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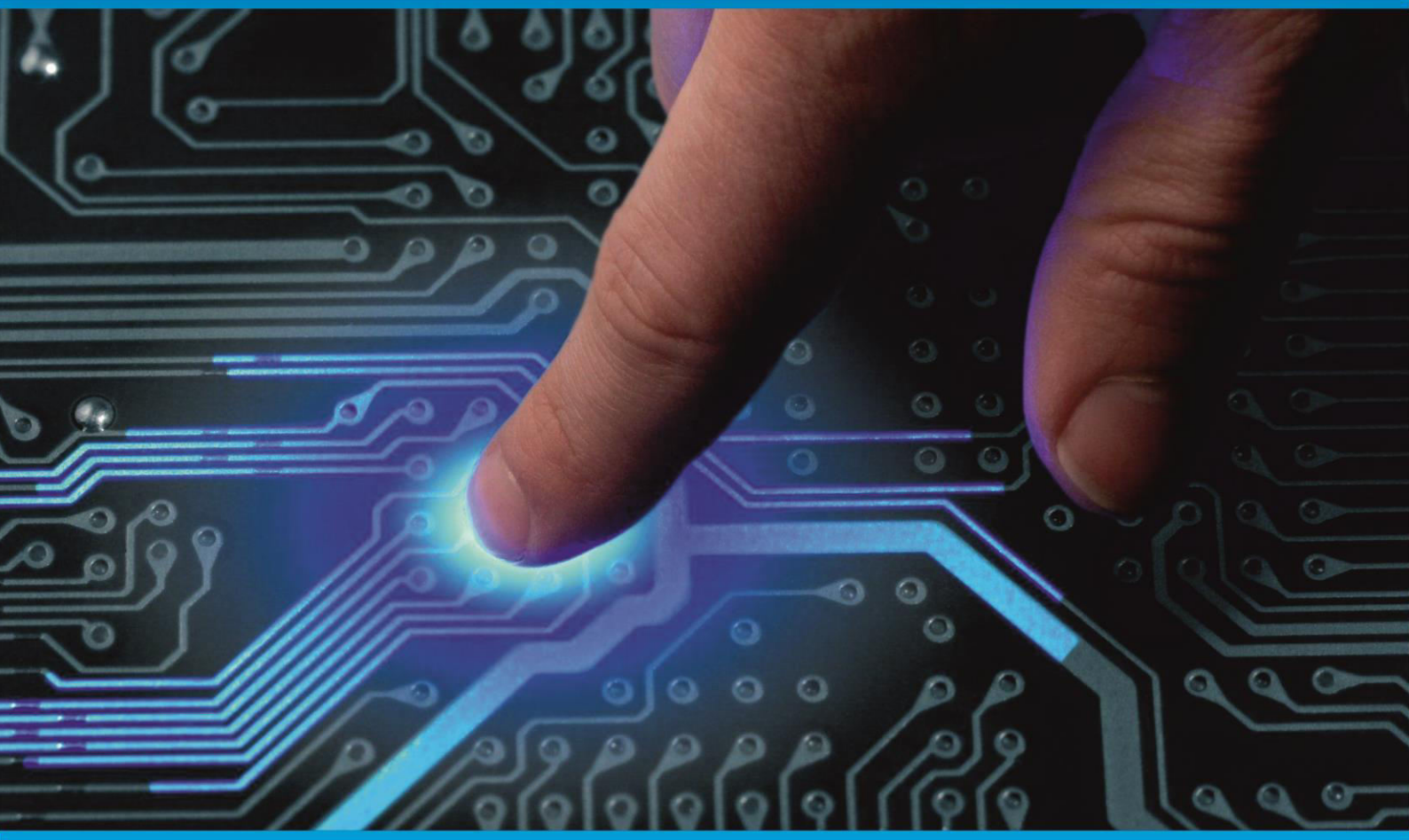

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Real Time Sweat Based Glucose and Stress Monitoring System

