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A New Modeling of Contactless Cardiac and Respiratory Signal Waves Monitoring Device using Wearable Sensor

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ABSTRACT:

The novel device presented here for monitoring respiration and pulse meets all the aforementioned requirements of an ideal on-body sensor. A mobile device is presented for monitoring both respiration and pulse. The device is developed as a bendable/flexible inlay that can be placed in a shirt pocket or the inside pocket of a jacket (wearable). It combines multiple sensors, both of which work in a non-contact way allowing unobtrusive monitoring. The device includes a microcontroller for data processing and a Bluetooth module for data transmission. The use of the sensor method is intended for pulse measurement. The sensors emit light of a specific wavelength into the tissue region under investigation, measure the amount of light that passes through the tissue, and arrive at a measurement unit. Since the light intensity at the measurement unit depends on blood content in the tissue, this sensor technique is well suited for cardiac pulse detection. The MQ-6 can be used to sense the CO2 level of the breathing (respiratory) air and converted into electrical signal. To achieve optimum monitoring performance, the device combines multiple sensor principles, which work in a safe noncontact way through several layers of cotton or other textiles. Because each sensor signal has some dependence on both physiological parameters, fusing the sensor signals allows enhanced signal coverage. And also the system introduces the Smart Bio-App for monitoring and measuring the ECG, Respiratory as well as body temperature.

Keywords: Wearable Sensor, ECG, Respiratory, non-contact measurement and Smart APP

1.INTRODUCTION

HOME or tele-monitoring systems need frequent records of vital signs on a regular basis to assess the health status of a patient. To maintain the patients' quality of life, monitoring of vital signs should take place as unobtrusively as possible. For this purpose, on-body sensors can be of considerable benefit. An ideal on-body sensor for home application should be mobile and easily wearable, so as not to restrict the patient's mobility. Also, it should be easy to use without the need for skilled personal and/or complex electrode application on multiple measurement locations. Because the device should be suitable for long-term monitoring, direct skin contact should be avoided to prevent skin irritation. Finally, for better acceptance by the patients, the sensor should be imperceptible, i.e., light weight, flat, and adaptive to body motion.

The novel device presented here for monitoring respiration and pulse meets all the aforementioned requirements of an ideal on-body sensor. It combines two sensors, both of which work in a noncontact way allowing unobtrusive monitoring. The device includes a microcontroller for data processing and a Bluetooth module for data transmission. The entire device is realized on a small printed circuit board (PCB) which can easily be placed in a shirt pocket or the inside pocket of a jacket. Since the carrier material of the circuit board is flexible, the device adapts its form to the thoracic surface. The use of the sensor method is intended for pulse measurement. The sensors emit light of a specific wavelength into the tissue region under investigation, measure the amount of light that passes through the tissue, and arrive at a measurement unit. Since the light intensity at the measurement unit depends on blood content in the tissue, this sensor technique is well suited for cardiac pulse detection. The MQ-6 can be used to sense the CO2 level of the breathing air and converted into electrical signal.

Combining both sensor techniques enables us to monitor various physiological parameters at the same measurement location. This reduces both application effort and the size of the device, and allows us to investigate the dependence between different physiological measures without time-shifts or damping effects due to mechanical propagation. The fact that both sensors measure both respiration and pulse could be used to enhance the coverage of respiratory and pulse rate estimation, i.e., the time during which a parameter extraction is possible. The fusion of two sensors at the same measurement location offers additional advantages: It allows investigating the dependence between different physiological measures without time lag or mechanical damping caused by different measurement locations. Such a measure could be the time-interval between the ejection of the heart (measured by the IR sensor via cardiac wall motion) and the corresponding arrival of the blood volume in the subcutaneous tissue. The spatial fusion of both sensors also allows the possibility of motion artifact cancellation, since motion artifacts will presumably couple in both sensors simultaneously and to the same extent. However, further verification of these ideas has to be provided in future investigation.

A. Existing Method

Flexible pressure sensors are gaining considerable attention as wearable devices to be potentially utilized in human machine interfaces. However, the preparation of pressure sensors through a simple, environmentally friendly, and cost-efficient fabrication process, remains as a challenge. In this study, we developed a flexible and wearable piezo resistive pressure sensor which consists of a polyethylene terephthalate (PET) as a flexible substrate for printing silver inter digitated electrodes and a poly(3,4-ethylenedioxythiophene) polystyrene sulfonate (PEDOT:PSS) coated tissue paper as an active material. The PEDOT-Paper pressure sensor showed a sensitivity of 1.7/kPa in the range of 0 to 0.46 kPa, a response time of 240 ms and a recovery time of 306 ms. The potential application of this sensor for human voice detection was also demonstrated by mounting the sensor on the throat of a volunteer and pronouncing the words, _Hello_ and _Inha University_. The good repeatability and characteristic curves were achieved for each word, confirming the promising application of the PEDOT-Paper pressure sensor in the field of voice recognition.

