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Light sensor optimization based on finger blood estimation and IoT-integrated

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ABSTRACT

Diabetes mellitus is a prevalent disease in society. This condition results from various causes, such as lifestyle choices or genetic predisposition. To prevent diabetes mellitus, blood glucose levels must be monitored periodically, and dietary consumption must be managed. Blood glucose monitoring still uses the incision or minimally invasive approach. This approach poses a risk of infection and damage. This study devised a method to optimize a light sensor to measure blood glucose levels. This approach uses sensor optimization and an integrated Internet of Things (IoT) technology. The research findings demonstrate that the use of the optimization strategy leads to increased consistency in sensor values, which may then be transmitted wirelessly through the IoT network. The research results demonstrate that using the optimization strategy leads to increased consistency in sensor values, which may then be wirelessly transmitted through the IoT network.

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1. INTRODUCTION

The prevalence of diabetes mellitus (DM) increases substantially annually [1]. By 2045, the population will reach 783.2 million people [2]. Indonesia is the fifth country in the world with the highest number of diabetes cases, following China, India, Pakistan, and the United States [3]. Diabetes has a significant risk of mortality [4], [5], amputation [6], and other complications that can disrupt normal bodily functions [7].

Current management of diabetes mellitus involves maintaining a healthy diet [8]–[10], early detection by medical consultation [11], and regular self-monitoring of blood glucose levels [12], [13]. Blood glucose levels can be measured using three methods: invasive [14]–[16], minimally invasive [17]–[19], and non-invasive [20]–[22]. In hospitals or clinics, pricking the finger with a needle to draw blood for testing with a strip test is the most commonly used method to accurately measure blood glucose levels.

Previous studies have utilized technology integration to measure blood glucose levels. Technology in blood glucose measurement using invasive methods has been widely used, such as in developing a glucose check device based on a microprocessor system [20], [23]. Additionally, minimally invasive approaches [19], such as [24] research, have already entered the market. In addition, innovation in blood glucose level measurement can also be done noninvasively. Research on noninvasive measurements has increased in recent years. Each method of measuring blood glucose levels, whether incisional or minimally invasive [25], carries risks such as infection [26], incision [27], slow wound healing [28], and contamination [29]. The non-invasive method has advantages for infectious risk and spreading of other diseases. Provides an opportunity to research noninvasive methods as an alternative to examining DM.

This research aims to develop a prototype blood glucose measuring device that uses a light sensor optimized by the Kalman method based on the equipment requirements and previous research. This study is limited to optimizing and developing IoT integration as a sensor data display.

2. METHOD

The research methodology used in this study utilizes the R&D approach [30], [31] and the Trial&Error method. The R&D approach involves analysis, design, development, implementation, and evaluation. This research process is generally depicted in Figure 1 below.

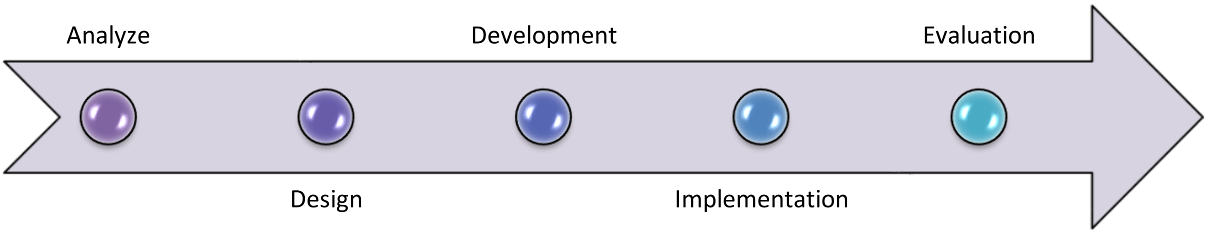


Figure 1. ADDIE method

Analyze

The analysis was conducted by formulating literature and foundational research on light sensors and their measurements. During the analysis stage, a literature review was conducted on optimizing light sensor usage and its sensitivity. This research used a light sensor with a pulse width of 4096.

