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Monitoring and Controlling Diabetes with Arduino Uno and Automatic Insulin Injection System.

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***Abstract*—A device that is extremely beneficial for diabetic people is an automatic glucose detector and insulin injector. Diabetes is now seen as a lifestyle condition. Diabetes mellitus, generally known as diabetes, is a metabolic condition characterized by high blood sugar levels. (Blood sugar). When you consume a carbohydrate, your body converts it into the sugar glucose and releases it into your blood. In order to assist your cells, absorb glucose from your blood and utilize it as fuel, your pancreas releases the hormone insulin. Your body won't use insulin as it should if you don't get therapy for diabetes. The condition when too much glucose lingers in the blood is known as high blood sugar. This might lead to significant or enduring health problems; it could lead to serious or even potentially fatal health problems.**

Based on the results of the blood test performed on a specific day, the doctor prescribes the quantity of insulin to be administered. The doctor's advised dose of insulin is larger than usual if the patient consumed more calories on that particular day. The amount of insulin the doctor ordered will lower the level of glucose in the blood if the patient eats less on some other days. It causes serious health issues. In this situation, the insulin injection quantity needs to be highly precise. The body will suffer from fluctuations in insulin release rate. We intend to create an automatic insulin detector to solve this issue. A blood sample is taken when the needle is introduced into the body tissue to measure the blood's amount of glucose. The gadget will inject the patient with the precise amount of insulin they require using previously recorded information about the blood glucose level. The preceding difficulty is thus resolved by the device. This system is designed to prevent high blood sugar levels. The machine gives a precise reading and administers the necessary dosage of insulin.

Index Terms—Diabetics, glucometer, glucose, insulin.

I. INTRODUCTION

Large systems or those built specifically for a computer system are examples of embedded systems. This complex system, composed of both hardware and software elements, has a number of subsystems. Microwaves, VCRs, and automobiles all utilize embedded systems for their digital interfaces. Embedded systems carry out a variety of tasks, including monitoring, controlling, and exchanging data. [1].

Environment Monitoring: In order to read the data from an embedded system, an input sensor is used. The output of the system is shown in an approachable manner.

Environment Controlling: The controllers for the actuators produce and transmit the commands.

Requirements for functionality

The processing and performance of the system are described by the functional requirements, they are

- The requirements for performance
- The requirements for efficiency
- The requirements for reliability
- The requirements for safety
- The requirements for security
- The requirements for usability

Several jobs that must be completed by an embedded system, each with a deadline. The time-based tasks to be completed are categorized depending on their temporal requirements.

Dependability Requirements

It covers availability, security, availability, maintainability, and reliability.

The Central Processing Unit, Random Access Memory, Read Only Memory, Real Time Operating System, and interfaces of communication are crucial parts of an embedded system. Central processing unit is what powers embedded systems (CPU). The entire system is managed and controlled by the CPU. The memory unit uses both ROM and RAM. Information is retrieved from the memory unit using ROM, and it is written to the memory unit using RAM. For large-scale embedded systems, the real-time operating system is necessary. The Real Time Operating Systems serves as the Operating Systems and is used to manage the process for the response time managed. Interrupts are a popular and efficient method of managing hardware sources. Real Time Operating Systems were used to manage files, devices, and mailboxes.

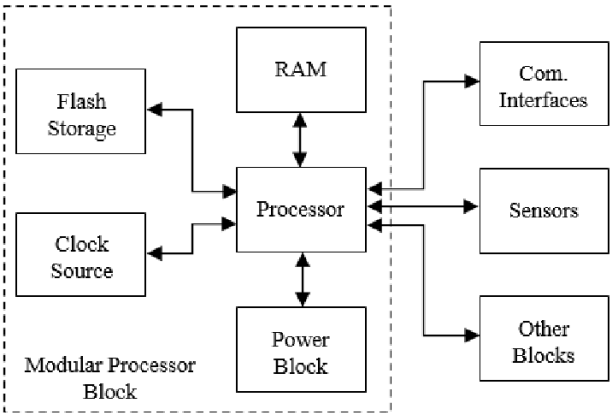

Fig 1. Embedded system block diagram

Embedded systems types

The two categories into which embedded systems are split are performance and functional requirements and microcontroller performance. [2]. These classifications further categorized their use. The four categories of the embedded system's performance and functional requirements include:

