RESEARCH PAPER

Instant Non Invasive Health Monitoring System With Glucose Monitoring.

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ABSTRACT
The escalating global burden of healthcare challenges underscores the imperative for worldwide healthcare monitoring. While technological advancements, governmental health initiatives, and personal hygiene practices have contributed to increased life expectancies in numerous countries, globalization has resulted in a progressively aging population and declining fertility rates, potentially affecting socioeconomic conditions. To effectively support the elderly, healthcare monitoring technologies must be both affordable and user-friendly. Autonomous healthcare monitoring, incorporating wearable devices with capabilities of communication along with actuators, and sensors, could be a viable solution. This approach enables effective individual care meant for older individuals, reducing their need for inflated clinic treatments. This work stresses on non-invasive blood glucose monitoring (NIBGM). This development aims to develop a non-invasive equipment through IoT connectivity and smart sensors to monitor multiple organs. The compact, interconnected sensor system will keep an eye on temperature of body as well as level of blood glucose. The device will monitor via internet communication, allow professionals to track real time patient's fitness level and transmit information to distant locations. This innovative approach empowers healthcare professionals to offer timely assistance and support, thereby improving patient outcomes..
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INTRODUCTION

In rapidly Globally healthcare monitoring market has seen substantial growth due to increasing health issues and disorders. Enhanced healthcare and public safety measures have extended lifespans, leading to more population with old age and accompanying economic and social challenges. Achieving the aforementioned objectives requires cost-effective and user-friendly wireless healthcare monitoring by means of advance sensors as well as communication technology. This approach simplifies and enhances the monitoring of population, thereby decreasing the need for costly hospital treatments. Researchers globally are investigating innovations in non-invasive blood glucose monitoring (NIBGM), which have expressively improved lives of numerous patients. However, monitoring multiple health metrics without an electronic equipment proficient of calculating all relevant indicators remains a challenge. Traditional blood sugar measurement involve finger pricking, which poses risks of infection and discomfort [1].

The primary objective of proposed work is to design as well as building a measuring method able of quantity physiological factors including body temperature as well as blood glucose level. This integrated device will be accessible to both residential and hospitalized patients. By leveraging IoT technology, the device will transmit collected data to a cloud server for virtual expert observing and initial well-being assessments [2]. The device's diminished dependency on referrals to health points for pulmonary function tests will augment patient accessibility and facility of utilization. Sensors, collects the data and transmit it to cloud server for virtual evaluation of health parameters [3]. It is an affordable, user-friendly, healthcare device that measures critical physiological parameters in one location and facilitates monitoring for improved healthcare quality, which is highly desirable these days [4].

This medical parameter measuring device concept represents a novel approach with the potential for substantial medical advancements. The integrated sensor system detects parameters like temperature, and blood glucose level, which eliminate need for multiple devices to monitor each vital sign [5]. This innovative device offers patients an affordable and user-friendly option.

By securely storing and managing collected data in a public cloud, healthcare professionals can effectively monitor patient health, identify medical conditions early, and ultimately improve patient outcomes. People can use this monitoring device at home deprived of complex procedures, making it accessible to everyone [6]. The proposed medical device represents a cost-effective, simple, and readily available solution to patient life assessment challenges, letting distant measurement and improving health outcomes.

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2 Proposed Work

The proposed initiative seeks to make unified remedial parameter measuring instrument that leverages IoT, sensor, and cloud storage for monitoring acute vital signs. The incorporation of these features allows the device to obviate the necessity for distinct instruments, consequently resulting in diminished costs and streamlined patient monitoring. Both patients and doctor can securely access information kept in a dependable environment based on cloud.

This instrument non-invasively measures temperature as well as glucose level of body using advanced sensors. Its user-friendly design ensures ease of use for patients [7]. The accompanying application empowers doctor to remotely view patient's fitness metrics, cultivating the efficiency of monitoring through device. Phone program reports for critical parameters enhance effectiveness, efficiency as well as facilitate rapid response [8].

This integrated healthcare medical parameter measuring instrument addresses task of evaluating health data which is cost-effective and user-friendly manner. The integration of IoT technology, advanced sensors, and a mobile application enhances instrument's effectiveness and efficiency. The health instrument improves patient's care as well as accessibility through non-invasive blood glucose monitoring [9]. This instrument has possibility to greatly enhance patient health and well-being by enabling remote tracking and automated data access [10].