Design

The system design phase is carried out using a block diagram approach. Block diagrams facilitate the identification of a system into input, process, and output components. The research block diagram can be viewed in Figure 2 below.

Development

The application development stage involves the installation of electrical devices and the assembly of them into a unified programmed system. During the development stage, an IoT system integration was carried out with a local server that can monitor the values of light sensors.

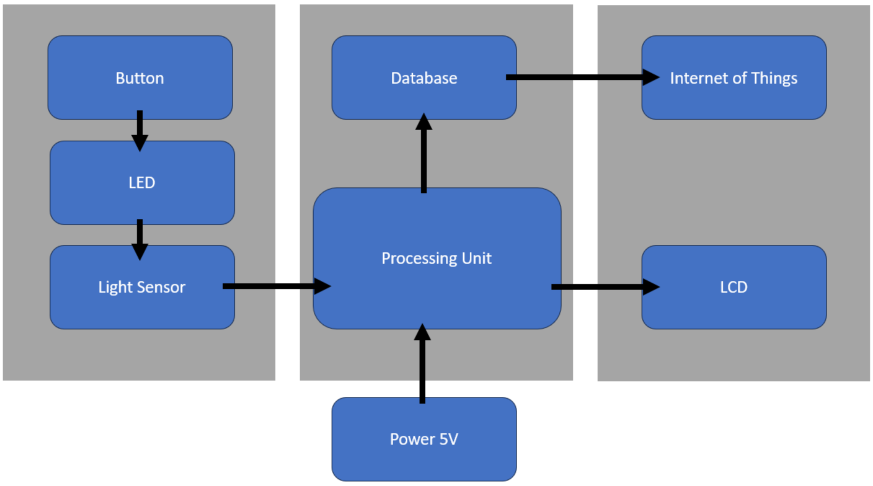
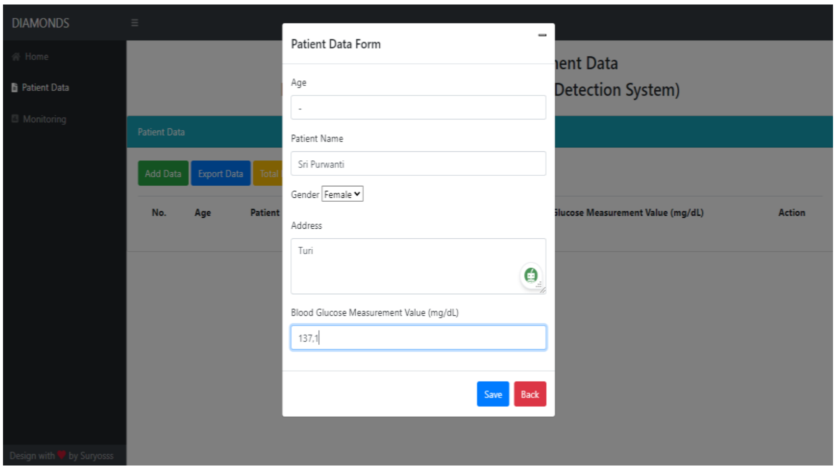