- Real time system
- Mobile system
- Standard alone system
- Networked system

The embedded system's performance is divided into three categories, including

- Sophisticated system
- Scale medium system
- Scale Small system

Diabetes and Treatments

Diabetes is now seen as a lifestyle condition. Diabetes mellitus, generally known as diabetes, is a metabolic condition characterized by high blood sugar levels (blood sugar). When you consume a carbohydrate, your body converts it into the sugar glucose and releases it into your blood. In order to assist your cells, absorb glucose from your blood and utilize it as fuel, your pancreas releases the hormone insulin.

If you don't receive treatment for diabetes, your body won't use insulin as it should. High blood sugar is the common name for the condition where too much glucose remains in the blood. Health problems that might be severe or even fatal could emerge from this.

Diabetes does not have a treatment. But you can live a long, healthy life if you receive therapy and make lifestyle modifications.

Diabetes comes in numerous forms, depending on the aetiology.

Prediabetes

You have prediabetes if your blood sugar level is higher than usual but not high enough for your doctor to identify diabetes. In the US, more than one third of people have it, yet the majority are unaware of it.

You have a higher risk of developing type 2 diabetes and heart disease if you have prediabetes. These hazards can be decreased by increasing your exercise and lowering additional weight—even only 5% to 7% of your body weight.

Types of Diabetes

Type 1 Diabetes

Insulin-dependent diabetes is another name for type 1 diabetes. It was once known as juvenile-onset diabetes due to the fact that it frequently starts in children.

Diabetes type 1 is an autoimmune disorder. It occurs when antibodies in your body target your pancreas. Because of injury, the organ cannot produce insulin.

This form of diabetes might be brought on by your genes. It could also occur as a result of issues with the insulin-producing cells in your pancreas.

Damage to the small blood vessels in your eyes (diabetic retinopathy), nerves (diabetic neuropathy), and kidneys (kidney disease) are the main causes of many of the health issues that type 1 diabetes can bring (diabetic nephropathy). Heart disease and stroke risk are also increased in type 1 diabetics.

In order to treat type 1 diabetes, insulin is injected into the fatty tissue right beneath your skin. You may employ:

- Syringes
- With a tiny needle and prefilled cartridges, insulin pens
- insulin is sprayed into your skin using jet injectors that employ high-pressure air.
- pumps that provide insulin via a tube to a catheter inserted beneath your belly's skin

The A1C blood test provides an estimate of your blood sugar levels over the last three months. It assists your doctor in determining how well your blood sugar is being controlled. They can assess your risk of experiencing issues thanks to this. You'll need to adjust things if you have type 1 diabetes, such as:

- monitoring your blood sugar levels frequently
- planning meals with care
- Daily exercise
- receiving insulin
- Using insulin and other drugs as necessary

Type 2 Diabetes

Adult-onset or non-insulin-dependent diabetes were the previous names for type 2 diabetes. But, during the past 20 years, it has become increasingly prevalent among kids and teenagers, partly because there are more young people who are overweight or obese. Diabetics of type 2 make up around 90% of the population.

In most type 2 diabetics, some insulin is typically produced by the pancreas. But either it is insufficient or your body is not properly using it. Fat, liver, and muscle cells are typically affected by insulin resistance, which is when your cells don't react to insulin.

Type 2 diabetes is frequently more manageable than type 1. Yet, it still has the potential to seriously harm your health, particularly the delicate blood vessels in your nerves, eyes,

and kidneys. Type 2 also boosts the risk of heart disease and stroke.
Obese people, defined as being more than 20% over their optimal body weight for height, are more likely to acquire type 2 diabetes and its related health problems. Insulin resistance is frequently a result of obesity, so your pancreas needs to work harder to produce more insulin. But, it's still insufficient to maintain healthy blood sugar levels.
Exercise, proper nutrition, and maintaining a healthy weight are all part of treating type 2 diabetes. Some folks also require medicine.

To assess your blood sugar management, your doctor may do an A1C test a few times each year.

