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A Smart Healing Mechanism for Diabetic Neuropathy using IoMT

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ABSTRACT

In recent times people affected by diabetic neuropathy is on a constant raise. Diabetic neuropathy will affect the neurons of the body and disrupts its functions and when it affects the leg it affects the neurons in the leg which are responsible for proper coordination and balancing. If it is left untreated it may lead to the amputation of that particular organ. Recent studies have revealed to us that early detection and proper treatment can be used to save the affected organ of the body. Studies have also showed us that sending imperceptible vibrations through the feet of diabetics and stroke patients significantly improves their balance of the person who is affected with diabetic neuropathy. This method is very reliable and can be used to design shoes with built in vibrators that can be used to treat the legs of the persons which got affected with diabetic neuropathy Recent advances in the scope of wearable devices and networks make body area sensor networks (BASNs) an extremely attractive tool to the fields of mobile and tele-health, owing to the range of medical applications they can serve and the diagnostic richness of patient data they can offer. However, for BASNs and IoMT to achieve true ubiquity, they must be scalable in their support of automated patient data collection, making usability and reliability key considerations.

Index Terms— Body area sensor networks, energy-efficient sampling, fault-tolerant sampling, power-constrained sampling.

I. INTRODUCTION

Diabetes is one of the major causes of illness and premature death worldwide. Diabetes causes Neurovascular complications, which result in the development of high pressure areas in the feet and hands. Diabetic neuropathy causes nerve damage which can ultimately lead to amputation or ulceration. Wikipedia says vascular and neural diseases are closely related and intertwined. Blood vessels depend on normal nerve function, and nerves depend on adequate blood flow. A person with diabetic neural dysfunction would also have Microvascular dysfunction.

Diabetic Neuropathy is a serious medical disorder and can be prevented by the early detection of abnormal pressure patterns under the foot. Although equipment to measure foot pressure distribution is available in India and elsewhere, these are still not readily accessible for a large segment of the population, are too expensive to own, and are too bulky to be portable. The foot pressure monitors are also not readily available in less developed countries which are home to many communities with a high prevalence of diabetes.

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Nowadays, there are various electronic technologies available in the market composed with embedded systems and wireless technology for controlling purposes. The embedded system technology is one of the highest growth areas because these systems are used in each and every market segments now days like electronics, automation, biomedical, wireless communication and using wireless and embedded systems we can design shoes with built in sensors and vibrators to monitor abnormal movements and pressure patters in the foot of people affects by diabetic neuropathy in our proposed paper "Cortex-Feet: Foot Analyzer and Blood Flow Stimulator". Diabetic neuropathy is one among the various diseases that is haunting humanity by early detection and proper medication can keep the disease in control for that purpose we have designed the low cost shoe with sensors that monitors abnormal movements and pressure patterns in the legs of the people who are affected with diabetic neuropathy and microcontrollers that controls the vibrating motors which are used to stimulate the blood flow in the particular part of the foot.

II. RELATED WORK

WSNs have emerged as a new class of systems that leverage the power of distributed computation, sensing, and actuation towards a host of scientific, military, and engineering applications. However, engineering these systems is not without challenges. As described therein, from the get go, energy has been identified as the single most important resource for this class. Furthermore, communication is recognized as the most demanding operation on this resource, and a number of designs have been proposed. The demand for similar sensor- embedded devices in the medical domain has spawned a new subclass of WSNs known as wearable or body area sensor networks(BASNs).BASNs have been applied to host of medical problems from geriatric assistance to emotional health monitoring. Given that it is possible to build systems that can interpret medical diagnostics from electrical signals, attention has also been paid to the energy-efficiency and power consumption of BASNs and their effects on system longevity.