3 Design of the System

As depicted in the illustration provided by Fig. 1, this information evaluation unit meticulously measures every crucial parameter through the utilization of sensors. This AMU subsequently assesses outcomes, also resultant unit processes the collected data [11]. The oled present at output end, displays the parameters monitored, simultaneously this is also archived in cloud meant for future reference.

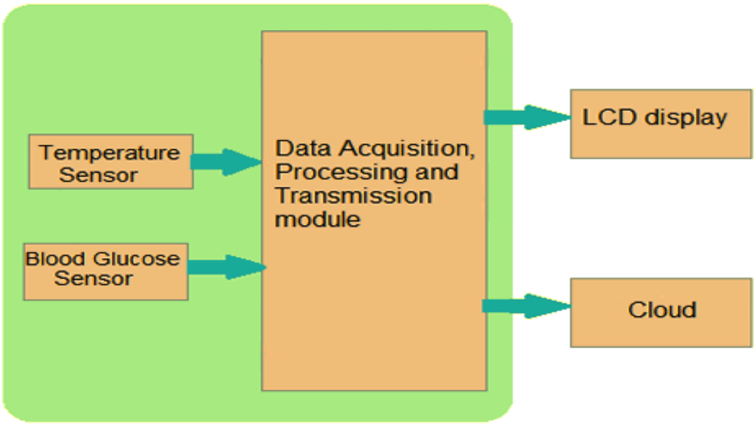

Fig. 1. Comprehensive overview of the system.

4 System's Hardware

The Node MCU ESP8266 unit, which incorporates Wi-Fi connectivity, functions in the form of the firmware for IoT applications within this project [12]. The AMU boards, founded upon the ATmega328P microchip, connect diverse display units, and sensors, which are automated utilizing AMU programming language.

The MLX90614 temperature sensor is depicted by Fig. 2, which is non-contact infrared sensor that communicates with AMU board through I2C interface. Sensor detects infrared energy and transforms it into electrical information to facilitate precise measurement of temperature.

The twin thermopile, integrated amplifier, as well as analog-to-digital converter converts infrared energy to digital outcome, which can be easily read by microcontrollers such as the Arduino or ESP8266.

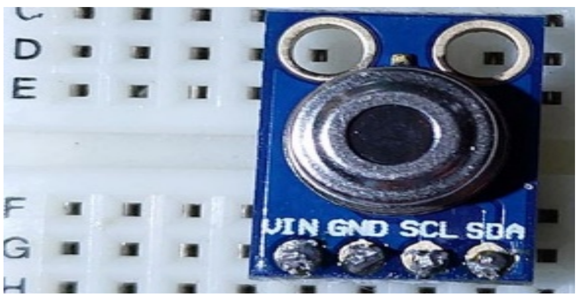

Fig. 2. Temperature device MLX90614.

The MAX30105 sensor, illustrated in Fig. 3, acts as PPG (Photoplethysmography) sensor. The closely integrated module, undergoing evaluation, employs light-emitting diodes and photodetectors to monitor glucose level through the process of radiation.

Fig. 3. MAX30105 sensor.

The MAX30105 sensor interacts with the AMU processor using I2C, operating between maximum 5.5 V to minimum 1.8 V. It helps in precisely determines blood glucose level by emitting radiation onto skin surface also analyzing the reflected light. Background light canceling algorithm minimizes interference from ambient light. This unit is reliable and accurate for healthcare and fitness applications.

5 Implementation

To explore the setup for measurement of body temperature and glucose level, this setup includes a sensor on a power-efficient board and a display screen. To connect the temperature sensor, its power and ground pins need to be connected to chip's connectors. The module's communication pins connect with specific pins on the board, with some resistors to support the connection. For the glucose level sensor, connect its power and ground to the board, and the signal to a digital pin. Then, it will retrieve and use the software tools to measure temperature and glucose level. The temperature data will be read from the sensor's grid of pixels. This setup is designed to provide a calm and gentle way to monitor your vital signs.

The Sensor library is expertly designed to meticulously read and analyze the user's glucose level data, precisely calculating their glucose level founded on the pulses detected [13]. This information is then seamlessly conveyed to cloud via service compatible to MQTT, ensuring a secure and reliable connection. To enable this data transfer, the MQTT library has been put in AMU, allowing the body temperature and glucose level measurements to be shown on display and transmitted to cloud storage, making them readily available for further examination [14].