Problem Statement

- The development of this system is analyzing or recognition the voice of human by using flexible and wearable sensor.

B. Proposed Method

A mobile device is presented for monitoring human body radiation, respiration and heart pulse rate. The device is developed as a bendable/flexible inlay that can be placed in a shirt pocket or the inside pocket of a jacket. To achieve optimum monitoring performance, the device combines three sensor principles, which work in a safe noncontact way through several layers of cotton or other textiles. And also the system proposes the Smart Bio-App for monitoring and measuring the ECG, Respiratory as well as body temperature.

2.LITERATURE REVIEW

Busra Ozlu1, Bong Sup Shim Flexible [1] Flexible pressure sensors are gaining considerable attention as wearable devices to be potentially utilized in human machine interfaces. However, the preparation of pressure sensors through a simple, environmentally friendly, and cost-efficient fabrication process, remains as a challenge. In this study, we developed a flexible and wearable piezo resistive pressure sensor which consists of a polyethylene terephthalate (PET) as a flexible substrate for printing silver inter digitated electrodes and a poly(3,4-ethylenedioxythiophene) polystyrene sulfonate (PEDOT:PSS) coated tissue paper as an active material. The PEDOT-Paper pressure sensor showed a sensitivity of 1.7/kPa in the range of 0 to 0.46 kPa, a response time of 240 ms and a recovery time of 306 ms. The potential application of this sensor for human voice detection was also demonstrated by mounting the sensor on the throat of a volunteer and pronouncing the words, _Hello_ and _Inha University_. The good repeatability and characteristic curves were achieved for each word, confirming the promising application of the PEDOT-Paper pressure sensor in the field of voice recognition.

Mahmood Khayatzadeh [2] This paper presents a fully integrated sub-1 V 3-lead wireless ECG System-on-Chip (SoC) for wireless body sensor network applications. The SoC includes a two-channel ECG front-end with a driven-right-leg circuit, an 8-bit SAR ADC, a custom-designed 16-bit microcontroller, two banks of 16 kb SRAM, and a MICS band transceiver. The microcontroller and SRAM blocks are able to operate at sub-/near-threshold regime for the best energy consumption. The proposed SoC has been implemented in a standard 0.13- m CMOS process. Measurement results show the microcontroller consumes only 2.62 pJ per instruction at 0.35 V. Both microcontroller and memory blocks are functional down to 0.25 V. The entire SoC is capable of working at single 0.7-V supply. At the best case, it consumes 17.4 Win heart rate detection mode and 74.8 Win raw data acquisition mode under sampling rate of 500 Hz. This makes it one of the best ECG SoCs among state-of the-art biomedical chips.

Prema Sundaram[3] Telemedicine is a rapidly developing application of clinic medicine where medical information is transferred through the phone or internet or other networks for the purpose of consulting and performing remote medical procedures or examinations. Telemedicine can be applied to a greater extend in the field of cardiology where ECG serves as the major tool. This project elaborates the experience; a methodology adopted and highlights various design aspects to be considered for making telemedicine in patient monitoring system effective. In this method, the patient's vital signs like ECG, heart rate, breathing rate, temperature, SpO2 are captured and the values are entered into the database. It is then uploaded into the web based server and sent to the doctor's phone using ANDROID technology. It also enables the doctors to instantly send back their feedback to the nurse station. The modern visionary of healthcare industry is to provide better healthcare to people anytime and anywhere in the world in a more economic and patient friendly manner. Therefore for increasing the patient care efficiency, there arises a need to improve the patient monitoring devices and make them more mobile. Recent works in communication technologies have inspired the development of telemedicine to a large extent. Telemedicine benefits not only the customers who are able to receive health care more efficiently; it also benefits the doctors who can streamline their efforts to assist more patients.