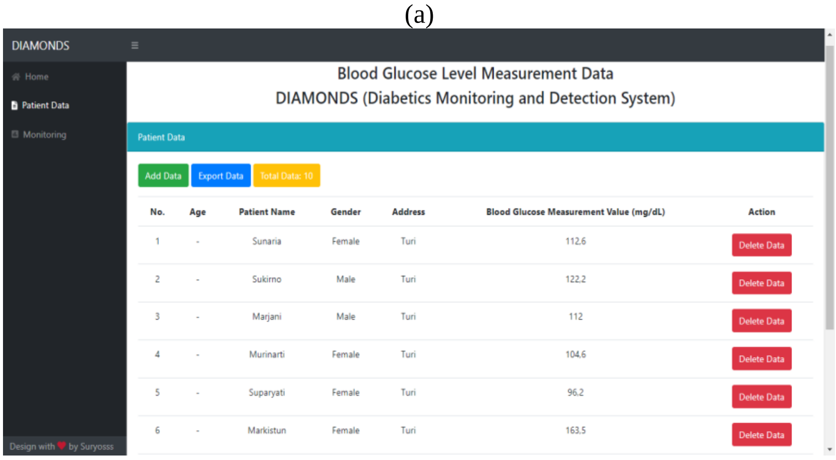
Figure 2. System design

Implementation

The implementation in this study involved the development of an IoT page integrated with a sensor system. The IoT page consists of a real-time monitoring page and a sensor data storage page. The IoT page can be viewed in Figure 3. Based on Figure 3, the localhost-based monitoring system will provide data in the form of a patient list along with the results of blood glucose checks. The main page of the system in Figure 4 provides monitoring of blood sugar values which can be saved on the data page.



(a)



(b)

Figure 3. Database implementation

Evaluation

The evaluation process is conducted after the application execution phase. This stage assesses the results by optimizing the sensors to display the best results without significant noise.

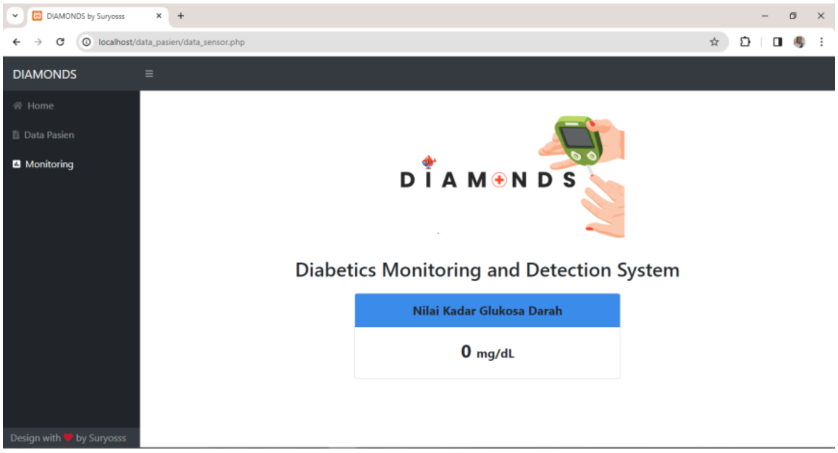


Figure 4. Realtime implementation page

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3. RESULTS AND DISCUSSIONS

The results of this research are summarized in several stages, including software results, hardware outcomes, and sensor value optimization. Software testing yielded varying sensor values depending on the measured object. The sensor values obtained by measuring the human subject's finger are shown in Table 1. Optimization is performed using the Kalman method based on Figure 5, which results in a graph shown in Figure 6.

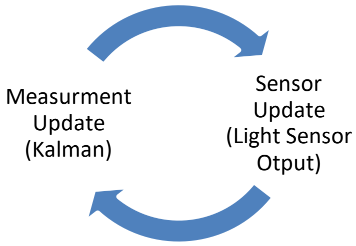

Figure 5 Kalman orientation

As shown in Figure 5, the Kalman filter operation involves updating the original sensor values with the integrated Kalman values at specific time intervals. The Kalman filter is used to eliminate sensor noise, and the sampling time is set to 10 seconds.

Table 1. The example of sensor output

No	Non-Kalman	Using Kalman
1	354,32	1382
2	464,16	1509
3	561,27	1485
4	646,48	1457
5	729,57	1520
6	801,62	1487
7	863,01	1447
8	925,03	1515
...	.....	.....
57	1467,6	1488
58	1468,12	1473
59	1466,3	1449
60	1469,88	1504

The image in Figure 6 shows that the initial sensor value fluctuates at a different rate than the original value. Using the Kalman filter can enhance the value by smoothing the sensor data. Sensor values are precisely transformed and shown on the IoT website, as seen in Figure 7.

