Design Non-Invasive of Blood Sugar Detector Prototypes Using Cellular Technology GPS-Based

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Abstract. Patients with diabetes mellitus need regular blood sugar levels. This research aims to design a blood sugar level detector without taking blood samples so that it will improve the comfort of patients with diabetes mellitus as long as the measurement process has been completed and the measurement results can be sent to the doctor or nurse's cellular communication device and the ambulance unit using cellular technology. The sensor used is the IR204 infrared LED to transmit infrared light with a wavelength of 850-940 nm and use PD204 photodiode for the receiver. Arduino Nano to be designed control all activities in the system, while for data communication using the GSM SIM800L module and the GPS module that is on a cell phone device. This tool is designed and calibrated to be able to measure blood glucose levels with a monitoring system that will later be measured and the location of the patient sent to the doctor's cell phone by SMS format, the location diabetes mellitus patients obtained by this tool has an average distance of 3,8 meters from five times testing.
The minimum measurements for all four samples with non-invasive techniques at 100 mg/dl blood sugar levels were measured with a minimum sensor reading of 65.600 and at a maximum sensor of 94.400, also at a blood sugar level of 102 mg/dl measured with a minimum sensor reading of 72.000 at a maximum sensor of 94.400. The novelty of this research lies in the measurement of blood sugar levels carried out in a non-invasive manner and utilizing GPS-based cellular technology on the prototype that was developed. Based on the accuracy and sensitivity values it can be concluded that a non-invasive blood glucose detector using an infrared IR204 LED sensor has been made to be used as an alternative tool for measuring blood sugar levels for diabetics so that the patient can control himself.

1. Introduction
Facts show that up to now there are still many diabetics who are still unable to control their blood sugar levels. This problem denies more complicated effects. Therefore, diabetics are advised to always make an assessment of their blood sugar levels using invasive methods. Measurement of invasive blood sugar levels requires a blood sample in which diabetics will be pricked by one finger to agree to use the patient's blood sample and administration of blood sugar levels. This method of measurement causes sufferers to require uncomfortable treatment and do not use advice to measure their blood sugar levels routinely.

[1] Dino, S., in his research conducted measurements of blood glucose using a series of amplifiers and voltage dividers synchronized with LED (Light Emitting Diode) infrared and photodiode. Also
developing techniques to measure blood sugar levels in a non-invasive way using 940 nm infrared LED waves, 940 nm photodiode and Arduino nano. In this research, a set-up of non-invasive blood sugar level research will be developed using Labview-based microwaves sensors that are equipped with measurement data storage so that diabetics can control themselves.

[2] Syed M. Usman Ali et al in 2011 created a system that shows remote monitoring of glucose levels with the existing GPRS / GSM network structure using ZnO which has enabled the nanowire sensor array to be integrated with standard cellular phones available. Next research from [3] Sali et al in 2013 discussed microcontroller-based heart rate monitoring using an LCD, buzzer, keypad and GSM module as an interface. Reference is also found in a study conducted by [4] K.A Unnikrishna Menon in 2013, namely a survey on non-invasive blood glucose monitoring using NIR.

[5] Abidin, et al in 2013 also conducted a study using non-invasive methods to measure blood glucose concentration levels. By implementing two infrared rays with different wavelengths; 940nm and 950nm based on the use of light-emitting diodes and measuring transmittance through a solution of distilled water and d-glucose concentrations from 0 mg / dL to 200 mg / dL using a 1000 nm photodiode.

[6] R. A Buda and Addi, M.Mohd in 2014 made a blood glucose monitoring device which is done non-invasively by using an infrared sensor. In addition to being able to detect glucose concentrations in the blood, this device is also capable of displaying the required glucose levels and insulin doses, according to the body mass index of the user. The development of the tool was also made by [7] Boby Irfauadin Anwar, Raditiana Patmasari, and Hilman Fauzi in 2016 with the whole system controlled by the Wemos D1mini device. For IR, RED LED, and Photodetector all are integrated into the Nellcor DS-100a oxymeter sensor

[8] Junian Wicaksono in 2017 designed a tool for measuring blood glucose levels in a non-invasive way using a range of different sensors from previous studies based on near infrared, photodiode and arduino.

Continuing the previous research, a non-invasive blood sugar detector will be developed using IR204 infrared LED sensor, PD204 photodiode and GPS-based Cellular Technology so that diabetics can control themselves and the measurement results can be sent to the communication device. doctors or nurses' cellular phones and ambulance units using cellular technology.