Gestational Diabetes

Insulin resistance is generally a side effect of pregnancy. Gestational diabetes is the term used if this develops. In late or middle pregnancy, doctors frequently detect it. In order to safeguard the growth and development of the fetus, gestational diabetes must be under control since the mother's blood sugars pass through the placenta to the unborn child.
2% to 10% of pregnancies are reported by doctors to have gestational diabetes. Usually, it disappears after childbirth. Yet, type 2 diabetes can develop in up to 10% of pregnant women, weeks or even years later.

The baby is more at danger from gestational diabetes than the mother is. A newborn may have an extraordinary prenatal weight growth, breathing difficulties at delivery, or a higher chance of developing obesity and diabetes in later life. A huge baby may require a caesarean section, or the mother may suffer injuries to her heart, kidney, nerves, and eyes.
Treatment for gestational diabetes entails:

- Preparing your meals carefully to ensure you obtain adequate nutrition without consuming too many calories and fat
- Regular exercise
- maintaining control over weight increase
- if necessary, using insulin to manage your blood sugar

Other Forms of Diabetes

In 1% to 5% of persons who develop diabetes, other illnesses could be the reason. They include infections, certain procedures and drugs, and pancreatic disorders. Your doctor may want to monitor your blood sugar levels in certain circumstances.

II. RELATED WORK

A brief overview of existing glucose sensor work is presented in this section.

S Jeyapriya [3] proposed a glucose monitoring system based on GSM module and Arduino Uno. To transfer the information to mobile devices, GSM is employed. This system's limited precision is one of its drawbacks.

A real-time glucose monitoring system based on a wireless electrochemical sensor was proposed by Xiao, et al. On-chip temperature sensor, 10.bit sigma-delta ADC, winding ferrite core antenna, and digital baseband all make up this sensor tag. The ISO15693 standard was used to examine the air interface. The total system's sensitivity was 4dBm. The implanted glucose monitoring application includes a basic sensor tag with low cost and low-power options. The system's advantages include precise results and usage in real-time applications. The system's gain in on-chip performance was a drawback.

Valentin and Mihaela developed a method for interpreting blood glucose levels cognitively and evaluating its effectiveness. [4]. This paper's goal is to lower blood glucose levels within 30 minutes. The blood glucose level is determined with an Accu-Check blood sugar metre. Three samples are measured using two cognitive processes and one motor coordination. The Vienna Test System's STROOP, 2HAND COORDINATION, and COG tests are conducted using the samples. The performance discrepancies were in the second and third samples.

According to Beaton, et al. [5], the key to controlling GLUT4 recycling in an insulin-mediated adipose tissue is glucose absorption. The incorrect disposal of glucose in response to insulin was thought to be a severe health issue. It would contribute to the development of type 2 diabetes and obesity. The utilization of the in vivo and in vitro methods to regulate insulin induced Glut4 mediated glucose uptake and examine the involvement of Tusc5. The correct recycling of Glucose Transporter Protein Type-4 was made possible by the extended insulin simulation. The TUSC5 protein, which is unique to adipose tissue, permitted adequate protein recycling.

The blood glucose sensor's development was started by Wang and Lee [6]. The rising number of diabetics throughout the world led to the development of blood glucose management and monitoring. The Continuous Glucose Monitor measures the blood glucose level in real time (CGMS). In this technique, the alert was used to indicate the level of blood glucose events, which is used to improve quality of life. The sensor's short life and poor precision were its drawbacks. A glucose sensor based on boronic acid derivatives has been proposed as an enzyme-free alternative. In the self-sensing and hospital environments, trustworthy diagnostic instruments were used. The fluorescent boronic acid sensor was straightforward and offered real-time detection and specificity.

III. PROPOSED METHOD

We intend to create an automated glucose tester and an insulin injector to solve the issue. A blood sample is taken when the needle is put into a bodily part in order to measure the blood's level of glucose. The gadget will accurately administer the patient's required amount of insulin using pre-recorded information on the blood glucose level.

