoff sounds without taking a help from any operator. Thus, necessity of using Korotkoff sounds recording system with an operator is eliminated. In figure 3.4, user informing window is shown. Back and Next buttons on informing window are used to show procedures about Korotkoff sound signal recording respectively. At the same time, user enters sample frequency of system and cuff pressure value on this window.

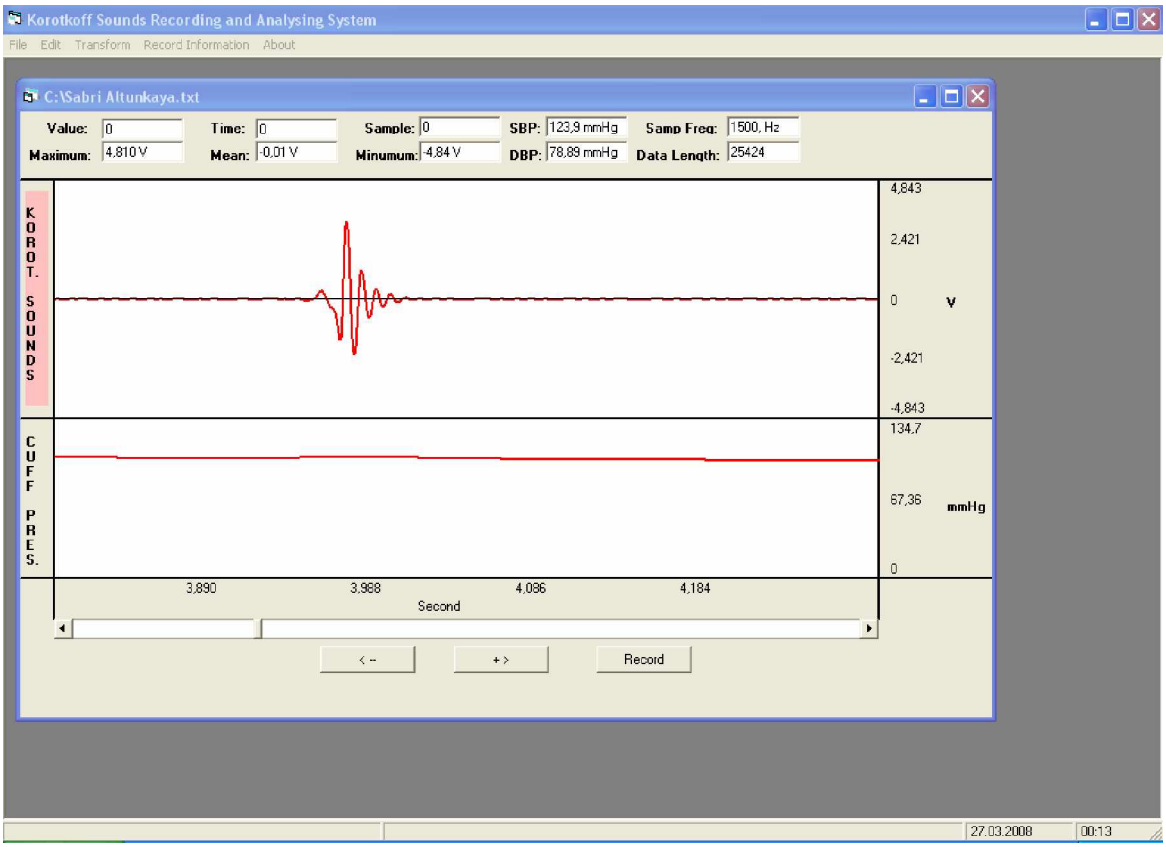

Figure (3.2): *GUI of Software*

Prepared software can be used to filter Korotkoff sound signals and find frequency component of Korotkoff sound signals. When "FFT" subtitle is chosen from "Transform" title on the main window, the window showed figure 3.5 is opened.