2. Method
The system design includes the working principle of a non-invasive blood sugar detector that is equipped with GPS-based cellular technology can be described in Figure 1. First turn on the detector device by pressing the ON switch, and on the first LCD display the name will appear. After that the command will appear to check the glucose level in the blood indicating the device is ready. Then one of the fingers is inserted into the sensor that has been provided. The device will start detecting blood sugar levels after pressing the check button once. After the patient's GPS location and blood sugar levels are detected, the device sends information to the doctor's cell phone with the command to press the check button twice vulnerable at one pressure per second.
The system designed in this research is a device that uses IR204 infrared LED sensor and PD204 photodiode, two Arduino nano, GPS module and GSM SIM800L module. The working principle of this tool can be shown by Figure 2.

The design of a blood sugar level detector for diabetic patients is composed of several circuit blocks, namely Arduino as a controller, a sensor circuit as a detector of blood sugar levels and as a feedback value on the system, GPS module as a determinant of coordinates, and cellular transmitter module as an intermediary for communication to cellphone. From the block diagram the working principle of the tool will then be assembled in a schematic series of tools that will be designed using the proteus version 8.0 application. The schematic of the device made can be seen in Figure 3.
3. Discussion
This sensor circuit analysis is intended to determine the working circuit by divided into three parts which are then assembled into a sensor circuit. A voltage divider circuit consisting of two 200 ohm and 56-ohm resistor components coupled with the basic theory of calculation with an input voltage of 5 volts, and the desired voltage to flow into the next circuit of 1 volt. so that for the calculation of the output voltage from the basic theory, a voltage of 1,094 volts is generated which flows in the next circuit to the LED photodiode. Low pass filter circuits filter high or high signals and pass low or low signals. Obtained the value of the frequency that is passed is 1592.35668 Hz according to the results of research conducted by Agung Junian Wicaksono, 2017. The non-inverting amplifier circuit uses OP07 which is an IC (Integrated Circuits) with low noise or low noise. the voltage entering the Op-Amp input V is 0.89 volts to 0.92 volts. Calculations of the Op-Amp circuit produce a measured voltage at the Op-Amp output of 0.40 volts to 0.45 volts.

In the analysis phase of the results of the fingers experiment aims to determine the value of the calibration results obtained from the invasive method and then do a comparison of quantities in accordance with the theoretical basis and direct application carried out on the voltage divider circuit, low pass filter, photodiode, infrared, and operational amplifier.

The data in the form of graphs were taken from the results of the trial of the first finger measurement on the fingers of a man aged 22 years with a height of 159 cm and a body weight of 72 kg. Readings from blood sugar measurement data that shows the results of 100 mg/dl as Figure 4.
Figure 4 it can be analyzed that measurement of blood sugar with an instrument using an invasive technique results in 100 mg / dL and if measured with a previously calibrated device using a non-invasive method with the same result that is 100 mg / dL the sensor parameter reading shows from the bottom rank determined from the maximum sensor value measurement of 94,400 obtained a sensor value of 65,600, while for the middle rank with a maximum sensor value of measurement of 94,800 obtained a value of 66,000, and the last in the upper rank with a maximum sensor value of measurement of 95,200 obtained a value of 66,400.

The results of the data in the form of graphs taken from the results of the experimental measurements of the 2nd finger experiment on the fingers of a man aged 28 years with a bandan height of 170 cm and weighing 98 kg. Readings from blood sugar measurement data that shows the results of 93 mg/dl as Figure 5.

![Figure 5. Experiment graph 2](image)

Figure 5 it can be analyzed that measurement of blood sugar with an instrument using an invasive technique results in 93 mg / dL and if measured with a previously calibrated device using a non-invasive method with the same result that is 93 mg / dL the sensor parameter reading shows from the bottom rank determined from the maximum sensor value measurement of 93,400 obtained a sensor value of 69,200, while for the middle rank with a maximum sensor value of measurement of 93,800 obtained a value of 69,600, and finally in the top rank with a maximum sensor value of measurement of 94,200 obtained a value of 70,000.

The results of the data in the form of graphs taken from the results of measurements of the trial of the 3rd finger on the fingers of a 44-year-old woman with a bandan height of 158 cm and weighing 99 kg. Readings from blood sugar measurement data that show the results of 102 mg /dl as Figure 6.
Figure 6 it can be analyzed that the measurement of blood sugar using an instrument using an invasive technique yields a yield of 102 mg / dl and if measured with a previously calibrated device using a non-invasive method with the same result that is 102 mg / dl the sensor parameter reading shows from the bottom rank determined from the maximum sensor measurement value of 93,100 obtained a sensor value of 70,200, while for the middle rank with a maximum sensor value of measurement of 93,600 obtained a value of 70,800, and the last at the top rank with a maximum sensor measurement value of 94,400 obtained a value of 72,000.

The results of the data in the form of graphs taken from the results of measurements of the 4 finger experiments on the fingers of a woman aged 18 years with a bandan height of 165 cm and weighing 94 kg. Readings from the blood sugar measurement data showing 114 mg / dl as Figure 7.