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ABSTRACT: Diabetes is a chronic disease or a group of metabolic disease where a person who suffers from a high level of glucose n the body. Diabetes is affected by most of the people nowadays. Diabetes is disease that can be controlled. Diabetes patients need to check the blood daily and take corresponding insulin. Taking blood from the body daily leads to many complications such as cardiovascular and kidney problems, stroke, blindness, and nerve degeneration. Monitoring blood glucose using sweat helps a person from painful blood-based monitoring. Here GSR Sensor is used to find the conductance of skin. From which the glucose level is calculated. When a player is going to perform in a task, the coach will not know the stress level of the player. Using the GSR sensor, stress level and hydration level is calculated. Sensor is connected to Arduino UNO. The detail of the person's diabetes level and stress level is stored in the cloud, so that the previous diabetes level and stress level can be known. This way of glucose measurement is said to be painless, cost-effective and easy monitoring.

KEYWORDS: Arduino UNO, Embedded system, GSR sensor.

I. INTRODUCTION

Diabetes is a chronic disease. It is caused due to the increase sugar level in blood and the circulatory system. A hormone is produced the pancreas which is called insulin. Conversion of food which a person eats to energy is done with help of this insulin. When is insulin is not produced by body then glucose does not does not reach cells to be used for energy. Due to the improper working of the pancreatic beta cells present in our body diabetes is produced. Diabetes is one of the dangerous diseases. When diabetes is not identified and remains untreated leads to main harmful effect and has many complications.

There are basically four types of diabetes: Type 1 diabetes, type 2 diabetes, pre-diabetes, gestational diabetes. Type 1 diabetes occurs when the beta cells in our pancreases is destroyed by the immune system. Beta cells are those which develop insulin in our body. By these conditions the glucose content developed in our body cannot be moved through body since the insulin is not present in our body. So, this glucose content is build-up in our body and hence blood glucose level in increased. By this high sugar level, it may have many other problems like dehydration, weight loss, diabetic ketoacidosis, and harmful effect to many other body parts. This type of diabetes is mainly occurring in youngsters and grownups. Type 2 diabetes is the most common diabetes which is caused by most of the people. Type 2 diabetes is the most common diabetes which is caused by most of the people. Type 2 diabetes is a condition in which sugar or glucose can no longer be regulated. This type mainly occurs or been affected mostly to the grownups. Type 2 diabetes occurs to many reasons such as: being overweight, eating a lot of foods or drinks which consist of sugar, artificial sweeteners, lack of activity, lack of exercise, high stress, due to genetics. The are many sign or symptoms to know whether a person is affected by diabetes. The most common symptoms are excess thirst, urinating a lot, when weight is increasing or decreasing unintentionally, dark skin under armpits, chin, or groin, fatigue, vision losing. When sugar level is more than 125 when fated and more than 200 under random check then that person is suffering from diabetes or that person has high sugar. The are many side effects due to type 2 diabetes like it effect the heart function, kidney functioning, neuropathy, sexual and/or urinary problems, eye vision will be affected, foot will be affected. This type of diabetes can be prevented by having proper nutrients and proper exercise. Prediabetes is a stage before the type 2 diabetes. The range for prediabetes is 100-125 milligrams per decilitre (mg/dL). A person with pre-diabetes has more chance to get diabetes. There are no particular symptoms for prediabetes. The many symptoms are that the person will be very much thirsty, will be tried, urinal problems, vision becomes blurry. The reasons to get pre-diabetes are if that person had gestational diabetes and give birth to a baby whose weight is more than 9 pounds, overweight, eating red meat and processed milk, lack of exercise, high cholesterol. Gestational diabetes is type of diabetes in which sugar level becomes high during pregnancy. Even that women have diabetes she can give birth to her baby. After pregnancy

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this type of diabetes will be cured. Normally doctors check a pregnant lady has gestational diabetes during the 24th and 28th week of pregnancy. Only few percent (less than 10 percent) of ladies are affected by this diabetes. Gestational diabetes occurs mainly during second pregnancy. The major causes are overweight before pregnancy, family history, had gestational diabetes before, high blood pressure, had given birth to overweight baby, the loss of your baby. Mainly gestational diabetes occurs after the age of 25. A lady who was affected by gestational diabetes has a high chance of getting affected by type 2 diabetes.