In accordance to the existing system if a person is detected with diabetic neuropathy he has to visit his physician regularly for checkups related abnormal pressure patterns under his foot so corrective actions can be taken by stimulating the required neurons under his foot by using a foot vibrator which are bulky and overpriced to own. By this process of stimulation by controlled vibration we can keep diabetic neuropathy in control.Our Cortex-feet foot analyzer and blood flow stimulator will be having hand-held unit which can be integrated to a wrist watch and a foot-unit which can be integrated with a shoe. In Our paper the cortex-feet foot analyzer and blood flow stimulator has two modes of operation one is the record mode and one is the vibrating mode, the decision to select which mode the device should be operated can done by a simple touch on the touch screen of the hand-held unit. In record mode the sensors in the foot-unit will be collecting data on the pressure patters and abnormal movements and will be transmitted to the hand held unit using MiWi protocol. In case of the vibrating

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mode by viewing the results if any abnormality is found then the particular blood flow stimulator can be used to stimulate the particular area.

III. HARDWARE SETUP

➢ **LPC1313 Microcontroller:**

The LPC1313 are ARM Cortex-M3 based microcontrollers for embedded applications featuring a high level of integration and low power consumption. The ARM Cortex-M3 is a next generation core. The LPC1313 operate at CPU frequencies of up to 72 MHz. The ARM Cortex-M3 CPU incorporates a 3-stage pipeline and uses a Harvard.

➢ **Peripheral of LPC1313:**

- 32kB of flash memory.
- 8kB of data memory (SRAM).
- One Fast-mode Plus I2C-bus interface.
- One UART.
- Four general purpose timers.

➢ 42 general purpose I/O pins.

➢ **FORCE SENSING RESISTORS:**

A force-sensing resistor is a material whose resistance changes when a force or pressure is applied. They are also known as "force-sensitive resistor" and are sometimes referred to by the initialize "FSR". Force-sensing resistors consist of a conductive polymer, which changes resistance in a predictable manner following application of force to its surface. They are normally supplied as a polymer sheet or ink that can be applied by screen printing. The sensing film consists of electrically conducting and non- conducting particles suspended in matrix. The particles are sub-micrometre sizes, and are formulated to reduce the temperature dependence, improve mechanical properties and increase surface durability. Applying a force to the surface of a sensing film causes particles to touch the conducting electrodes, changing the resistance of the film. As with all resistive based sensors, force- sensing resistors require a relatively simple interface and can operate satisfactorily in moderately hostile environments. Compared to other force sensors, the advantages of FSRs are their size (thickness typically less than 0.5 mm), low cost and good shock resistance. However, FSRs will be damaged if pressure is applied for a longer time period (hours). A disadvantage is their low precision: measurement results may differ 10% and more. These force sensing resistors are used for sensing the applied pressure on the legs and in case of abnormal pressure input the stimulators can be activated.

➢ **MEMS Accelerometer:**

Micro electromechanical systems (MEMS) are the technology of very small devices; it merges at the nano-scale into nano electromechanical systems (NEMS) and nanotechnology. MEMS are also

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referred to as micro machines (in Japan), or micro systems technology – MST (in Europe). MEMS are separate and distinct from the hypothetical vision of molecular nanotechnology or molecular electronics. MEMS are made up of components between 1 to 100 micrometres in size (i.e. 0.001 to 0.1 mm), and MEMS devices generally range in size from 20 micrometres (20 millionths of a metre) to a millimetre (i.e. 0.02 to 1.0 mm). They usually consist of a central unit that processes data (the microprocessor) and several components that interact with the surroundings such as microsensors.

At these size scales, the standard constructs of classical physics are not always useful. Because of the large surface area to volume ratio of MEMS, surface effects such as electrostatics and wetting dominate over volume effects such as inertia or thermal mass. In the case of mems in our paper, the mems accelerator is used to detect the abnormal motion of the leg in the vertical and the horizontal direction. the mems has the geographical location and in case of awkward movement then the mems accelerometers sends information to the buzzer of the handheld unit and the buzzers starts buzzing.

Fig 2.Flexi Force Sensor

- **VIBRATOR:**

This paper consists of three vibrators for the stimulation of the nerves that are not in active mode. When the diabetic patient has got his nerves numb these vibrators can be activated with the help of the handheld device. This in turn activates these vibrators and they help in the stimulation of the nerves.