![Figure 7. Experiment graph 4](image)

Figure 7 it can be analyzed that the measurement of blood sugar with a device using an invasive technique results in 114 mg / dl and if measured with a previously calibrated device using a non-invasive method with the same result that is 114 mg / dl the sensor parameter reading shows from the bottom rank determined from the maximum sensor value measurement of 94,400 obtained a sensor value of 69,400, while for the middle rank with a maximum sensor value measurement of 94,600 obtained a value of 69,600, and finally in the top rank with a maximum sensor value measurement of 95,200 obtained a value of 70,200.

Minimum measurements for all four samples by comparison of invasive techniques with non-invasive techniques on blood sugar measured 100 mg / dl with a minimum sensor reading of 65,600 at a maximum of 94,400 sensors and 102 mg / dl with the highest reading of 72,000 sensors at a maximum of 94,400 sensors.

Testing of GPS data retrieval on this tool aims to retrieve coordinate or location data from the GPS module that is implanted in this blood sugar level detector. From the coordinate point that was previously determined using the google maps application then the results of the coordinates are compared with the results of the coordinates reading from the GPS device, following the results of the experiment.
Table 1. Difference in the reading distance of coordinates that have been determined with GPS data on the device

| Test | Fixed Coordinate | Measurement | Difference Distance (m) |
|------|------------------|-------------|------------------------|
|      | Long.            | Lat.        | Long.                  | Lat.          |                  |
| 1.   | 110.356098       | -7.788126   | 110.356101             | -7.788121     | 1                |
| 2.   | 110.356094       | -7.788137   | 110.356101             | -7.788093     | 6                |
| 3.   | 110.355138       | -7.779813   | 110.355085             | -7.779808     | 3                |
| 4.   | 110.393616       | -7.763098   | 110.393637             | -7.763085     | 2                |
| 5.   | 110.356353       | -7.787228   | 110.356356             | -7.787124     | 7                |
|      |                  |             |                        | Mean          | 3.8              |

Testing of GPS data retrieval on this tool aims to retrieve coordinate or location data from the GPS module planted in this glucose detector tool. From the coordinates previously determined using the Google Maps application, the results of the coordinates are compared with the results of the coordinates from the GPS device. The results of the test as much as 5 times is getting an average of 3.8 meters from the tool location coordinates.

Table 2. Time of sending and receiving SMS

| Test | Time (s) |
|------|----------|
|      | Sending  | GPS Tracking |
| 1.   | 10       | 41           |
| 2.   | 8        | 6            |
| 3.   | 9        | 6            |
| 4.   | 8        | 7            |
| 5.   | 8        | 6            |
| Mean | 8.6      | 13.2         |

Experiments above the GSM module can send SMS messages received by mobile phones in 10 seconds and the fastest time to send SMS messages is 8 seconds. However, the analysis conducted was in a good signal condition because the speed of sending messages depends on the signal quality of the sim card operator.

GPS module location tracking gets vulnerable for a long time only when the device is turned on for the first 41 seconds and for subsequent use at the same location GPS module location tracking gets the fastest time of 6 seconds, research is carried out in the open.

4. Conclusion
The design of the device consists of several circuits using GPS-based cellular technology which consists of several circuits using two Arduino Nano supported by a series of sensors (Photodiode and Infrared), SIM800l module, NEO-6M GPS module, and a power supply circuit (two lithium batteries) -ion) with an input voltage of 4.16 V DC changed by the step up module to 5.02 V DC and a step down module
used to supply the transmitter driver (SIM800l) with a voltage of 3.72 V DC. This tool can provide measurement results in real time, at a minimum measurement for the four samples with a comparison of invasive and non-invasive techniques at a blood sugar level of 100 mg/dl measured with a minimum sensor reading of 65,600 at a maximum sensor of 94,400 while at a blood sugar level of 102 mg/dl the highest sensor reading is 72,000 at a maximum sensor of 94,400. This tool can provide coordinates or the location where the patient with diabetes is located that has an average distance difference of 3.8 meters from the location of the device with GPS tracking speed outside the room counted 14 seconds and the fastest counted 6 seconds, while the long GSM transmitter sends SMS messages received the cell phone counts 10 seconds and fast delivery counts 8 seconds. Based on the accuracy and sensitivity value, the non-invasive blood sugar level detector based on GPS technology that has been made can be used as an alternative tool for measuring blood sugar levels for diabetics so that patients can control themselves and can be monitored directly by a doctor.

5. Acknowledgment
On this occasion the researcher thanked LPPM Institut Sains & Teknologi AKPRIND Yogyakarta, so that this researcher could be completed well.

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