Wireless photoplethysmography finger sensor probe

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ABSTRACT: A sensitive, digital, wireless sensor probe has been developed for photoplethysmography (PPG) measurements. It uses standard light emitting source and detector. The main advantage of this approach is to measure discharge time of the photodiode as amplitude of PPG signal. It reduces the cost, dimensions, power consumption and filtering of the device. First results of distant monitoring of heart rate using the newly developed sensor probe are presented.

1 Introduction

In the last years wireless technologies have become a self-evident part in many spheres. By enabling comfortable and continuous cardiovascular monitoring outside of a clinical setting over extended periods of time, wearable biosensors could play an important role in medicine as this kind of technology would increase patient's mobility as the patient's movement would not be limited due to wires.

Photoplethysmography (PPG) ensures detection of blood volume pulsations by time-resolved analysis of the tissue back-scattered or absorbed optical radiation [1]. PPG technique has good potential for express diagnostics and early screening of cardio-vascular pathologies, as well as for self-monitoring of the vascular condition [2, 3]. And PPG has become increasingly popular due to its low cost and non-invasive possibility of cardio-vascular measurement without the needs of electrodes.

A classic PPG probe is placed on the periphery of body, most commonly on a finger or a toe and can operate in reflectance or transmittance mode. It consists of LED and photodiode. In addition to the detector, decent quality electronics (ADC, filters, amplifiers) are needed to record a good quality PPG signals.

The PPG sensor we have proposed is a small size LED-photodiode type which can be built in various devices.

2 Method

The basic design of the device that was developed is relatively simple and inexpensive. It consists of an optical contact probe, a bio-signal amplifying/filtering circuit (both powered by a rechargeable battery) and wireless module (Fig. 1. a,b).

The reflective photo sensor comprises a photodiode with an amplifier and an infrared LED (peak emission wavelength at 940 nm).

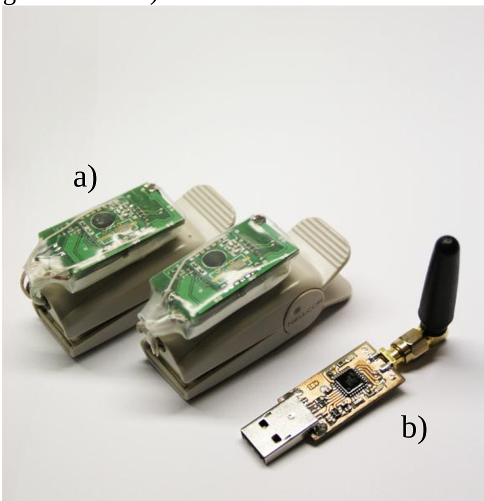

Fig. 1. Wireless sensor a) transmitter, b) receiver.

The AC-component of the photodiode output signals is selected, pre-amplified and converted into digital format, then accumulated and processed by the computer. The signal sampling rate can be changed; the time resolution of 1 millisecond is satisfactory for recording of well-resolved heartbeat signals.

Fig. 2. a) shows the schematic of the wireless sensor. The processing unit was designed to fit into a standard Nellcor finger sensor. Fig. 2. b) shows wireless receiver operating in 900 MHz frequency.

The dimensions of transmitter PCB containing the control/processing module are 20x40x12 mm. The dimensions of receiver PCB are 18x32x3 mm.

The 350 mAh battery can be recharged from a USB port by an on-board single cell Li-Po battery charger. All circuitry can sustain about 12 hours continuous functioning.

The transmission distance is up to 50 m.

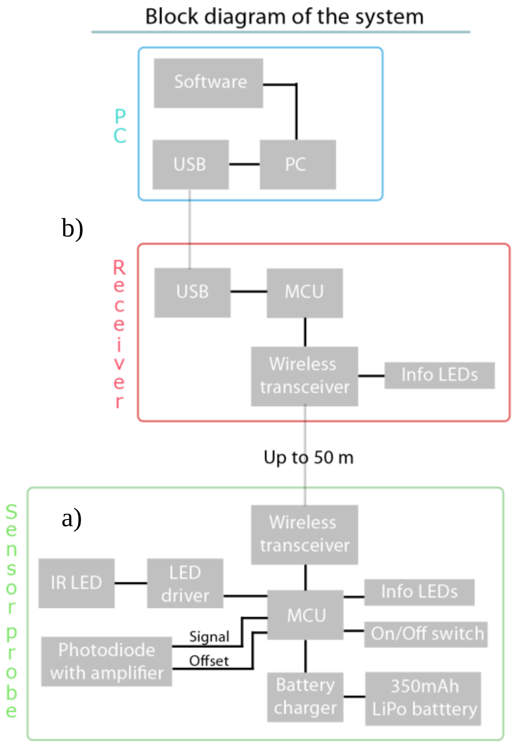

Fig. 2. Schematic of wireless PPG sensor: a) PC and receiver, b) sensor probe.

Special software (Fig. 3.) was developed for the PPG bio-signal acquisition, processing and data storage, offering various options, e.g.,

- Illustrates PPG signal;
- FIR filter to remove noise;
- Calculation of pulse rate;
- Shows battery level and transmission quality.

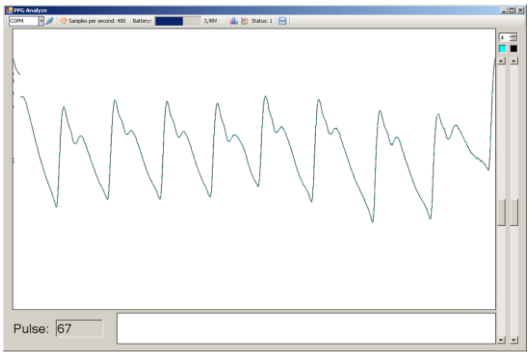

Fig.3. The monitor screenshot during PPG measurement.

3 Results

We performed series of wireless PPG measurements in the laboratory. The monitored volunteers – about 10 in total - were persons of different ages, genders and training background. The PPG signals were detected from the right middle fingertip. All the participants reported that the wireless finger sensor felt comfortable. Fig. 4. shows an example of a typical PPG signal recorded from the finger.

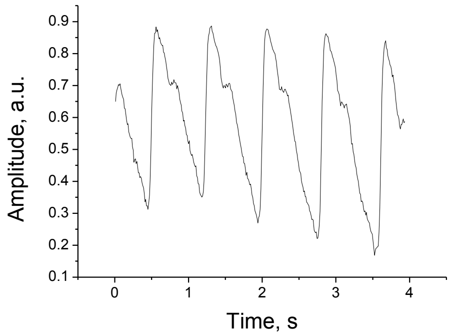

Fig. 4. Example of detected PPG signal.

4 Conclusions

A low cost finger probe for PPG data acquisition and visualization has been developed. Its design allows easy technological updates and further improvements: motion artifacts presents the most challenging problem. Incorporating wireless technologies open possibilities for a wide range of application scenarios. The special software solution was developed to realize the PPG signal acquisition and analysis in real-time and off-line. Software solution has open modular structure: it is easy to add new analysis functions. Besides, application of advanced telecommunication technologies to long-term home care of the elderly is a rapidly growing segment of the health care industry. The current trend is home and community-based care, so this solution may be successfully used in this area. This technology could be used for patients having long-term medical needs and diseases, including patients with congestive heart failure, chronic wound care, permanent disability, terminal illnesses, etc.

Acknowledgments

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