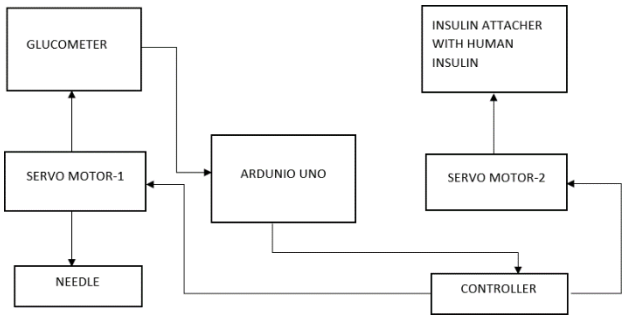

Fig 2. Proposed system Block Diagram

Figure 2 shows the proposed system's overall workflow, which consists of the following elements:

- Glucometer
- Relay
- Needle
- Controller
- LCD
- Arduino Uno

Arduino Uno

An open source, user-friendly, and reasonably priced microcontroller is an Arduino. Software development is also free. Programming the Arduino board is followed by the construction of the interface circuits to read switches. The motors are also controlled by it. With 32 Kb of flash memory for storing programmes and 1 Kb of EEPROM for storing settings, the Arduino runs at 5V. 3, 00,000 lines may be executed per second, and the clock speed is 16MHz. The board includes 6 analogue pins and 14 digital input/output pins. DC power is used to power the external 6-20 V power source. The controller was easy and affordable. It can be used with a wide variety of operating systems, such as Windows, Linux, and Mac OS.

LCD

The LCD, is a type of electronic display that has various uses. The circuitry and applications for the 162 LCDs varied. These modules are often designed with multi-segment and seven segment LEDs. 16x2 LCD refers to a display with two lines and 16 characters per line. The command register's information can be gathered by the LCD. The LCDF's specified duty to wipe the screen, the cursor location, and the controlling display is part of its command. Data is stored in the data registers, which are also utilized to show the LCD

Relay

Relay is also known as switch. Switches are used in manual operation to open or close circuits. The two circuits can also be connected or disconnected using it. Electromagnets, mechanically moveable contacts, switching points, and springs might be its major components. The relay operates on the electromagnetic induction theory.

Glucometer

The blood's glucose level is monitored using a glucometer. It is more sensitive than other parts of the body to changes in glucose levels in the finger blood. The sensor may be used easily and conveniently. It is portable and yields reliable outcomes.

The figure 2 Displays the general blocks in the system. The entire circuit is managed by the Arduino Uno. The switch in use is a relay. Blood glucometer is used to measure the glucose level and verify to Arduino. Servo motor is used to draw blood, suck the insulin and inject the insulin. By altering rpm, a controller or motor controller is utilized to operate the servo motor (rotation per minute). The output is shown on the LCD.

Methodology

Step 1

The bodily tissue is injected using a machine needle. A blood sample is taken for analysis.

Step 2

The device's electro-chemical test strips are then filled with the blood sample that was taken. Glucose oxidase is an enzyme found in every test strip. Gluconic acid is produced when this enzyme combines with the glucose in the blood sample. The reaction between the gluconic acid and ferricyanide, another chemical included on the test strip, follows. Then, Ferrocyanide was produced by combining Ferricyanide with Gluconic acid. The gadget then passes an electrical current across the blood sample on the strip once ferrocyanide has been produced. The amount of glucose in the blood sample on the testing strip may then be determined by reading the ferrocyanide using this current.

The glucose testing device then shows that value on its screen.

Step 3

The amount of insulin to be administered is calculated using the result obtained from the previous step. The precise insulin is sucked from the insulin vial using a sucking motor. The sucked insulin is injected into the bodily tissue using a different motor.

EVALUATION OF PERFORMANCE

A blood glucose monitoring system is shown in figure 3. Arduino board, the system's brain, which can be programmed using an Arduino sketch. The Arduino board was attached to the system's components, including the needle, battery, relay, controller, and blood glucose meter. The entire system is controlled using Arduino. The relay functions as a switch and is used to turn systems ON and OFF. Servo motors are managed by the controller. Blood glucose levels are measured using a blood glucometer, which shows the results on an LCD. The Arduino is programmed with a chart that will determine how much insulin needs to be injected into the blood. The technology will provide patients an accurate result.