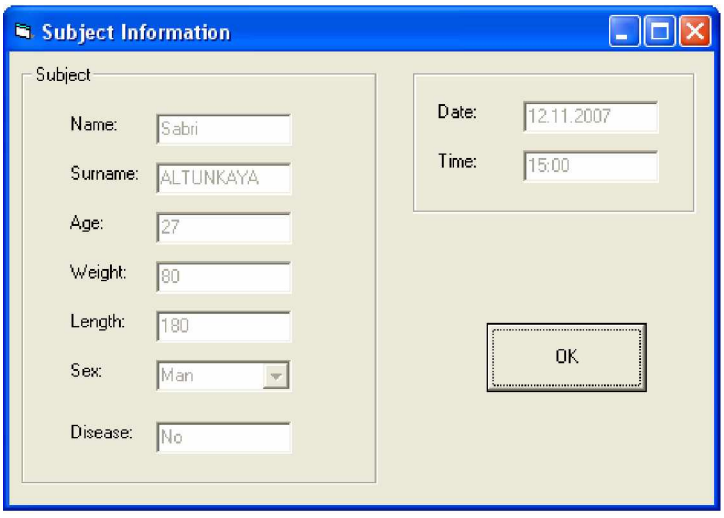

Figure (3.3): *Inquiring Subject Information Window*

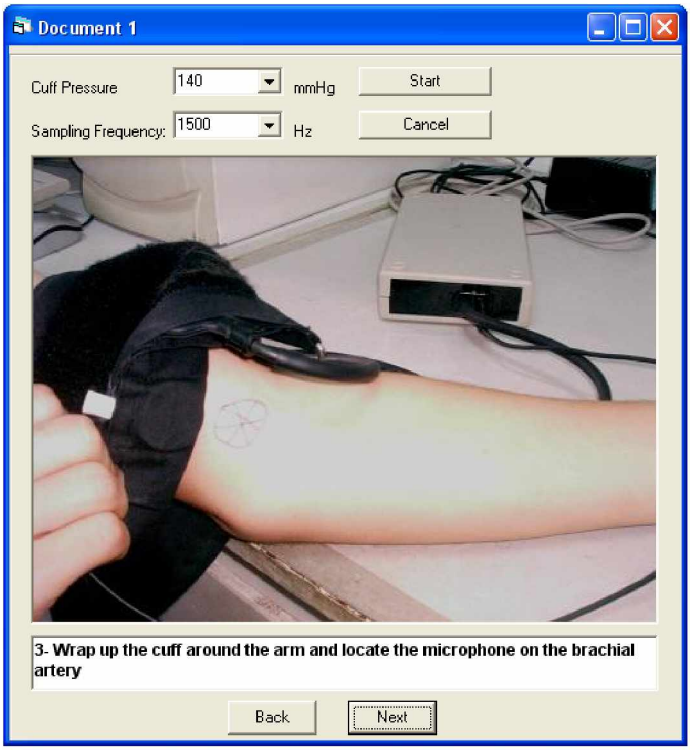

Figure 3.4. User Informing Window

This window is used to choose starting point, length of data and windowing function of Fourier transform. After this information of Fourier transform is defined, the user clicks start button to calculate Fourier transform on this window. When Fourier transform is calculated, frequency component of Korotkoff sound signals are shown on this window.

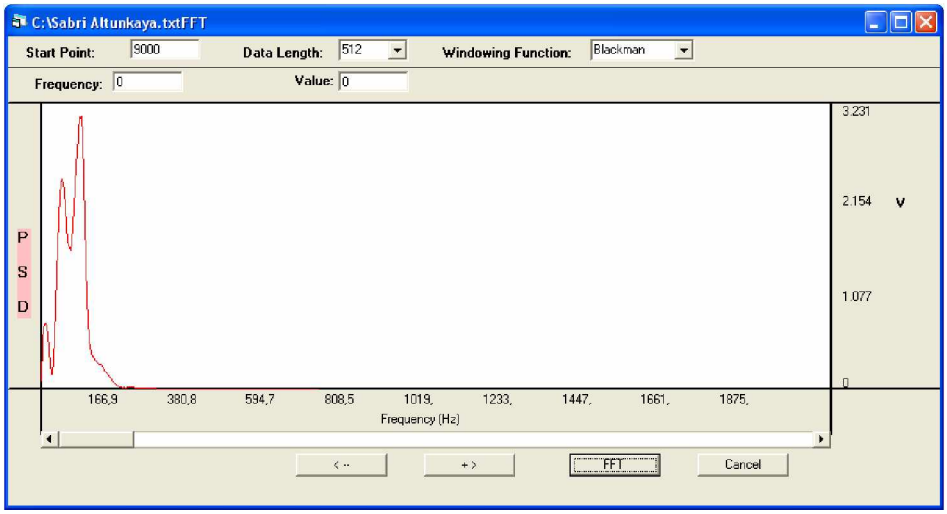

Figure (3.5): *Window for Fourier Transform*

4. Conclusion:

Together with increasing mortality because of cardiovascular diseases in developing country, it is important to develop new methods that are diagnostic, preventing and curative for cardiovascular diseases [6],[10]. Korotkoff sounds only used for blood pressure measurement until now, can be used to find out new methods for diagnostic, preventing and curative medicine [4],[6],[7],[11]. Also, necessity of correct and consistent blood pressure monitors as factor of both diagnostic and preventing medicine has increased together with high mortality because of cardiovascular diseases [1],[7].

The recording system developing in this study can be used to produce a large database by recording some important information such as weight, age, and disease name in addition to Korotkoff sounds. Basic analysis processes like filtering and finding frequency component of recorded data is accomplished by means of the designed software. Thus, the necessity of using different software for analyzing and recording data has been eliminated.

In researches on Korotkoff sounds, cuff is deflated by manual pump during recording of Korotkoff sounds [6],[12]. In realized system, cuff pressure is deflated at an approximate constant rate by a pump. Thus, error source related deflating rate is eliminated and recording of Korotkoff sound signals has succeeded more accuracy.

Also research on Korotkoff sounds, recording of Korotkoff sound signals have accomplished by an operator [6],[12]. The obligation of using recording system with an operator has been eliminated by informing user about placing cuff around arm and procedure during the recoding with prepared software.

Acknowledgements:

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