Development of a Photonic Non-Invasive Diabetic Detection System using Skin Temperature

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Abstract

Diabetics Mellitus is the most common, non-curable serious diseases in the form of Type 1 and 2. It occurs due to high/low levels of sugar in the blood due to unbalanced insulin. Type-2 diabetes can occur at any age, whereas Type-1 occurs in the mid age. This paper describes on the photonic non-invasive predication of the diabetic using skin temperature. By this method the diseases can be self-predicted and for further analysis the data can be wirelessly transferred by means of VLC (Visible Light Communication) to the medical examiner. VLC (Visible Light Communication) is an emerging optical data transmission due to its major advantage of no radiations due to frequency range lies between 480nm-750nm and is easily adoptable to the environments.

KeyWords: Diabetics, Non-invasive, Wireless, Visible Light Communication

1. INTRODUCTION

Around the world, ever-increasing numbers of diabetics are in exponential growth and the conventional diabetic monitoring methods are invasive, painful, and time-consuming and a constant burden for the household budget [1, 3, 9]. These limitations can be overcome by using non-invasive methods [8]. However, this method is not straight forward but is feasible by implementing using well known technologies such as electrical (voltage & current), thermal (Heat) [4], Frequency in Spectrum, Near Infrared and Ultrasound [2]. Diabetic is a disease due to excess or insufficient of glucose in the blood cells [5]. The occurrence of diseases not limited to certain age and is life threatening. Hence to predict the occurrence by any common man a solution on non-invasive method is required. For further analysis the data can be transmitted to the examiner using the optical wireless communication such as visible light communication [6, 7].

1.1 Background and Related Work

Non-Invasive detection of the diabetics due to variation in the glucose content is a major study by the researchers for determining the accuracy of the examined results very similar to invasive method. Many methods and techniques are being proposed to determine the diabetics through optical, thermal, Nanotechnology and Electrical Method are briefly represented in the Fig. 1. Although there are methodologies and techniques [3], there is a need to have an analysis for the variation of glucose non-invasively. Researchers focus on many areas such as saliva, skin [1, 15], eye and sweat. The other analysis is to use the transmission technology from user to the medical examiner and vice versa.

Fig. 1: Method and Techniques [3]

VLC communication is the suitable method for the hospitals due to its non-harmful and skin is considered as the analyzing parameter for the prediction of diabetics.

1.2 Conventional diabetics detection

Conventional Diabetics are complete invasive or semi invasive because sample of blood is required. In complete invasive method, prickled blood sample is examined under chemical composition and is analyzed for the glucose content in laboratories by medical examiner. In semi invasive there are available glucometer, but still needs the blood sample within the meter and is invisible to eye. The meter self-test and reports the glucose

content. In the non-invasive method [13, 14], no blood sample is required, and glucose content can be examined from skin, sweat or saliva and eye. But each of the method has its own complication in prediction of the glucose content. This paper discusses a non-invasive system which leads to better accuracy and self-analysis for the predication and in the case of medical examiner consultation the data can be transmitted over VLC.

2. PROPOSED WORK

An optical wireless based system using visible light communication to transmit the data for analysis and to receive the analyzed results as a prediction the early stage of diabetes from the data due to the variation in the skin temperature. Skin temperature varies based on the glucose content it absorbs and radiates heat [5]. Higher the glucose, the resistance of the blood flow increase, therefore heat generates and tries to exit through the skin. Basically, the blood flow supports in regulation of the body temperature and shall keep uniform through entire body. Due to decrease in the blood flow the temperature of the body varies that can be measured on the skin. To read the skin temperature a specific or a special type of sensors with absolute low resistance must be constructed.

2.1 Design and Implementation

A sensor-based design to read the skin temperature shall be digitized by strengthening the sensed analog signal by an embedded microcontroller as shown in Fig 2.

