

Smart Embedded Medical Diagnosis using Beaglebone Black and Arduino

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Abstract— Now a day's healthcare industry is to provide better healthcare to people anytime and anywhere in the world in a more economic and patient friendly manner. The Medical Diagnosis Shield allows Arduino and Beaglebone Black users to perform biometric and medical applications where body monitoring is needed by using 9 different sensors. This information can be used to monitor in real time the state of a patient or to get sensitive data in order to be subsequently analysed for medical diagnosis. Biometric information gathered can be wirelessly sent using any of the 6 connectivity options available: Bluetooth, 802.15.4, ZigBee, WI-Fi, 3G and GPRS depending on the application.

Keywords—Pulse, SPO2, airflow (breathing), Body temperature, ECG, glucometer, galvanic skin response, blood pressure, patient position, muscle/electromyography sensor (EMG).

I. INTRODUCTION

The electronics technology has entered almost in all aspects of day-to-day life, and the medical field is not exception for that. The need for well-equipped hospitals and diagnostic centres is increasing day by day as the people are becoming more conscious about their health problems. In biomedical fields special units are used, such as intensive care unit or coronary care unit. All of these units are designed to offer the advantage of the low Nurse - Patient ratio and concentration of the equipment and the resources needed, to take care of critically ill or seriously injured units. The medical world today faces two basic problems when it comes to patient monitoring, firstly the need of healthcare providers present beside the patient and secondly the patient is restricted to bed and wired to large machines. In order to achieve better quality patient care, the above cited problems have to be solved. As the technologies are advancing it has become feasible to design to home based vital sign monitoring system to display, record and transmit signals from human body to any other location.

This paper discusses the aspects of acquisition of physiological Parameters like pulse, SPO2, airflow (breathing), body temperature, ECG, glucometer, galvanic skin response, blood pressure, patient position, muscle/electromyography sensor (EMG) gathered information can be wirelessly sent using any of the connectivity options like Bluetooth, 802.15.4, ZigBee, WI-Fi, 3G and GPRS depending on the application.



Fig. 1 Modules interfacing with Arduino board

If real time image diagnosis is needed a camera can be attached to the 3G module in order to send photos and videos of the patient to a medical diagnosis center.

Data can be sent to the Cloud in order to perform permanent storage or visualized in real time by sending the data directly to a laptop or Smartphone. iPhone and Android applications have been designed in order to easily see the patient's information. This system is expected to monitor patient under critical care more conveniently and accurately for diagnosing which can be interfaced with computer to bring it under a network system widely for the doctor to monitor the patient's condition sitting in his own office without being physically present near to the patient's bed.

II. THE OVERALL FRAMEWORK OF THE MEDICAL DIAGNOSIS SYSTEM

The mobile Medical Diagnosis system is based on Zigbee wireless sensor network technology, which integrates pulse, SPO2, airflow (breathing), body temperature, ECG, glucometer, galvanic skin response, blood pressure, patient position, muscle/electromyography sensor (EMG) And the collected physiological information and position location information can be transmitted, stored, analyzed and displayed by the mobile Medical Diagnosis management system. The overall framework of the Medical Diagnosis management.

A. Design Specification

The system's main design specification it to be a portable real time embedded system that capture the pulse, SPO2, airflow (breathing), body temperature, ECG, glucometer, galvanic skin response, blood pressure, patient position, muscle/electromyography sensor (EMG) and utilize wireless capabilities to communicate measured data. The Measured data will be wirelessly transmitted to mobile or any other six ways. The Hardware-Software co-design methodology was used to implement the system and select component.

III. SYSTEM ARCHITECTURE

The main architecture of the system is generic and can be implemented to target various applications. Our prototype is implemented as shown in Figure 1 which shows the high level system architecture with the main interfaces. Only the controller, sensors, and a method of output are mandatory , but the rest of the system is expandable. The following subsections provide more details of the components used in our prototype:

A. Pulse and Oxygen in Blood (SPO2)

Pulse oximetry a noninvasive method of indicating the arterial oxygen saturation of functional hemoglobin. Oxygen saturation is defined as the measurement of the amount of oxygen dissolved in blood, based on the detection of Hemoglobin and Deoxyhemoglobin. Two different light wavelengths are used to measure the actual difference in the absorption spectra of HbO2 and Hb. The bloodstream is affected by the concentration of HbO2 and Hb, and their absorption coefficients are measured using two wavelengths 660 nm (red light spectra) and 940 nm (infrared light spectra). Deoxygenated and oxygenated hemoglobin absorb different wavelengths



Fig. 2 Pulse and Oxygen Mesurment sensor to to Arduino board

B. Electrocardiogram (ECG)

The electrocardiogram (ECG or EKG) is a diagnostic tool that is routinely used to assess the electrical and muscular functions of the hear.

