Research and manufacture health monitoring device using ZigBee wireless technology

Hoang The Viet[1], Vu Kha Khoi[2]

Student, Faculty of Electronics Eng., Posts and Telecommunications Institute of Technology
(Km 10, Nguyen Trai Road, Hadong dist., Hanoi, Vietnam)
E-mail: hoangtheviet93@gmail.com

In modern health care system, the demand for personal health tracing devices is increasing significantly. To solve this problem, we have developed a portable equipment which can monitor heart rate, blood pressure and health status. The measured data will be sent to the webserver to process and give out result in form of graphs so that users can monitor and judge their health status accurately. In some emergency situations, for example, someone may fall down or their heart rate goes down, a warning message will be sent to caregivers' phones immediately. This device is especially helpful for aged people.

Keyword: *Zigbee, Health monitoring, heart rate, wearable sensor system.*

1. INTRODUCTION

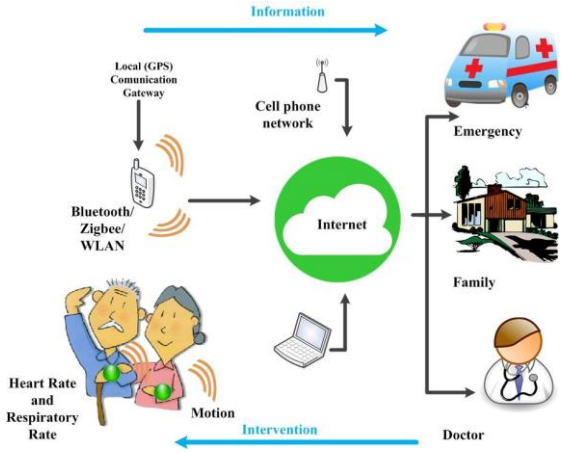
The elderly are more vulnerable to diseases and easily suffered from health problems than younger age groups. Health care needs of the elderly have increased fast. It is really necessary to have a remote health monitoring system based on wearable device. Health related information is gathered via body-worn wireless sensors and transmitted to the caregiver via an information gateway such as a mobile phone. Caregivers can use this information to implement interventions as needed.

This remote health monitoring device can monitor your heart rate, the operating status of the body like Activity, Sleep or free-fall, these parameters are extremely important. These informations can be sent to the nurse or doctor, the information will be displayed as graphs so that they can be easily observed and monitored. [Ref]

Beside that this device also send reminders for tests and treatments, and alerts in case of potential hazardous conditions like free fall, heart rate go lower than threshold. (Fig 1)

Despite the potential advantages of a remote monitoring system relying on wearable sensors like the one described above, there are significant challenges ahead before such a system can be utilized on a large scale. These challenges include technological barriers such as limitations of currently available battery technology as well cultural barriers such as the association of a stigma with the use of medical devices for home-based clinical monitoring. [Ref] In the following section, we discuss key technologies enabling the development and deployment of wearable technologies and remote monitoring systems.

Figure 1.
Illustration of health care system using wear able sensor



2. KEY TECHNOLOGIES

(1) Medical Devices

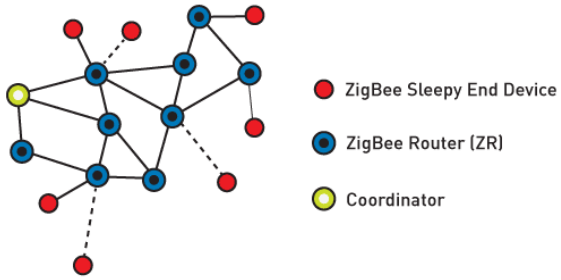
a) Zigbee

Zigbee is a cheap wireless communications solution for embedded systems, the name of this protocol stems from the behavior of honeybees. Honeybee distributed on a large empty field, they perform a communication network to transmit information to the nest. They do this by forwarding the message follow zigzag shape until the nest received the message.[Ref]

A ZigBee network is a self-configuring, multi-hop network with battery-powered devices. This means that two devices that wish to exchange data in a ZigBee network may have to depend on other intermediate devices to be able to successfully do so. Because of this cooperative nature of the network, it is required that each device perform certain networking functions. These functions are determined by the logical ***device type***.

Figure 2.

ZigBee networking protocol stack delivers robust and reliable mesh networking



Coordinator: This is the device that "starts" a ZigBee network. It is the first device on the network. The coordinator node chooses a channel and a network identifier (also called PAN ID) and then starts the network.

Router: As well as running an application function, a Router can act as an intermediate router, passing on data from other devices.