Fig 3:Vibrators

- **IEEE 802.15.4 Transceiver:**

IEEE 802.15.4 is a standard which specifies the physical layer and media access control for low-rate wireless personal area networks (LR-WPANs). It is maintained by the IEEE 802.15 working group, which has defined it in 2003. It is the basis for the ZigBee , ISA100.11a, Wireless HART, and MiWi specifications, each of which further extends the standard by developing the upper layers which are not defined in IEEE 802.15.4. Alternatively, it can be used with 6 LoWPAN and standard Internet

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protocols to build a wireless embedded Internet. IEEE standard 802.15.4 intends to offer the fundamental lower network layers of a type of wireless personal area network (WPAN) which focuses on low-cost, low-speed ubiquitous communication between devices (in contrast with other, more end-user oriented approaches, such as Wi-Fi). The emphasis is on very low cost communication of nearby devices with little to no underlying infrastructure, intending to exploit this to lower power consumption even more. The basic framework conceives a 10-meter communications range with a transfer rate of 250 kbit/s. Tradeoffs are possible to favor more radically embedded devices with even lower power requirements, through the definition of not one, but several physical layers. Lower transfer rates of 20 and 40 kbit/s were initially defined, with the 100kbit/s rate being added in the current revision. Even lower rates can be considered with the resulting effect on power consumption. As already mentioned, the main identifying feature of IEEE 802.15.4 among WPANs is the importance of achieving extremely low manufacturing and operation costs and technological simplicity, without sacrificing flexibility or generality.

Important features include real-time suitability by reservation of guaranteed time slots, collision avoidance through CSMA/CA and integrated support for secure communications. Devices also include power management functions such as link quality and energy detection. IEEE 802.15.4-conformant devices may use one of three possible frequency bands for operation.

In this paper we use the transceiver for communication between the handheld and the footwear unit. The Proposed System consists of Following steps

- The Android application unit communicates wirelessly with the foot attached unit and collects real-time data, stores it in the memory card for analysis by a doctor at a later time.
- The device monitors the user foot movement using a 3-axis **MEMS Accelerometer** and actively looks for situations leading to foot injuries.
- Once the system detects an anomaly in the user's foot pressure distribution or foot motion, it issues an alert to the handheld touch screen device.
- To improve the blood flow the smart footwear has a set of miniature **Vibrating Motors** that stimulate the nerves by vibrating in different amplitude that can be configured individually, started and stopped by the user using the handheld touch screen unit.
- The smart footwear will collect data from foot pressure sensors and foot motion sensor and periodically transfer this data to the handheld unit where it will be stored in a SD card for future reference or for an analysis by a doctor.
- In this system, the foot pressure distribution is measured by a set **Flexi Force** pressure sensors located on the insole of the shoe. These sensors are based on force-sensing resistors, whose resistance varies inversely with the applied force.
- The footwear unit measures the pressure sensor outputs and transmits the information using **IEEE 802.15.4** wireless transceiver to the handheld monitoring unit.

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- The monitoring device is equipped with a **65K Color Touch screen TFT Display** that receives the wireless data and displays the foot pressure information on color bar graph as well as store that data in the memory card.
- Apart from the application software and the device driver firmware the microcontroller also runs software such as a **Graphics Library**, a **FAT-32 File System** and an **IEEE 802.15.4 Wireless Networking Protocol Stack.**

IV. CONCLUSION

Thus, the embedded based low power foot analyzer and blood flow simulator has been developed using Force Resistor-Sensor and mems accelerometer. The abnormal pressure pattern and motion due to lose of coordination are detected automatically and the information will be sent automatically to the users hand-held unit and corrective actions can be taken by user by activating the required stimulator motor via MiWi protocol.The challenges and difficulties of deployment of sensors and MiWi protocol in practical scenarios have been identified. Found out the successful operating rate of the deployed sensors. Measured the performance of the sensors based on battery life as well as communication and sensing reliabilities.

The proposed work has overcome the disadvantages of the existing scheme. Stimulation by controlled vibrations has the drawbacks of over size, non-portability, difficulty in operations, high power consumption and so on all these draw backs have been overcome in our proposed system.

V. FUTURE SCOPE

To improve the accuracy and sensor reliabilities of this system, the commercial manufacturer should develop a much smaller version of the Force Sensing-Resistors so that more number of Force Sensing-Resistor sensors can be deployed on the sole of the foot-unit.

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