The Electrocardiogram Sensor (ECG) has grown to be one of the most commonly used medical tests in modern medicine. Its utility in the diagnosis of a myriad of cardiac pathologies ranging from myocardial ischemia and infarction to syncope and palpitations has been invaluable to clinicians for decades.

The accuracy of the ECG depends on the condition being tested. A heart problem may not always show up on the ECG. Some heart conditions never produce any specific ECG

changes. ECG leads are attached to the body while the patient lies flat on a bed or table.



Fig. 3 Electrodes for ECG attached to Arduino board

C. Airflow: breathing

Anormal respiratory rates and changes in respiratory rate are a broad indicator of major physiological instability, and in many cases, respiratory rate is one of the earliest indicators of this instability. Therefore, it is critical to monitor respiratory rate as an indicator of patient status. AirFlow sensor can provide an early warning of hypoxemia and apnea.

The nasal / mouth airflow sensor is a device used to measure the breathing rate in a patient in need of respiratory help or person. This device consists of a flexible thread which fits behind the ears, and a set of two prongs which are placed in the nostrils. Breathing is measured by these prongs.

The specifically designed cannula/holder allows the thermocouple sensor to be placed in the optimal position to accurately sense the oral/nasal thermal airflow changes as well as the nasal temperature air.



Fig. 4 Airflow mesurement sensor to Arduino board

D. Body temperature

Body temperature depends upon the place in the body at which the measurement is made, and the time of day and level of activity of the person. Different parts of the body have different temperatures.



Fig. 5 Body Temperature Mesurer to Arduino board

E. Blood pressure

Blood pressure is the pressure of the blood in the arteries as it is pumped around the body by the heart. When your heart beats, it contracts and pushes blood through the arteries to the rest of your body. This force creates pressure on the arteries. Blood pressure is recorded as two numbers—the systolic pressure (as the heart beats) over the diastolic pressure (as the heart relaxes between beats).



Fig. 6 Blood pressure monitor

F. Patient position and falls

The Patient Position Sensor (Accelerometer) monitors five different patient positions (standing/sitting, supine, prone, left and right.)

In many cases, it is necessary to monitor the body positions and movements made because of their relationships to particular diseases (i.e., sleep apnea and restless legs syndrome). Analyzing movements during sleep also helps in determining sleep quality and irregular sleeping patterns. The body position sensor could help also to detect fainting or falling of elderly people or persons with disabilities.



Fig. 7 Position Monitoring sensor to Arduino board

G. Galvanic Skin Response (GSR)

Skin conductance, also known as galvanic skin response (GSR) is a method of measuring the electrical conductance of the skin, which varies with its moisture level. This is of interest because the sweat glands are controlled by the sympathetic nervous system, so moments of strong emotion, change the electrical resistance of the skin. Skin conductance is used as an indication of psychological or physiological arousal, The Galvanic Skin Response Sensor (GSR - Sweating)

measures the electrical conductance between 2 points, and is essentially a type of ohmmeter.



Fig. 8 GSR sensor to Arduino board

H. Glucometer

Glucometer is a medical device for determining the approximate concentration of glucose in the blood. A small drop of blood, obtained by pricking the skin with a lancet, is placed on a disposable test strip that the meter reads and uses to calculate the blood glucose level. The meter then displays the level in mg/dl or mmol/l.



Fig. 9 Glucose mesurer attached to Arduino board

I. Electromyogram (EMG)

An electromyogram (EMG) measures the electrical activity of muscles at rest and during contraction.

Electromyography (EMG) is a technique for evaluating and recording the electrical activity produced by skeletal muscles. EMG is performed using an instrument called an electromyograph, to produce a record called an electromyogram. An electromyograph detects the electrical potential generated by muscle cells when these cells are electrically or neurologically activated. The signals can be analyzed to detect medical abnormalities, activation level, recruitment order or to analyze the biomechanics of human or animal movement.



Fig. 10 EMG Sensor attached to Arduino board

J. GLCD

This is a smaller version of our serial graphic LCD. The Serial Graphic LCD backpack is soldered to the 128x64 pixel Graphic LCD and provides the user a simple serial interface to a full range of controls.



Fig. 11 Graphical LCD attached to Arduino board

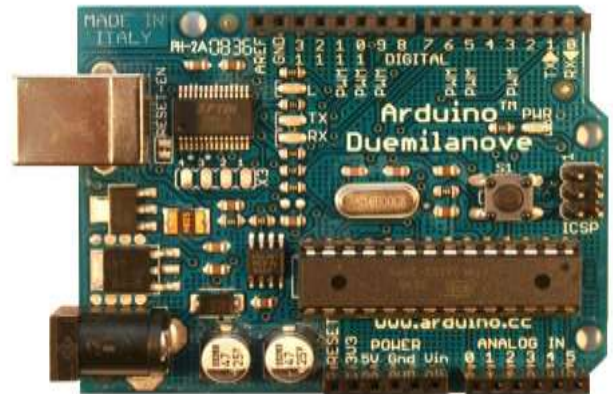


Fig. 13 Arduino board

K. BeagleBone Black

The Beagle Bone has a main processor core running at 700MHz, a chunk of 256M DDR RAM, and permanent storage onto a microSD card.