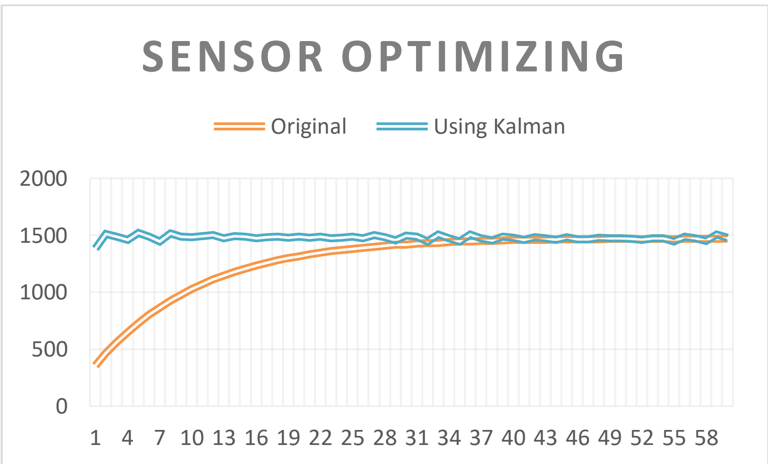

Figure 6. Sensor optimizing

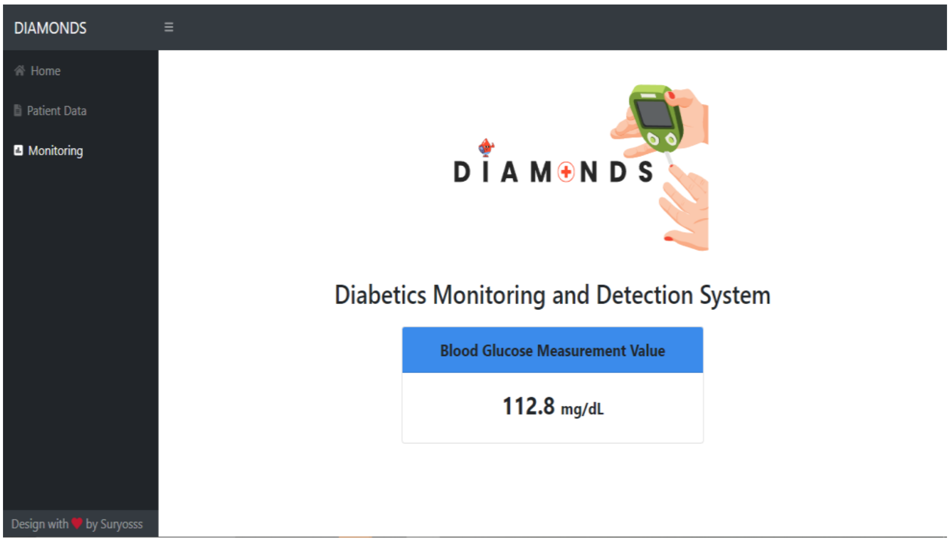

Figure 7. Real-time monitoring

4. CONCLUSION

On the basis of research experiments, light sensor optimization using the Kalman filter shows promising results. Based on the findings of this research, the sensor with a filter can provide better values than the sensor without a filter. Testing with human fingers yielded varying sensor values and results depending on the sensor's level of sensitivity. In future research, the optimized sensor results of this study might be further developed as a foundation for implementation in other topics such as artificial intelligence and intelligent systems.

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CREDIT AUTHORSHIP CONTRIBUTION STATEMENT

Author1: Conceptualization, Methodology, Software, Project administration. **Author2**: Software, Writting – original draft. **Author 3**: Data Curracation – training and testing. **Author4**: Validation and Supervision.

DECLARATION OF COMPETING INTERESTS

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