The hardware components are described in Table 1 below:

Components	Specification
Arduino Uno	326
Glucometer	
Relay	12V
Controller	SC16A 16 Channel
LCD	16V* 2
Transformer	0-230v

Table 1. Component specifications

The following table 2 & 3 demonstrate the insulin injection dosage and any necessary adjustments.

Blood Sugar (mg/dl)	Low Dose Scale	Moderate Dose Scale	High Dose Scale
<70	Initiate Hypoglycemia Protocol	Initiate Hypoglycemia Protocol	Initiate Hypoglycemia Protocol
70-130	0 units	0 units	0 units
131-180	2 units	4 units	8 units
181-240	4 units	8 units	12 units
241-300	6 units	10 units	16 units
301-350	8 units	12 units	20 units
351-400	10 units	16 units	24 units
>400	12 units and call MD	20 units and call MD	28 units and call MD

Table 2. Dosage of insulin

Pre Meal	Dose Adjustment	Description
<70	-4 units	If blood sugar is low, reduce the insulin dose.
90-140	-2 units	If blood sugar is low, reduce the insulin dose.
90-140	Continue	Same dose of insulin
140-160	+2 units	Increase insulin dose if blood glucose raised
160-180	+4 units	Increase insulin dose if blood glucose raised
>180	+6 units	Increase insulin dose if blood glucose raised

Table 3. Dose adjustment of Insulin

IV. SUMMARY AND A VISION FOR THE FUTURE

The key element of this system is the blood glucose sensor. It is employed to detect or keep track of a person's blood glucose level. The blood glucose sensor has to be correctly fixed so that it can give accurate results. The individual will receive an injection of the readings or amount of insulin that is presented on the Screen. A blood glucose report is produced and shown on an LCD. Only drugs that meet the predetermined criteria stated by the program are provided by this system. The technology's potential for the future is to improve the body's autonomous insulin administration and blood glucose monitoring system.

REFERENCE

[1]. Catthoor F, Wuytack S, De Greef G E, Banica F, Nachtergaele L, & Vandecappelle A. "Custom memory management methodology: Exploration of memory organization for embedded multimedia system design". *Springer Science & Business Media*. Vol 3, no.6, pg 212-213, (2013).

[2]. Wolf M, " High-performance embedded computing: applications in cyber-physical systems and mobile computing". *Newness*, pg 54-57 (2014).

[3] S. Jeyapriya, "Glucose monitoring and control in diabetes using GSM and automatic insulin injector system for human bodies", IEEE International Conference on Intelligent Techniques in Control, Optimization and Signal Processing, (2017)

[4]. Valentin C M, & Mihaela C, "The Relationship between Blood Glucose Levels and Performance at Cognitive Processing and Motor Coordination Tasks". *Procedia-Social and Behavioral Sciences*, pg 187, 777-782. (2015).

[5]. Beaton N, Rudigier C, Moest H, Müller S, Mrosek N, Röder E, & Augustin R. "TUSC5 regulates insulin-mediated adipose tissue glucose uptake by modulation of GLUT4 recycling". *Molecular metabolism*, vol 4 no.11, pg.795-810, (2015).

[6]. Wang H.C, & Lee A R, "Recent developments in blood glucose sensors", *journal of food and drug analysis*, vol23, no. 2, pg 191-200, (2015).

[7] Lokinendi V. Rao, Felice Jakubiak, James S. Sidwell, James W. Winkelman, Michael L. Snyder, "Accuracy evaluation of a new glucometer with automated hematocrit measurement and correction", *Clinica Chimica Acta*, Vol 356, Issues 1–2, Pages 178-183, June 2005.

[8] Geralyn Spollett, Steven V. Edelman, Alfred Penfornis, "Improvement of Insulin Injection Technique: Examination of Current Issues and Recommendations", *The Diabetes Educator*, Volume 42, Issue 4, May 23, 2016.

[9] Bastaki S, "Diabetes mellitus and its treatment", *Department of Pharmacology, Faculty of Medicine & Health Sciences, United Arab Emirates University, Al Ain United Arab Emirates*, Vol.13, No. 3, July 2005.