Digital Arterial Pulse Waveform Measurement System with the PPG Sensor

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Abstract - *To get the arterial pulse waveform, we had to use a digital air-pressure sensor on the wrist and oppress the vessel or artery with high pressure that blocks and release the blood current in the vessel. Most of the digital tonometer adopted the oscillometric method to get the blood pressure and gave a severe hurt on the artery if there are continuous trials on the same position. Therefore we need a sort of continuous arterial pulse measuring system that has no high pressure on the artery for implementing the continuous measuring system. In this work, we designed and implemented the arterial pulse waveform measurement system includes digital PPG sensor, ADC, Raspberry PI 3 and smartphone app that can save and display the continuous arterial pulse waveform. The android smartphone app processes the arterial pulse waveform with lightweight digital signal processing algorithm and displays the amplitude variation, pulse variation and peak point of each arterial pulse in real time. The result of this work can be effectively used on the blood pressures estimation or heart rate check on the smart devices.*

Keywords: Arterial pulse waveform, Continuous measurement, PPG sensor, Raspberry PI, Smart device

1 System design concept

Current smartphone and smart watch have a kind of biomedical application such as heart rate checker or blood pressure measuring app. These applications adopt the PPG sensor and software that can transform some kind of bio-signal to the meaning displayable data format. Although most of the bio-signal processing methods are concentrated on the transition of the signal, several recent researches are focusing on the arterial pulse waveform to get the important biomedical information from the waveform itself.[1][2]

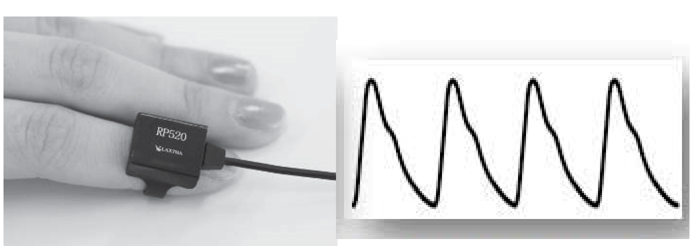

Fig. 1 Laxtha PPG sensor and the output signal

Fig. 1 shows the PPG sensor and the output waveform from the fingertip. The waveform can directly reflect the arterial pulse waveform and shows the details of the blood pressure variation in vessel or artery. In previous works, bio signal experiments require much analog-digital processing circuits including analog filters and amplifier and digital processing system.[3] But now this day, raspberry PI module and Linux based software development system can help easy system implementation without complicated parts and module. Therefore, we designed and implemented an arterial pulse waveform measuring system in a simple method to get the continuous signal acquisition with a PPG sensor.

2 Measurement system design

Fig. 2 shows the block diagram of the implemented measurement system in this work. The system was composed of a PPG sensor unit, ADC module, Raspberry PI 3 module and power unit on the breadboard. Since the Raspberry PI 3 module has built-in Bluetooth chip and driver, it can send something dedicated data to any other Bluetooth client such as the smartphone.

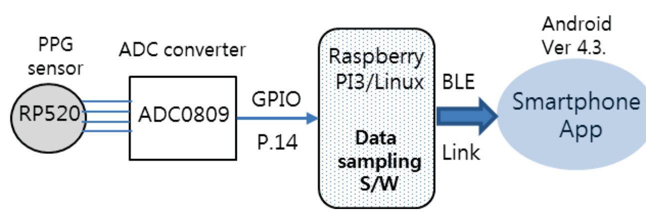

Fig. 2 Block diagram of the measurement system

Fig. 3 shows the implemented system. The PPG sensor has 4-wired photo electronics unit. It detects the blood current variation inside the artery by photo electronics LED and outputs the integral type analog signal offset by the reference voltage. In this work, we use the Laxtha RP520 product as a PPG sensor that has a finger-ring type structure that would not be disturbed by the small body movement and not highly oppress the vessel so much as the Kortokoff-type tonometer.[4] Since the RP520 PPG sensor produces just the continuous analog signal, we have to convert the analog signal into the appropriate digital signal fit to the Raspberry PI 3 GIOP by using analog to digital converter.