The diabetes patient needs to check there glucose daily. Glucose level will be changing. So, in order to check their glucose level, the patient need to take a drop of blood from their body by creating wound. Some diabetes patients also need to take insulin. Since this all is a painful task, most of the patients refuse to create wound, so necessary medicines cannot be taken. If a method is developed to check glucose level in body by any non-invasive method it will be very helpful to many patients and even doctors.

Stress is defined as any physical, mental factors that causes tension. There are mainly two types: external and internal stress. External stress is caused by the environment, psychological, or social situations. Internal stress is caused by any illness and medical problem. Catecholamine hormones which includes adrenaline or noradrenaline and facilitate for immediate physical reactions associated with violent muscular action. Stress causes psychological and medical problems. The stress causes poor healing, irritable bowel syndrome, high blood pressure, diabetes. Sources of stress can be individual level stressors, group level stressors, organizational level stressors, extra organizational stressor.

The stress level of a player is one of the important features to be considered will playing a match. When stress level is high then there is chance getting injury. The player cannot perform level in that match. So, if there is proper method to know the stress level of a player, coach can take necessary precaution. So, the chance injury can be reduced. Similarly, by knowing the hydration level also helps to reduce the chance of getting injury. By obtaining the sweat reading stress and hydration can also be determined.

A. Survey of Existing Systems

Mostly for checking blood glucose level invasive method are used. Glucose level is tested using an instrument called glucometers. To check glucose level small amount of blood is taken from fingertip. For testing glucose using glucometer a finger-prick is used to get blood from our finger then a drop of blood is made to drop on the meter to calculate glucose level. There are many risk factors that are included in monitoring blood glucose by invasive method. There is a chance of been affected by HIV, hepatitis B, hepatitis C. Since the level of glucose be changing, diabetes patients need to check their glucose level regularly or daily. By checking the glucose by invasive method (i.e. by creating wounds in our body) can even cause many other diseases, due to the daily checking and creating wound in body. Blood needs to be checked before and after meals so this multiple time checking causes to be painful. It is not a healthy method of using invasive method for glucose checking.

Fig.1. Invasive glucose monitoring system

Fasting plasma glucose test, oral glucose tolerance test, random blood glucose test, haemoglobin A1C are common tests done to know the glucose level. In fasting plasma glucose test blood for test morning after being dieting overnight. Blood sugar levels remain between 70 and 100 milligrams per decilitre (mg/dL) in the normal case. A person is said to have diabetes if the blood glucose level is more than 126 mg/dL. In oral glucose tolerance test the blood sugar is measured after two hours, drinking 75 grams of glucose. By this test the person is said to have diabetes if the blood

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sugar level is 200 mg/dL or higher. In random blood glucose test blood sugar of 200 mg/dL or greater at a time combined with symptoms of diabetes. Haemoglobin A1C test measures the average level of glucose over the prior two to three months. A person is said to diabetes if the haemoglobin A1C level is 6.5 percent or higher. Blood creation and urine micro albumin. These tests are done for evidence of kidney disease. Lipid profile. Here the measures levels of triglycerides and total, HDL, and LDL cholesterol. This evaluates the risk of atherosclerosis. People with diabetes who also have high levels of total cholesterol or LDL cholesterol which have increased risk for heart disease and strokes.

Since the level of glucose is changing the diabetes patients need to check their glucose level regularly or daily. By checking the glucose by invasive method, by creating break in our body it can even cause many other diseases, due to the daily checking and creating wound in body.

In the field of sports, the coach does not understand the stress level of a player. When a player is having high stress then there is a much chance of getting injuries. The stress level increase not only causes mental problems it also effects the physical condition of the player. So, coach can train the player accordingly. Similarly, the hydration level also cannot be known.

