Development of a Motion-Based Message Conveyance System with Continuous Glucose Monitoring for Diabetes Care and Patient Communication

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ABSTRACT

This paper presents a low-cost reliable system which establishes communication between disabled patients and a nurse. The objective is to make the patients who are dependent on their family members, independent to communicate. This makes the nurse's job easy. It helps the patients to communicate with the nurse by tilting an accelerometer attached to the moving part of the body. This technique provides simple and effective solutions to issues faced by nurses in traditional communications. This paper also includes an automatic sugar insulin measurement technique which automatically tracks the glucose level and adjusts the insulin levels with no input from the user.

KEYWORDS: Accelerometer, Arduino Uno, Speech module, GSM Module, Blood glucose sensor, Insulin injector.

1. INTRODUCTION

Paralysis is the loss or impairment of voluntary muscular power. It is commonly caused by stroke, head injury, and spinal cord injury. Paralytic people never regain mobility or sensation in the affected areas. But, even if the person's paralysis isn't curable, the health care team can provide assistive technologies, therapeutic interventions, or other strategies to help to improve the quality of life.

Physically challenged patients or bed-ridden patients often had to rely on others to operate switches for light, fan etc. Paralytic people face difficulties, when they want to convey messages. Therefore, many products and ideas have been proposed to help paralyzed/disabled patients, based on their hand gestures, facial expressions etc. [1] uses a real time image processing technique to recognize hand gestures and to translate them into control actions.

Diabetes is an incurable disease [2] resulting from an insufficiency of insulin in the body, causing elevated blood glucose levels, known as hyper glycaemia or reduced glucose concentrations, known as hypo glycaemia. Wearable sensors have the potential to play a major role in the continuous and non-invasive monitoring of biomarkers for diabetes and other disease conditions.

Out of large number of advancements done in the medical sector very few really focus on helping patients with paralysis for whom communication is difficult. Though, monitoring systems make it easier for doctors to collect and to observe patient's vitals, there aren't many options for actual verbal communication for disabled patients. In the present condition, the patient must depend on a family member or mostly on a nurse, to attend the patient constantly. The objective is to make such disabled/paralytic patients independent to communicate with the nurse by just tilting an accelerometer located on any body part capable of movement.

The blood glucose sensor is the other main component, that senses or monitors the glucose level of the human. When some abnormal events happen, that is when the glucose level is high or low, it is sensed by glucose sensor and insulin injector will be used to inject the insulin. In our work, a painless measurement of glucose is introduced, which is non invasive. Non invasive glucose monitoring is to predict the glucose level of the

patients without finger pricking. The prime concerns while fabricating the device were to reduce cost, utilize available component from local market for easy reproduction and easy user-friendly operation.

The paper presents implementation of a low-cost reliable system which will help to establish communication between paralytic patients and nurse. Details of the circuit and implementations are discussed in the next sections.

2. RELATED WORKS

First, this section presents some of the existing work related to motion-based message conveyor and glucose sensor.

The blood glucose level monitoring and control was developed due to growing global population of diabetes. Wang and Lee [3] developed a blood glucose sensor, that measures the blood glucose level by Continuous Glucose Monitor (CGMS). This method uses the alarm to intimate the level of the blood glucose and is used to improve the quality of life.The main disadvantage of this sensor was minimum life time and low accuracy.

Zhang, et al. [4] utilized the Saliva Nano-Biosensor for noninvasive glucose monitoring. This method is used to reduce the complications and management cost. A disposable Saliva Nano Biosensor system was developed. The system was simple, reliable, low cost, and fast. The UV spectrophotometer was used to obtain the accuracy of the salivary glucose. The disadvantage of the system was it cannot detect the high or low values.

A wearable rehabilitation device for paralysis [5] is a portable, lightweight, and low-cost rehabilitation system for people with a paralyzed hand. The wearable device helps a disabled person to perform specific movements and exercises to train the patients impaired hand. Thus, the disabled patient gradually starts to restore the functionality of hand.

Assistive system for physically disabled people using gesture recognition [6] is based on hand gesture recognition to recognize the different gesture used by a deaf to communicate using scale-invariant feature transform algorithm (SFIT)

An electronic support system for dumb and paralyzed person [7] is used to help dumb and paralyzed persons to communicate their needs to the attender. When a disabled patient needs some help/support, he or she shakes the hand/finger and the speed is measured by accelerometer. The proposed system is used to improve lifestyle of a dumb/paralyzed person. It will provide dumb and partially paralyzed persons a voice to speak for their needs and to express their gestures. It requires low power operating systems and having less weight.

3. DESIGN CONSIDERATIONS

Following were the points considered while designing the device:

Low cost: The device was designed using cheap and easily available components at local retailers.

Easy operation: The device was fabricated to be easily operable. Minimum technical knowledge is required to utilize the device.

Safety: The device is designed in a such a way that it could not contain any potentially dangerous component which can harm patient in way.

Necessary Feedback: The device had to have means to interact with the user through audible signal, which offers effective performance.

4. HARDWARE DETAILS ARDUINO MICROCONTROLLER

An Arduino microcontroller is an opensource microcontroller. Its hardware is reasonable priced. The development of software is free. It is used to control the motors. Arduino is operating at 5v with 32 kb

flash memory for storing programs and 1 kb of EEPROM for storing parameters. Arduino board consists of 14 digital input/output pins and 6 analog pins.