Real-time visualization of this invaluable data is attained on display unit, allowing for immediate monitoring and analysis [15]. Contactless temperature as well as glucose level readings, providing a clear and accessible record of the collected data. This comprehensive information is also then effortlessly transferred to the cloud, facilitating in-depth analysis and enabling informed decision-making.

6 Blood Glucose Level Measurement

The non-invasive method for monitor glucose levels utilizing near-infrared (NIR) sensors is a remarkable technological advancement. These specialized modules emit light energy within NIR wavelength array, around 940 nanometers, that is readily absorbed by the blood coursing through the skin. The degree of light absorption varies directly with the concentration of glucose molecules present in the blood.

NIR light energy when directed on skin, it enters underlying tissue also interacts to blood vessels. A portion of light is immersed in blood, while remaining light is mirrored back to module, the light scattering with glucose level is shown in Fig. 4. Module then senses the strength of mirrored light; this is utilized for estimation of current blood glucose level.

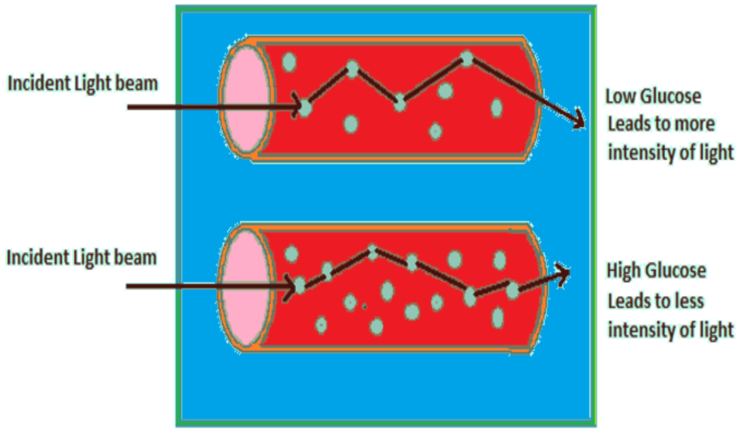

Fig. 4. Light scattering with glucose level.

Absorption of NIR light is influenced by glucose present in blood. As the blood glucose level increases, more light is absorbed, leading to a decrease in strength of reflected light detected by the sensor. Conversely, when blood glucose levels are lower, there is less absorption, resulting a higher strength of reflected light. This direct correlation between glucose concentration and light absorption forms the basis for the non-invasive glucose monitoring using NIR sensors [16].

Non-invasive measurement of glucose levels utilizing Near-Infrared sensors provides numerous benefits in comparison to invasive techniques, like pricking of finger. This approach eradicates requirement of painful measures, diminishes the infection risk, as well as facilitates frequent measurement of blood glucose levels [17].

7 Measurement of blood glucose level with hardware structure

The hardware configuration for measuring blood glucose levels is illustrated by Fig. 5.

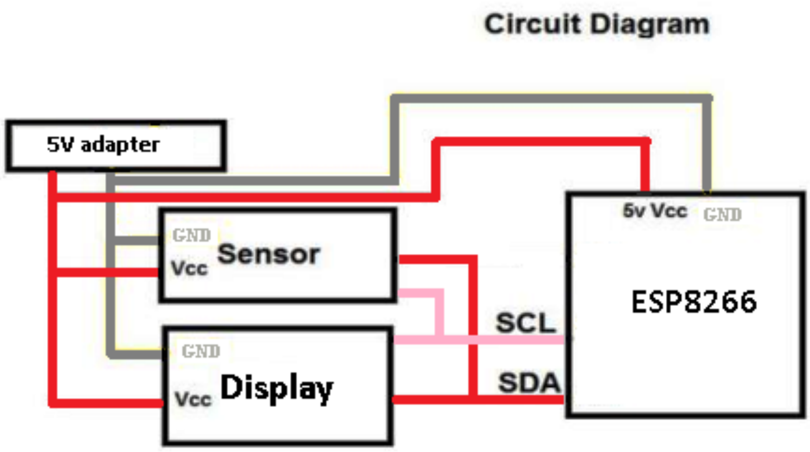

Fig. 5. Circuit Diagram of the Non-Invasive Blood Glucose Monitor

The typical setup involves NIR transmitter as well as NIR receiver (photodetector) positioned on opposite sides, commonly on fingertip. NIR light penetrates the skin and interacts with blood glucose molecules, resulting in absorption based on the glucose concentration. As blood glucose levels vary, the amount of NIR light absorbed also changes, influencing the amount that passes through the fingertip. The measured NIR light intensity is then correlated with blood glucose levels, which are displayed on both the display and a web-based interface. The device is shown in Fig. 6.