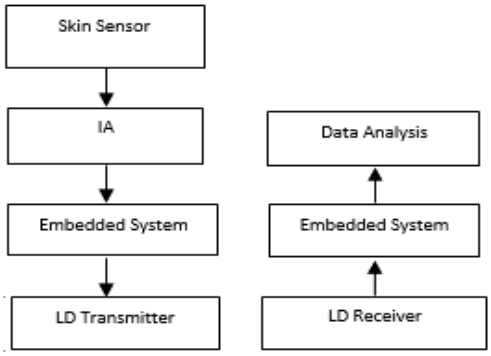

Fig. 2: Design and Implementation

2.2 Present Challenges

Presently there are methods based on measuring glucose concentration from its chemical, thermal, electrical, or optical sensing properties and can be further classified as detection in tissues (skin, aqueous eye humour, oral mucosa, tongue, and tympanic membrane) and fluids (sweat, urine, saliva, and tears). But all these have following challenges

Accuracy of the diabetics' detection while compared to the invasive should exceed [10]. Commercialization of the non-invasive system is a challenge in terms of confident of results by users

Proving benefits is critical for decision on administering insulin with the obtained results. Usability, suitability and applicability challenges and device calibrations

2.3 Skin Sensor integration

Skin varies its temperature based on the glucose content in the blood. Due to this heat absorption and emission happens on the surface of the skin as well the electrical variation due to glucose resist blood flow. The sensor works on the principle of inductive coupling [6] by placing the sensors in between the skin and applying the small reference voltage to the primary coil, due to mutual inductance voltage in the secondary coil gets induced. The output is compared with the reference voltage. The criticality is to use high sensitivity sensors. An equivalent model of the sensor, that is more sensitive to change in temperature, sense the change in skin temperature variation. The normal skin temperature is 38 °C, whereas for a diabetic diseased, after the food intake the glucose content raises by delta of +/- 0.5°C. Therefore, the temperature of the skin shifts slightly above normal. Sensing the delta change in temperature, the sensor shall output in the formal of electrical parameter. Table-1 represents the delta change in temperature with respect to the changes in voltage.

Table 1. Interpretation of skin Temperature and Voltage variation

Skin Temperature In °C	Sensor Output in µV	Amplified Output in mV
37.9	126	645
38.0	128	650
38.1	130	655
38.2	132	660
38.3	134	665
38.4	136	670
38.5	138	675

2.4 Data Conversion

The micro volt data read by sensor is analog in nature and to be amplified by IA (Instrumentation Amplifier). A high precision Analog to digital converter (ADC) convertor is deployed for

conversion into digital. The converted digital output is formatted into Pulse Width Modulation (PWM) Signal. The PWM signal generation is processed in Microcontroller Unit (MCU) system. Any microcontroller can be deployed for generating the PWM signal. Fig 3 represents the data conversion.

Fig. 3: Data Conversion

2.5 Data transmission and reception

The PWM carries the data read by the sensor for transmission. As transmitter LD Laser Diode or LED (Light Emitting Diode) [11, 12] can be interfaced to the Microcontroller. The PWM (Pulse Width Modulation is chosen to drive the LD (Laser Diode) because of better transmission characteristics if LD has switching inputs. By switching, the signal ON and OFF, the PWM gets ON till the data is read continually and gets OFF when the data is not read. Hence the read sensor signal is transmitted using PWM signal from the LD transmitter. Embedded system is the core system consisting of a 16bit microcontroller and associated electronic components. The PWM data to be generated for the LD driver is based on the logic. With its specific ADC input pins, the data is read from sensor and with a reference and tolerance the PWM signal is generated as high or low at the dedicated output pin such that to drive the LD transmitter. The Embedded system is deployed in transmitter and receiving ends. Visible Light communication is wireless technology due to its major advantage of higher bandwidth and free from radiations. Its frequency spectrum falls between 480nm-700nm. Since the Laser Light Spectrum falls in the range of visible spectrum i.e. from 480-700nm the transmission is termed as Visible Light Communication [7]. On the receiver end, a LD detector is deployed to receive the data. The LD is interfaced to another MCU, to process the received data. In the receiver MCU, the diabetic's reference data is embedded into it. Upon receiving the transmitted inputs, the data is compared with the base data. This analysis helps to predict the diabetic diseases.