B. Proposed System

One of the non-invasive methods is used for checking the glucose level of a person. There are many non-invasive methods like interstitial fluid, light-based methods, earlobe clip, smart contact lenses, sweat patches. For blood glucose monitoring sweat, saliva, breathe can be used. Here sweat is chosen the non-invasive method for glucose monitoring. A sensor is used for monitoring the conductance of skin which can be used to obtain the voltage level. Based on the value obtained, the glucose level of a person can be obtained. Galvanic skin response sensor is the sensor used in the real time monitoring part. Creating wound and taking a drop of blood is a painful method which most of the patients are suffering. So here in-order to avoid it we are using sweat to monitor glucose level. Glucose level of a person is stored in cloud. The date and time of taking values are also stored in the cloud. ThingSpeak is used to store the value. Storing result in cloud helps the person to get the health results later for reference.

II. RELATED WORK

Hyunjae Lee, Changyeong Song [4] deals with non-invasive glucose monitoring system. Collection of sweat is a different task. Careful multilayer patch design and miniaturization of sensor increases the efficiency of sweat collection and sensing process. In real time correlation based on pH, temperature and humidity measurements. This system maximizes the accuracy of sensing. Here a patch based wearable strip type disposal system for non-invasive sweat glucose monitoring. Here humidity sensor monitors the sweat collection procedure through impedance change. Here the glucose sensors are used for human sweat analysis. The wearable patch is connected to a portable electro chemical analyser. Here the monitoring starts with humidity sensing to determine the optimal starting. The patch work reliably under different skin temperature before, during, and after physical movement. The strip type sensor is used here which first absorbs sweat and then connected to hardware. The amount of sweat should cover the pH sensor and glucose sensor. For accurate reading the correlation factor between blood glucose and sweat should be found for each individual subject. The reading is calculated before and after meals.

K. Nivetha, N. Ramya, R. Thendral [5] deals with a non-invasive blood glucose monitoring method. The researchers are using sweat to measure the blood glucose which contains of dissolved ions which contributed between two copper electrodes. The normal glucose level for diabetes persons is discussed. Invasive method for glucose monitoring and its effect are discussed. From studies if salt content is low in our body then it results in low glucose. The hardware used in this paper or experiment are copper electrode, Arduino UNO, LCD display. Salt has high conductivity and by measuring the conductance salt level is measured. The output is taken and fed to Arduino and displayed. Interpolation equation is used in-order to monitor glucose level. Here copper electrode is used as sensor.

Wira Hidayat bin Mohd Saad1, Muhd. Shah Jehan Abd [6] deals with the implementation of low power wearable system for continuously monitoring the glucose level in human blood by using GSR sensor. This project detects the GSR value and establishing a correlation between GSR and blood glucose level. Basically, the GSR sensor consists of voltage divider, resistor, capacitor circuit and operational amplifier. This resistor was placed between v- and one of the sensor electrodes as the voltage value across it is vary based on body GSR. By using the high value of resistance, it can develop the resistance voltage curve linear over a wide range of skin resistance despite producing noise. The RC high pass filter was used to calibrate a steady baseline since the skin resistance can be varied based on individual condition. A low pass RC filter was used to filtering out the high frequency noise that produces from nearby. The operational amplifier is a function to measure the skin resistance and form one of the resistors in the operational amplifier feedback loop and amplify the voltage. GSR function in the way that subject body will act as the resistor and then the voltage

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output will be differing from time to time based on the increasing in calories burnt and glucose concentration in blood. From the result GSR is inversely proportionate to the value of blood glucose level.

Maria Viqueira Villarejo, Begona Garcia Zapirain[7] says a stress sensor is designed based on GSR and controlled by zig bee. It uses two electrode which are placed on the finger and act as if they were the two terminals of one resistance. Output is given to ADC of zig bee board. The GSR electrode collect the skin resistance and after this the device can determine the person's stress level. Person's skin act as a resistance to passage of electrical current.By placing two electrodes on the finger, one resistor in series with the skin resistance, to form a voltage divider.Observed that the output voltage is inversely proportional to the value of skin resistance. The more stressed the person more his will be sweat, so resistance will be decreased. Therefore, more the stress the person is higher the output voltage.