I. SYSTEM FUNCTION

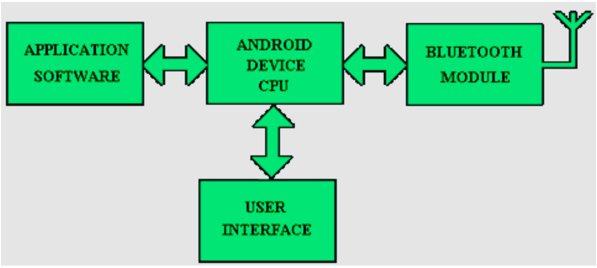

Fig.1 Block Diagram of the Smart APP

Here we develop an Android Application for sending communicating with the hardware base station. The user controls and Bluetooth connectivity is designed for the application using "Android SDK" software tool. The application was developed in android studio using java. This app enables the smart phone to connect to a Bluetooth modem via Serial Port Profile (SPP). Software packages required include Java Development Kit (JDK), the Eclipse software environment, Android Development Tools (ADT) and Android SDK (Software Development Kit). An Android phone sends its command to the client Bluetooth-enabled devices through an embedded Bluetooth module. The phone is used as a host controller which establishes their communication with Bluetooth modules.

Typically the module could interface with a host through the UART port. The PIC 16f877a microcontroller is a low-power, high-performance CMOS 8-bit microcontroller with 8K bytes of in-system programmable Flash memory. The PIC 16f877a provides features of Up to 8K x 14 words of Flash Program Memory, Up to 368 x 8 bytes of Data Memory (RAM), Up to 256 x 8 bytes of EEPROM Data Memory In addition, the PIC 16f877a is designed with software that supports two selectable power saving modes. PIC 16f877a is a powerful microcontroller which provides a highly-flexible and cost-effective solution to embedded control applications.

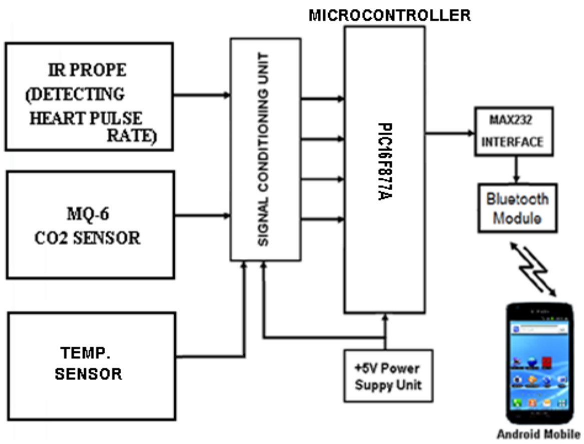

Fig.2 Functional Block Diagram of the System

The IR probe consists of IR LED (Infra Red Light Emitting Diode) and IR photodiode. The IR LED transmitting the light wave to photodiode through finger. The light waves cuts by the blood vessels and reach the photodiode in non linear periods. These non-linear times can be converted into pulses which represents the heart rate. This rate is applied to the one of the input of microcontroller.

The MQ-6 sensor is a CO_2 sensor which is used to sense the carbon-di-oxide level from breathing air. This sensor converts the co2 level into electrical signal. This electrical output is applied to the input of the microcontroller.The LM35 transistor is used to produce the electrical signal according to their body temperature. This output can be applied to the input of the microcontroller through transistor driver. The microcontroller receives the signals from sensor and executes the corresponding predesigned program to communicate the data's to Bluetooth module through IC MAX232. Bluetooth module receives the data' and displays on screen.The Smart APP "wave analyzer" display the all bio-wave signals in the form graph.

II. SENSORS

I. MQ6 - CO2 Sensor

Fig.3 Schematic Diagram of GAS sensor MQ-6

Sensitive material of MQ-5 gas sensor is SnO_2, which with lower conductivity in clean air. When the target combustible gas exist, The sensors conductivity is more higher along with the gas concentration rising. Please use simple electro circuit, Convert change of conductivity to correspond output signal of gas concentration. MQ-5 gas sensor has high sensitivity to Methane, Propane and Butane, and could be used to detect both Methane and Propane. The sensor could be used to detect different combustible gas especially Methane, it is with low cost and suitable for different application.

Features:

- Good sensitivity to Combustible gas in wide range.
- High sensitivity to Methane, Butane and Propane.
- Long life and low cost.
- Simple drive circuit.

II. LM35 – Temperature

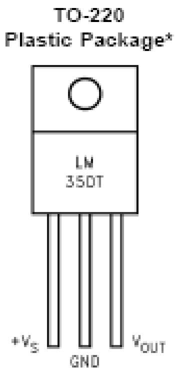

Fig.4 Pin diagram of LM35

The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in ° Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling.