This makes for a powerful machine, that has no problems running Linux, a webserver, Python, FTP clients, SSH, etc. The Bone also has great accessories built in, such as onboard Ethernet with 10/100M connectivity, mini USB port with TTL serial converter, JTAG debugger for advanced hacking, USB

A host port for connecting a hub/WiFi/etc, power management IC that keeps the board safe from a misplugged adapter, and tons of 0.1" spaced breakouts.

One of the powerful abilities of the Bone is that it has I2C, SPI, and GPIO at a hobbyist-friendly 3.3V level (instead of the more difficult to interface 1.8V) while also running complex applications such as a webserver.

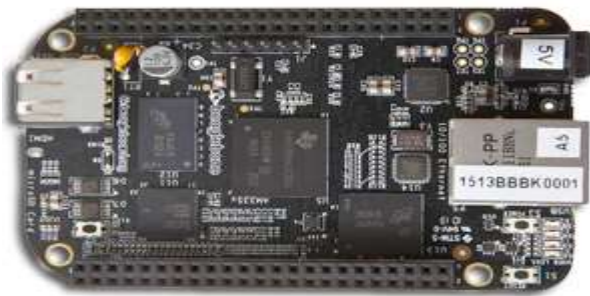


Fig. 12 BeagleBone Black

L. Arduino Duemilanove

The Arduino Duemilanove ("2009") is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

M. Bluetooth

Bluetooth Modules for Arduino/Beaglebone black are able to be plugged into the XBee Shield and get a serial communication between the computer and an Arduino/Beaglebone black board through Bluetooth protocol.

Bluetooth module PRO for Arduino supports Serial Port Profile (SPP) to exchange data with other devices. This profile allows to create connections to another device using the same profile (p2p connection). It sends data to the specified device.



Fig. 14 Bluetooth module

N. GPRS

GPRS Quadband Module for Arduino/ Beaglebone black (SIM900) offers GPRS connection to your Arduino/Beaglebone Black board. You can send your data by SMS or do missed calls from your Arduino to mobile devices or to another Arduino/ Beaglebone Black connected to this module.

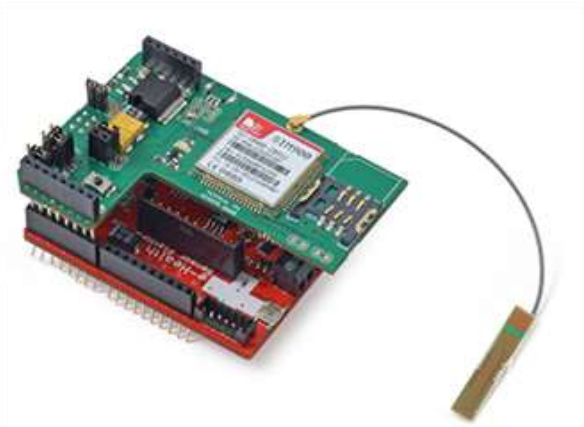


Fig. 15 GPRS module

IV. EXPERIMENTAL RESULTS

Practical tests have been conducted to evaluate the real time performance of the wireless Medical Diagnosis platform,. In particular, an experiment was carried out in which one of the authors wore a wearable sensor's on his body to perform real-time monitoring for 10 minutes. The wireless Connectivity node, which is connected to the wearable sensor's placed on the patient's body to collect health parameters, further transfers the data to the Wireless gateway. The wireless Connectivity node stores the measured signals in a buffer.

The gateway provides reliable IPv6 communication transmit a patient's biomedical signals to a doctor or server via the internet. Utilizing IPv6 with the IEEE 802.15.4 standard is a special match of the two technologies.

All packets transmitted through the internet are verified in the server monitoring program. This program performs an accurate recognition even if the patient is unconscious. Receiving all the transmitted packets via user datagram protocol (UDP) communication in the server, the monitoring program stores its value in a database and plots all the measured biomedical signals dynamically. Various algorithms are combined and implemented as mobile application software with the Java Android language to handle all the processes from the server. The query processes handle the communication between the server and Android mobile device to display the biomedical signals graphically on a mobile screen in real time.

The monitoring program also shows the records of sensing values and relevant personal information, such as a

PPG waveform display and heart rate, the IPv6 address of the node, the IPv6 address of the wireless gateway, the server IP, and buttons for the initiation and termination of a monitoring activity, as shown in Fig. 16 , Fig 17. This program is also accessible to a client PC with an IPv4 address. The server PC can share the measured signals with any internet-connected client, such as a desktop, a laptop, a tablet PC, or a mobile device, provided that the client has a fixed IPv4 address.