Soniya Lakudzode, Prof.S.M.Rajbhoj [8]says that stress is not able for a physician to continuously monitor, its diagnosis is significant. A wearable sensor system is developed to monitor number of physiological relations of mental stress. Stress is a big problem in most of the people life. Sometime stress will be released when they are involved in any busy activities. There are many technologies developed in order to monitor the stress level. Some of the methods used are physiological signal, blood pressure volume, heart rate, skin conductance. The medical issues related to human such as overweight, high blood pressure, irregular heartbeat or diabetes. Discus about the collecting physiological data by using bio sensor sending to personal computer. GSR to measure the skin conductance which varies with human mental and emotional conditions and working of GSR is discussed.

III. METHODOLOGY

In the real time monitoring part GSR sensor is used to get the reading from sweat. A controller used for controlling the system. Here Arduino Uno is used as the controller. Power supply is provided to the controller. GSR sensor is used for monitoring the sweat. Output of GSR sensor is the skin conductance. Output from the sensor is analog, in-order to convert it to digital and analog to digital converter (ADC) is used. From the skin conductance the salt level can be measured.

Skin conductance is inversely proportional to the salt content. Conductance is converted to voltage reading. GSR sensor is inversely proportional to the value of glucose level. From the voltage obtained sugar level, stress level and hydration level can be monitored. Salt level is directly proportional to sugar level. The voltage obtained is converted to the sugar level by using the equation (1) given below. The obtained results are stored in cloud. ThingSpeak is used here as IoT.

$$(Out - a/b - a) * (c - d) + d \qquad eq.\ (1)$$

Out=Acquire from sensor
a=Minimum voltage
b=Maximum voltage
c=Maximum sugar value
d=Minimum sugar

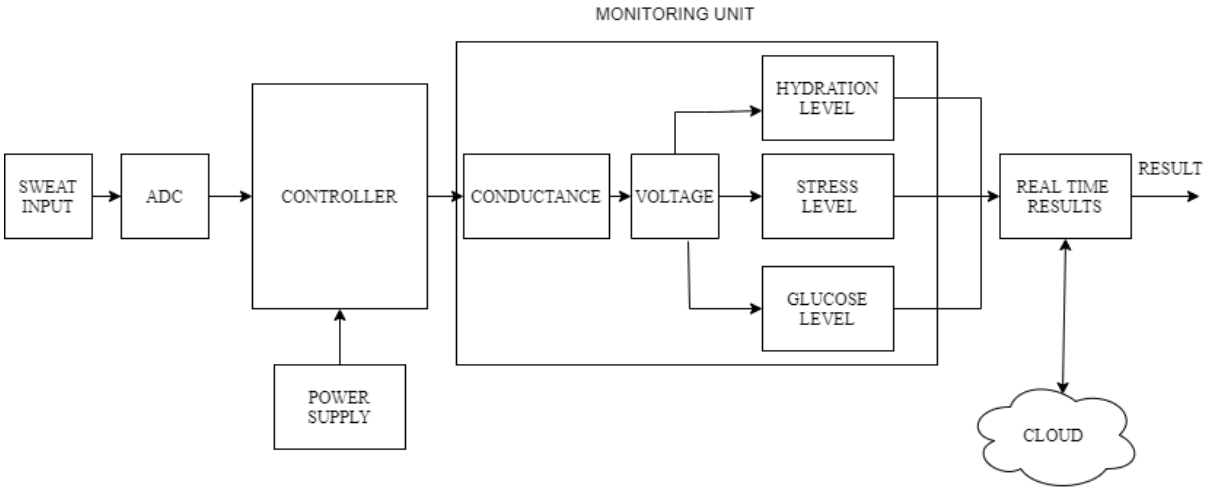

Fig. 2: Functional Block diagram

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A. *Workflow*

In the real time part, monitoring is based on sweat. Output from the sweat sensor is obtained as conductance, that is converted into voltage values. From the voltage value glucose value, stress and hydration level are calculated. Result is stored in cloud. Figure3 shows the work flow of the proposed system.