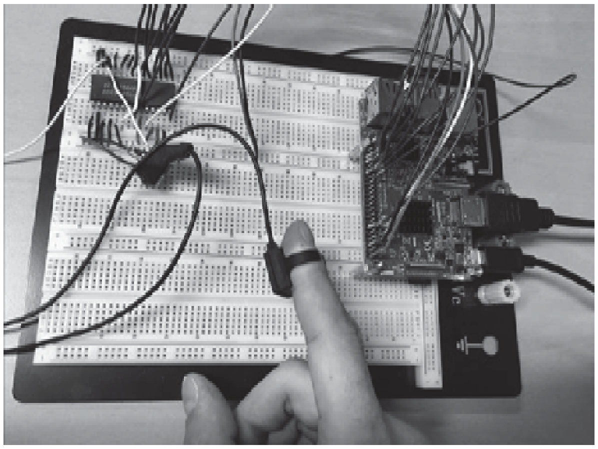

Fig. 3 Implemented Measurement System: PPG sensor, ADC, Raspberry PI 3 module

The Raspberry PI 3 can only permit the digital signal through the IO ports directly and needs external ADC module to connect the RP520 sensor unit with the Raspberry PI 3.[5] ADC0809 is a typical 8-bit analog-digital converter that can connect the RP520 to Raspberry's GPIO. Raspberry PI 3 module processes the digitized arterial pulse waveform, filters noise and sends the waveform data to the smartphone app through the Bluetooth link protocol. Once the Raspberry PI 3 activates the internal Linux application for data sampling, it continuously produces the digital PCM modulation data from the arterial pulse waveform and sends samples data to the Bluetooth link.

3 Smartphone app implementation

The smartphone app runs on the Android smartphone displays the waveform on the screen, save the arterial pulse waveform as s series of data format, and checks the number of peaks and peak variation continuously. Java programming language and Android Studio environment are applied to build the smartphone app. Since human's heart rate has about 60 ~ 80 bpm, we have to set the analog sampling rate of ADC0809 as 150Hz, around double of average heart rate by Raspberry PI 3 pin setting and Linux data sampling program.

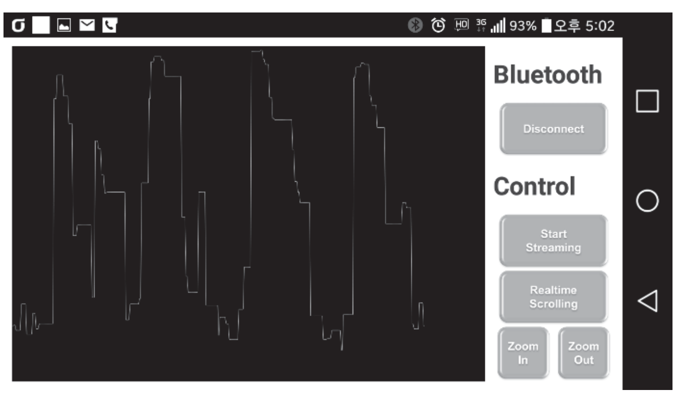

Fig. 4 Smartphone app view displays unfiltered arterial pulse waveform

Fig. 4 shows the smartphone app display view when inputs unfiltered arterial pulse waveform. To remove the noise from the cable and connector, we applied the low-pass filter library in the Linux data sampling program.

4 Conclusion and Further works

In this work, we designed and implemented the continuous arterial pulse waveform measurement system with PPG sensor, ADC and raspberry PI 3 module to process the software noise filtering and to connect with the smartphone app. This measuring system can provide the continuous biomedical signal based on the arterial pulse waveform and can be effectively used in the area of the bio-signal analysis and biomedical application development. At the next stage, we implement the instrumental version of the measuring system that can provide more precise data and robustness against the biomedical signal noise such as body movements for the u-Healthcare application.

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6 References

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