EndDevice: An end-device has no specific responsibility for maintaining the network infrastructure, so it can sleep and wake up as it chooses. End-devices only wake periodically to send and/or receive data to/from their parent. Therefore end devices can be powered by batteries for long periods of time.

b) Heart Rate

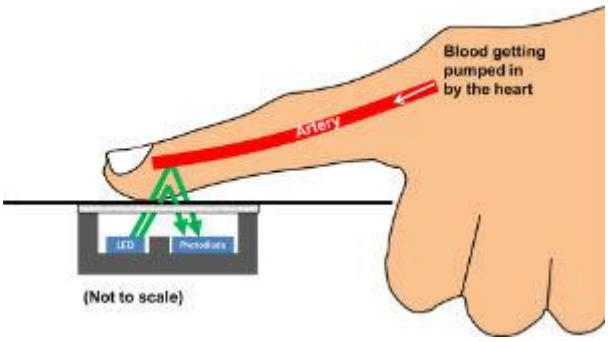
This theory of heart rate measure is based on the principle of photoplethysmography (PPG) which is a non-invasive method of measuring the variation in blood volume in tissues using a light source and a detector. [Ref]

Since the change in blood volume is synchronous to the heart beat, this technique can be used to calculate the heart rate. Transmittance and reflectance are two basic types of photoplethysmography. For the transmittance PPG, a light source is emitted in to the tissue and a light detector is placed in the opposite side of the tissue to measure the resultant light. Because of the limited penetration depth of the light through organ tissue, the transmittance PPG is applicable to a restricted body part, such as the finger or the ear lobe. However, in the reflectance PPG, the light source and the light detector are both placed on the same side of a body part. The light is emitted into the tissue and the reflected light is measured by the detector. As the light doesn't have to penetrate the body, the reflectance PPG can be applied to any parts of human body.

In either case, the detected light reflected from or transmitted through the body part will fluctuate according to the pulsatile blood flow caused by the beating of the heart.

Figure 4.

How a reflective optical heart rate monitoring solution works to measure the heart rate.



c) Activity status

For a human, experiencing a fall unobserved can be doubly dangerous. The obvious possibility of initial injury may be further aggravated by the possible consequences if treatment is not obtained within a short time. For example, many elderly individuals can suffer accidental falls due to weakness or dizziness—or, in general, their diminished self-care and self-protective ability. Since they tend to be fragile, these accidents may possibly have serious consequences if aid is not given in time. Statistics show that the majority of serious consequences are not the direct result of falling, but rather are due to a delay in assistance and treatment. Post-fall consequences can be greatly reduced if relief personnel can be alerted in time.

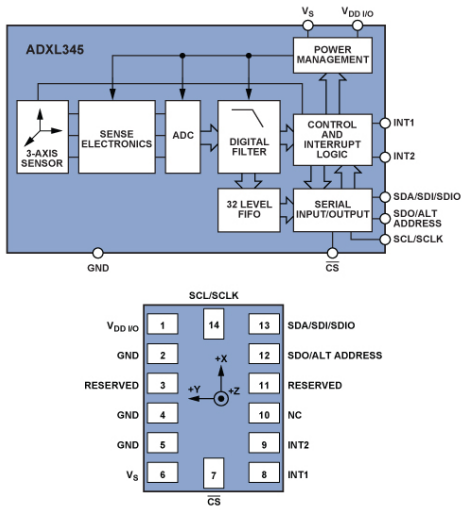
Activity status based on research into the principles of fall detection for an individual body, proposes a new solution for detection of fall situations, activity status utilizing the ADXL345,1 a 3-axis accelerom-

eter from Analog Devices.

The fall-detection solution proposed here takes full advantage of these internal functions, minimizing the complexity of the algorithm—with little requirement to access the actual acceleration values or perform any other computations.

Figure 6.

ADXL345 system block diagram and pin designations.

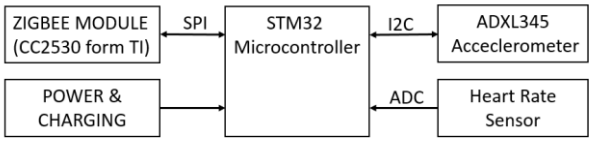


1. **ACTIVITY** is set when acceleration greater than the value stored in the THRESH_ACT register is experienced.
2. **INACTIVITY** is set when acceleration of less than the value stored in the THRESH_INACT register is experienced for longer than the time specified in the TIME_INACT register. The maximum value for TIME_INACT is 255 s.
3. **FREE_FALL** is set when acceleration of less than the value stored in the THRESH_FF register is experienced for longer than the time specified in the TIME_FF register. FREE_FALL interrupt is mainly used in detection of free-falling motion. As a result, the FREE_FALL interrupt differs from the INACTIVITY interrupt in that all axes always participate, the timer period is much shorter (1.28 s maximum), and it is always dc-coupled.

d) Medical Device Prototype

Figure 7.