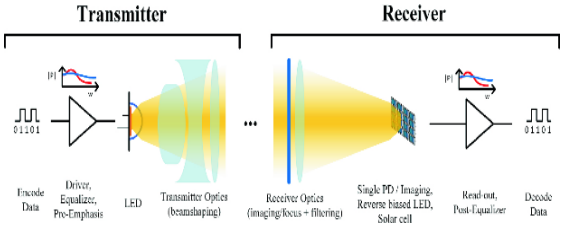

Fig. 4: VLC Transmission & Reception

2.6 Transmitter Driving Signals

The Amplified signal is fed as input to the ADC of the embedded system. Based on the variation in the voltage internal threshold is determined for high and low signal. The low and high signal is processed as a PWM (Pulse Width Modulation) as shown in Fig. 5 to switch the LD transmitter. The PWM can switch to amplitude of 24Vp at 50Hz frequency.

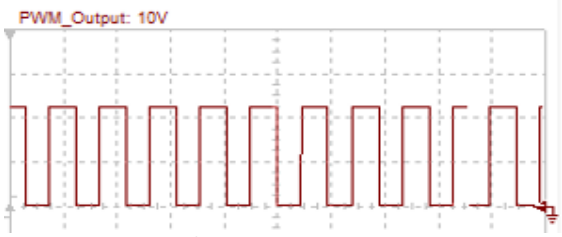

Fig. 5: PWM Signal for Transmission & Reception

2.7 Reception using VLC

Fig. 6 shows the VLC reception flow diagram. Figures 7 and 8 shows the experimental setup used for the transmitter and receiver. The received data is fed to the rectifier and then passed through the low pass filter. After the comparison with the stored data in the embedded system, the output text is generated and received by the concerned person.

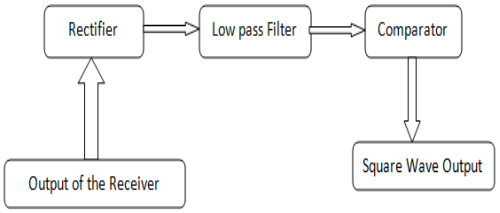

Fig.6: VLC Reception

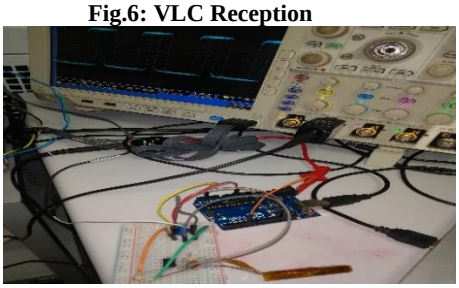

Fig.7 VLC Transmission

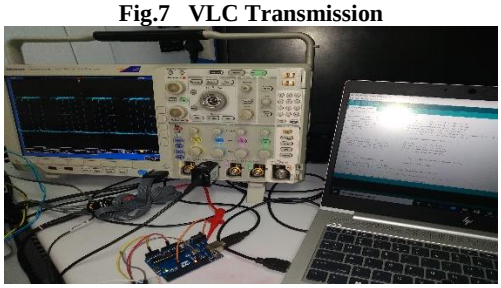

Fig. 8 VLC Receiver

2.8 Output Data

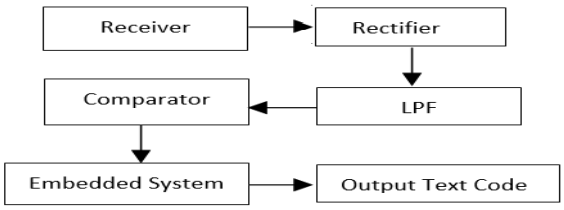

Fig. 9. Final output block diagram

The received and predicted data is shown in Fig. 10 and it reads as follows:

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Blood glucose Level
135mg/dl-Before Meal
170mg/dl-After Meal
210mg/dl-after 2 hours of meal

Normal
Min-99mg/dl Max-130mg/dl
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Fig. 10. Final output Text

3. CONCLUSION

A prediction of diabetic by non-invasive method using the skin temperature that is further analyzed by transmitting the collected data over VLC based wireless communication system is been presented. The temperature variation of 0.1 degree Celsius and corresponding sensor output has been observed. It has major advantage of less radiation and can be implemented in the hospital environmental within the line of sight. To develop a more sensible sensor with more precise and less complication different bands in the electromagnetic spectrum can be analyzed.

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