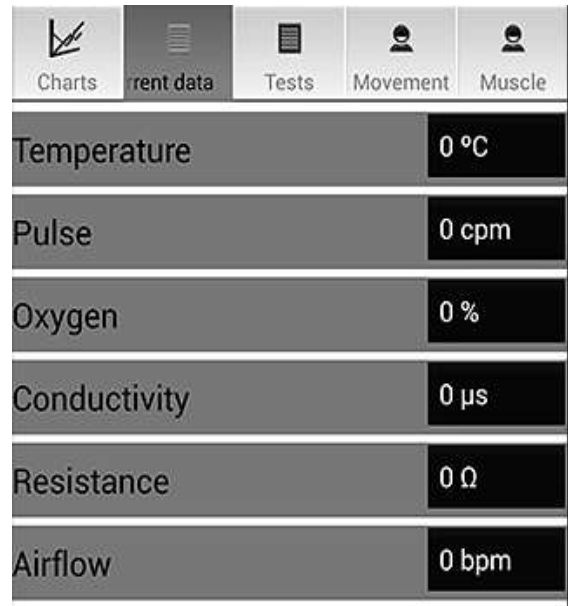


Fig.16 Shows Airflow, Glucometer and GSR

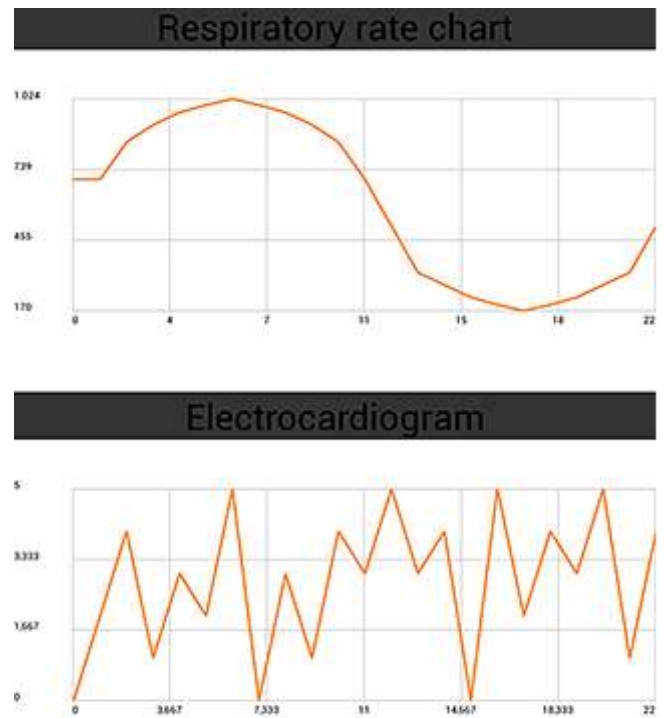


Fig. 17 Shows Measured ECG values

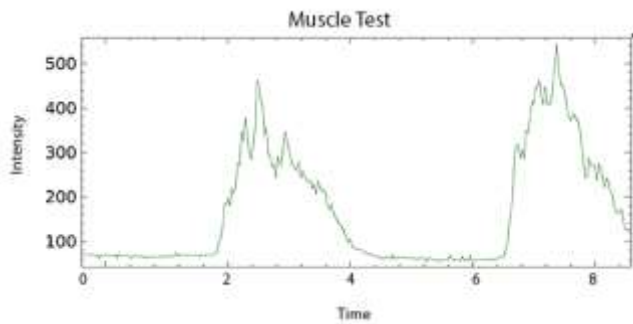


Fig. 18 Shows Measured EMG values on the graph

Secondly, to support the mobile monitoring service, monitoring tests are required by using the Android emulator in the server before installation on the mobile device.

The Android software development kit (SDK) provides emulators that can mimic a variety of Android versions, screen dimensions and phone behaviours. Although the emulator runs a bit slower than a real phone, it provides adequate support for all the features and lifecycle events, including persistent state and writing local files, and launches automatically from Eclipse.

In addition, we would like to add that the popularity of mobile application stores (e.g., the Apple App Store and the android Market) has opened an effective software delivery channel whereby a healthcare application can be installed in seconds, further lowering the barrier to user adoption. We expect that in the near future it will be possible to deliver production quality healthcare applications globally with near zero user effort and with universal access.

V. CONCLUSION

On the background of the applications of WSN in the smart embedded medical health management, mobile health management software based on the Android platform has been developed, which achieves the real-time monitoring by processing and displaying physiological information and the location of the abnormal users. The health management software has the characteristics of strong instantaneity, convenience and practicality. The health management software has been applied to process and display the health information of users of a specific area and is convenient for user health information management.

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