The LM35 does not require any external calibration or trimming to provide typical accuracies of ±1⁄4°C at room temperature and ±3⁄4°C over a full −55 to +150°C temperature range. Low cost is assured by trimming and calibration at the wafer level. The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. It can be used with single power supplies, or with plus and minus supplies. As it draws only 60 µA from its supply, it has very low self-heating, less than 0.1°C in still air. The LM35 is rated to operate over a −55° to +150°C temperature range, while the LM35C is rated for a −40° to +110°C range (−10° with improved accuracy).

Features:

- Calibrated directly in ° Celsius (Centigrade)
- Linear + 10.0 mV/°C scale factor
- 0.5°C accuracy guaranteeable (at +25°C)

- Rated for full −55° to +150°C range
- Suitable for remote applications
- Low cost due to wafer-level trimming
- Operates from 4 to 30 volts
- Less than 60 µA current drain
- Low self-heating, 0.08°C in still air
- Nonlinearity only ±1⁄4°C typical
- Low impedance output, 0.1 W for 1 mA load

III. Heart Pulse

Silicon Finger Clip Based

Fig.5 Heart Pulse Sensor with OP-AMP

Heartbeat sensor provides a simple way to study the function of the heart which can be measured based on the principle of psycho-physiological signal used as a stimulus for the virtual- reality system. The amount of the blood in the finger changes with respect to time. The Sensor is Based IR moulded in silicon , So Once the Finger is inserted Heart Beat will not miss t. In order to calculate the heart rate based on the blood flow to the fingertip, a heart-rate sensor is assembled with the help of OP-AMP for monitoring the heartbeat pulses.

Specification

- Input Voltage - 5v
- POT Given to adjust Sensitivity
- Pulse Output - 3.3 and 5 volt level

3. EXPERIMENTAL RESULT

Fig.6 &7 Shows the Respiratory and Heart Rate respectively.

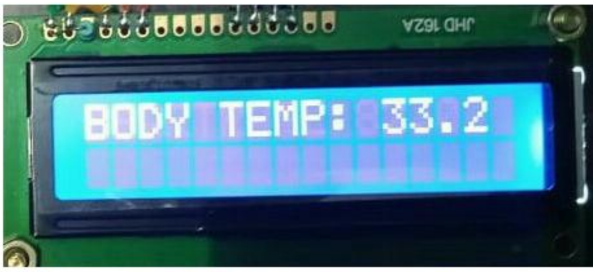

Fig. 8 Shows the Body Temperature

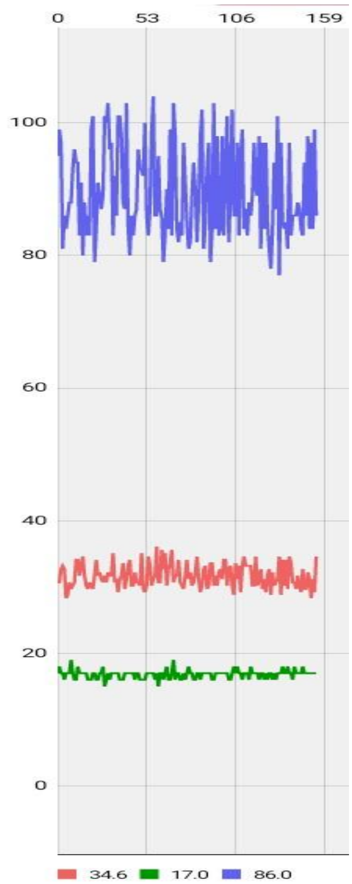

Fig.9 Shows the Signals of the Body Temperature, Respiratory, Heart Rate using Bluetooth connected .

4.CONCLUSION

The device presented here shows excellent ability to monitor cardiorespiratory activity. Despite several layers of cotton textile between the sensor and skin, it is still possible to obtain signals suitable for the extraction of respiratory and pulse rate (CO2 sensor: SNRresp = 98.5 dB, SNRpulse = 42.2 dB;). Combining two noncontact sensor principles and placing them at the same measurement location allows enhancement of both physiological information and signal quality. It has been shown that it is likely to happen that the amount of cardiac or respiratory related signal content of the CO2 and IR sensor changes in dependence on body posture. Therefore, by fusing both sensor signals, the coverage rate of the parameter extraction could be enhanced. Furthermore, physiological measures derived by combinations of both signals could be monitored. The spatial sensor fusion enables the use of adaptive motion artifact cancellation techniques because both signals will be affected by the same motion artifact. Since the device is mobile, wearable, easy to apply, easy to operate, noncontact, unobtrusive, motion adaptive, and multimodal, it seems to be well suited for on-body sensor networks in telemonitoring applications.

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