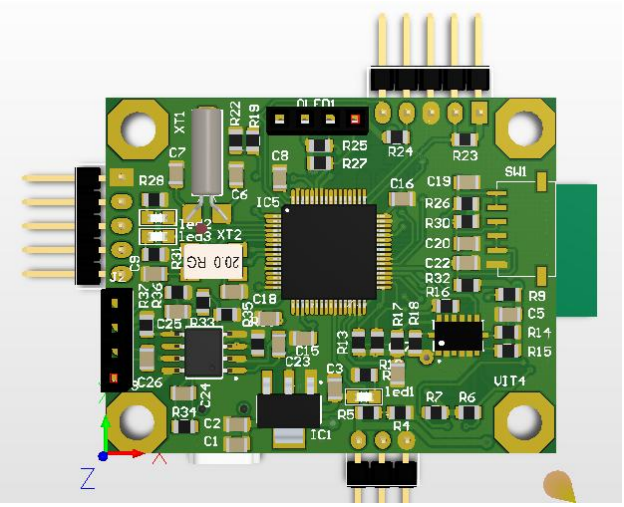
Medical Device Block.



1. STM32 Microcontroller: is an 32bit ARM Cortex M core form ST Microelectronics. It read Heart Rate values from sensors, calculate them and Activity status form ADXL345, send the heart rate values and the activity status to the gateway via Zigbee module. It also displays information on the LCD for user.
2. Zigbee Module: is a Zigbee Network Processor (ZNP) based on CC2530 SoC contain 8051 microcontroller core form Texas Instrument. It run Z-Stack(Zigbee protocols stack solution form TI) to handling data packet, communication to other Device (Gateway) in network and leave STM32 MCU free to handling other task.
3. ADXL345 Acclerometer read 3 Axis Value, calculate them and export corresponding Interrupt(ACTIVITY, INACTIVITY, FREE_FALL) with input Parameter form STM32 MCU like THRESH_ACT, THRESH_INACT.
4. Hearte Rate Sensor: using SPRF359 IR sensor to mesuare Heart Rate follow the theory above, PPG Signal will pass 2 stage op-amps to filter unnecessary frequencies and increase the Amplitude of signal create conditions for ADC measurements correctly

Figure 8.

Medical Device in 3D.



(2) Gateway device

Gateway is a device used to Health monitoring system to communicate with nurses through the internet and GSM, it is essential to keep track of information Activity status, the heartbeat of the elderly and immediately alert to a nurse if dangerous situations like fall.

Information from the medical device will be moved to the gateway via ZigBee, here gateways will be configured as coordinator, this information will be processed and posted to the database mySQL and webserver running on the gateway will obtain information from mySQL and displayed on graphs. Sim900A Module is used as a warning device, it uses the GSM network to communicate with the nurse's

phone. If dangerous situation occurs a phone call or call or sms message will be sent to the nurse's phone.

Figure 9.
Gateway Device.

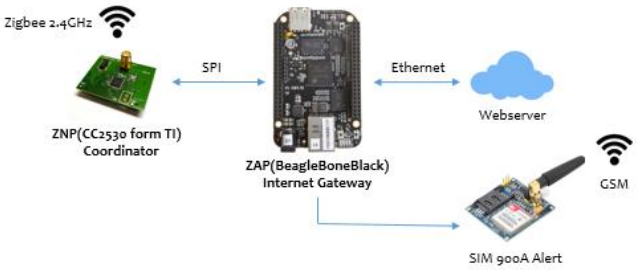
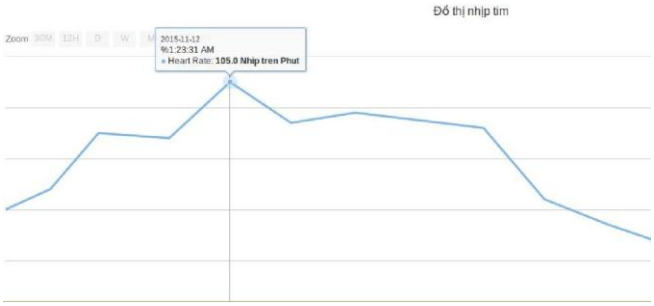


Figure 10.
Heart Rate Graph.



CONCLUSION

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