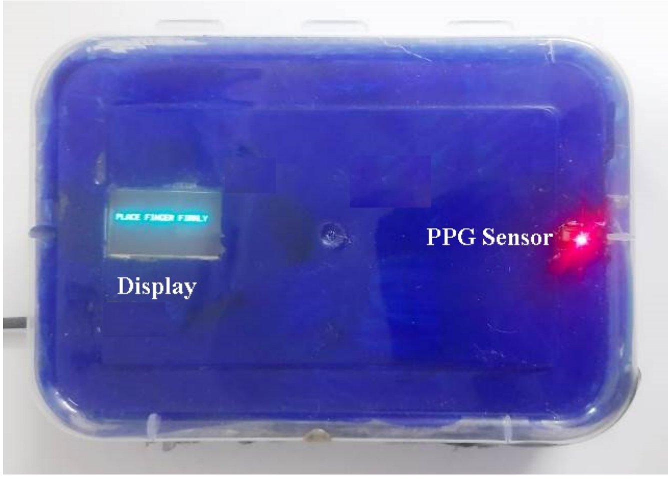

Fig. 6. Prototype of Non-Invasive Blood Glucose Monitor

8 Result Validation

Figures To validate the proposed method, blood glucose levels of 15 people were measured utilizing both invasive as well as non-invasive techniques, whose result is summarized in Table 1.

Fig. 7 depicts an assessment of glucose level values obtained utilizing invasive as well as non-invasive approaches. The chart reveals a strong correlation between the two sets of data, validating precision of suggested blood glucose estimation instrument.

Table 1. Comparison of Glucose Level Measure Value with actual Value with Percentage Accuracy

S.No.	Measured Value in mg/dL (Noninvasive)	Actual Value in mg/dL (Invasive)	% Accuracy
1	115	108	93.5
2	97	109	88.9
3	101	94	92.5
4	118	104	86.5
5	104	119	87.3
6	98	92	93.4
7	107	104	97.1
8	109	127	85.8
9	95	104	91.3
10	119	117	98.2
11	115	100	85
12	220	199	89.4
13	110	128	85.9
14	119	125	95.2
15	151	160	94.3

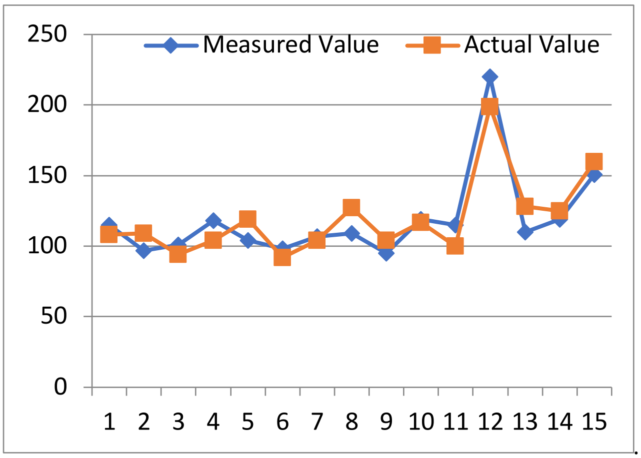

Fig. 7. Blood Glucose Level Comparison: Invasive vs. Non-Invasive

Accuracy is assessed utilizing the formula given below:
Accuracy = 100% − Error Rate
Error Rate = 100 × (Observed Value – Actual Value) / Actual Value
The total accuracy obtained is 90.9%.
NIR module may susceptible to external influences like ambient light as well as variation of skin. Therefore, it is essential to address these factors during calibration and measurement procedures.
Also the Table 2 showing the temperature reading taken by device compared with temperature measuring device available in market, along with the graph exhibiting the same is shown in Fig. 8, where actual value is represented in red color and measured value is represented in blue color.

Table 2. Comparison of Temperature Measure Value with Actual Value.