The external 6-20 v power source is connected using power. This controller was cheap and simple. This can be used with different operating systems like Linux, Windows, and Macintosh.

ACCELEROMETER

Sensitivity, precision and small size of MEMS [Micro electro mechanical] accelerometer sensor make it a powerful tool to analyze motion pattern and other physical activities. The device contains an accelerometer ADXL345 for sensing motion. The characteristics of accelerometer are their compact structure, flexible control, simple and reasonable design.

LCD
LCD is the liquid crystal display. It is an electronic display and is used in many applications. Various circuits and applications use 16*2 LCDs. The 16*2 LCD represents 16 characters per line and 2 lines. The LCD collects information from the command registers. Other characteristics are, low power consumption, thin geometry, and wide range of display sizes and applications.

GSM
Global System for Mobile Communication, is open and digital cellular technology is used for transmitting data. It operates at 850 MHZ, 1800 MHZ, and 1900 MHZ frequency band. Time Division Multiple Access (TDMA) technique is used for GSM in communication. GSM is widely used for wireless communication. The flexibility and convenience offered by mobile communications made it one of the fastest growing areas of telecommunications.

SPEECH MODULE
The board is controlled through serial commands. It is compact, flexible, and low cost. It can interface with any microcontroller or with PC serial port, and it can accept any micro SD memory card from 128 MB to 32 GB.

Text-to-speech module is a multi –language voice synthesizer. This converts a stream of digital text into natural sounding speech.

BLOOD GLUCOSE SENSOR
The Blood glucose sensor is used to monitor the level of glucose in blood. This sensor is simple and easy to use. It provides reliable result and has small size. If the glucose level is increased or decreased, insulin injector will inject the insulin into the body. This glucose sensor should be fixed properly, and it provide the correct readings.

MICROMOTOR
Micromotors have applications in medicine because they deliver materials to living cells in an organism. There are many different micromotors operating under a host of mechanisms.

A catheter is used to inject insulin into the body contained in an ampoule. A small motor pushes the plug of the insulin ampoule forward, causing insulin to be released. The motor diameter must be no more than about 10 millimeters. It must be compact in size and light in weight, reliable and precise so that it is not difficult for the patient to wear the device. Since the insulin is to be injected into the body every five minutes, the motor must start and stop at regular intervals.

5. WORKING PRINCIPLE

Accelerometer acts as an input, and it is connected to Arduino Uno controller. The main part of this device is accelerometer. It is used to sense acceleration and is interface with controller. The second stage of the system is the controller. This controller will process the data from the accelerometer, if the conditions are satisfied, then it will select the message which is set, and is then given to LCD. At the same time, this instruction will be given to speech module and the speaker, so that the patient can hear whether the given instruction is correct or not. SD

card/memory card can be inserted, in which we can store the instructions or messages, which is to be given by the patient. Buzzer will turn ON at the same time, and it gives alert to the nurse and doctor or relatives of the patient. An emergency alert is given to the registered number using GSM as information can be exchanged from remote place [9]

BLOCK DIAGRAM

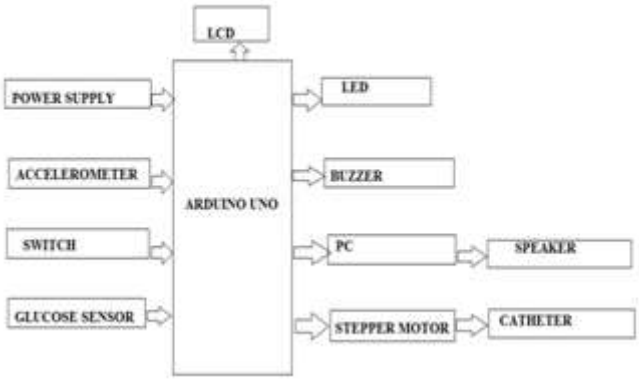

Fig 1

The components of automatic insulin injection system such as, insulin injector, power supply, micromotor, and a blood glucose sensor are connected to the Arduino board. The blood glucose sensor is used to sense or monitor the glucose level of the human. This sensor is fixed properly, which provides a correct reading. The readings are displayed on LCD. If the glucose level is high or low, it is sensed by glucose sensor and the insulin injector will inject the insulin [10].

6. CONCLUSION AND FUTURE WORKS

A simple device for paralyzed or disabled patients can be implemented without use of complex form of inputs. This system offers fast and effective communication. The simulation of the system is done in Arduino. This project shows transmission of messages. The message is remotely sent to doctor of concerned person through SMS. Based on tilting of accelerometer, different messages such as 'Need Water, Hungry, Pain, Call Doctor' are displayed on the LCD. The messages are also sent to registered number via GSM. Blood glucose sensor is used to sense blood glucose level and if glucose level is high or low, insulin injector will inject insulin into the body.

A low-cost reliable device for paralytic patients was developed as an attempt to take part in the technological advancements. We can also use other android applications, through which the real time patient's health status updates will be given to the doctor. The doctor will immediately give solutions to the nurse or on the status of the patient's health. We can also use Wi-Fi system for communication through which we can expand communication distance. With more in depth research and development, this system can play a substantial role in medical sectors.

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