S.No.	Measured Value in degree Celsius	Actual Value in degree Celsius	% Accuracy
1	36	35	97.1
2	34	34	100
3	35	34	97
4	34	33	96.9
5	33	34	97
6	35	35	100
7	37	36	97.2
8	35	34	97
9	33	34	97
10	36	35	97.1
11	35	36	97.2
12	36	36	100
13	35	36	97.2
14	34	35	97.1
15	35	34	97

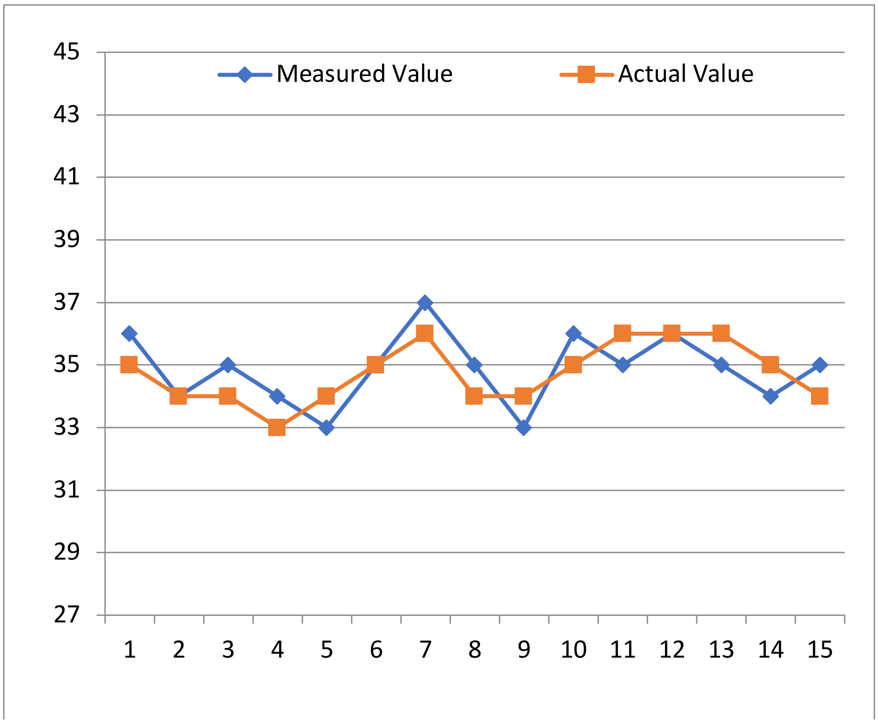

Fig. 8. Temperature Level Comparison: Measured vs. Actual.

9 Conclusion and Future Directions

This research presents a comprehensive approach for monitoring vital signs, including body temperature as well as blood glucose level. By utilizing cloud-based data storage and advanced sensors, the proposed system offers a cost-effective and efficient solution for healthcare monitoring [18]. The device's remote access capability empowers patients to actively manage their health and improve their quality of life.

The integrated ESP8266 microprocessor chips and sensors enable accurate measurement of vital signs. OLED display provides clear visual feedback, enhancing user experience. The NIR sensor's blood glucose level measurements demonstrated a 90.9% accuracy rate, highlighting its potential as a valuable healthcare tool. The non-invasive nature, user-friendly interface, and internet connectivity of the device make it accessible to a wide range of patients.

Early diagnosis and intervention are critical in healthcare. To optimize this system, several key areas require further exploration. Firstly, enhancing data analysis capabilities can facilitate more timely identification and resolution of health issues. Secondly, developing a smartphone application would enable real-time monitoring, personalized medical recommendations, and remote healthcare support. Finally, optimizing energy consumption, improving charging mechanisms, and implementing long-lasting batteries are essential to ensure uninterrupted health monitoring. Encryption, stringent person confirmation, as well as secure data storage are fundamental to safeguarding data privacy and security. Rigorous medical investigations also testing in collaboration by clinical experts as well as research points are crucial to ensure accuracy and effectiveness. Cost-effectiveness is essential for widespread accessibility and affordability.

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Contribution of Individual Authors:
Dr. SVAV Prasad carried out the conceptualization, formulation of research goals and aims.
Dr. Arvind Rehalia supervises the research activity planning and execution.
Nikhil Kaushik has prepared original initial draft, later on edited and writes the paper and also executed the experiments of Section 8.
The authors equally contributed in the final findings and solution.

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19. The authors have no conflicts of interest to declare that are relevant to the content of this article