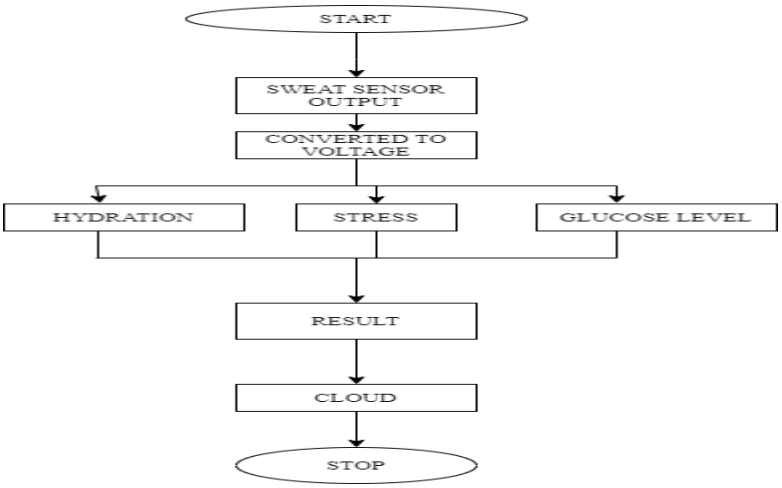

Fig. 3: Flowchart

IV. RESULTS AND DISCUSSION

In the real time part the GSR sensor is used for monitoring the sweat. Based on the sweat values glucose, stress and hydration are plotted. The glucose value obtained from this part is applied the prediction part. Not only the glucose value the age and family history are applied through GUI for prediction. The prediction use made and obtained resultas a pop up message. The results are also stored in a cloud ThingSpeak is used for storing.

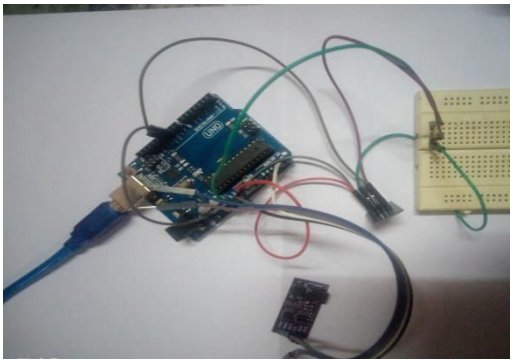

Fig. 4: Real time part

Graph of glucose level of various age group are plotted. The results are stored in ThingSpeak. Figure 5 shows the graph representing the sugar value for age group 20-25. Figure 6 shows the representation of sugar value for age group 40-70 using this system as a graph. Comparison with existing and proposed system is also shown as graph and table. Figure 7 shows this graph

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NO	EXISTING SYSTEM	PROPOSED SYSTEM
1	82	88
2	99	92
3	188	187
4	176	172
5	218	221
6	236	238

TABLE I: Sugar value for age group 20-25 using this system

PERSON	GLUCOSE LEVEL
A	88
B	92
C	187
D	172
E	221
F	238

TABLE II: Sugar value for age group 40-70 using this system

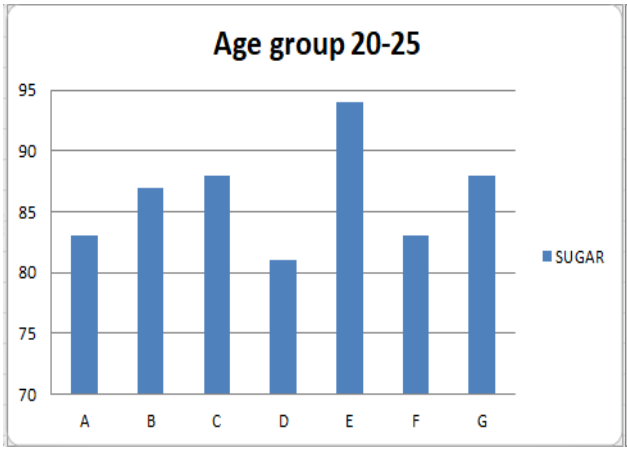

Fig. 5: Sugar value for age group 20-25

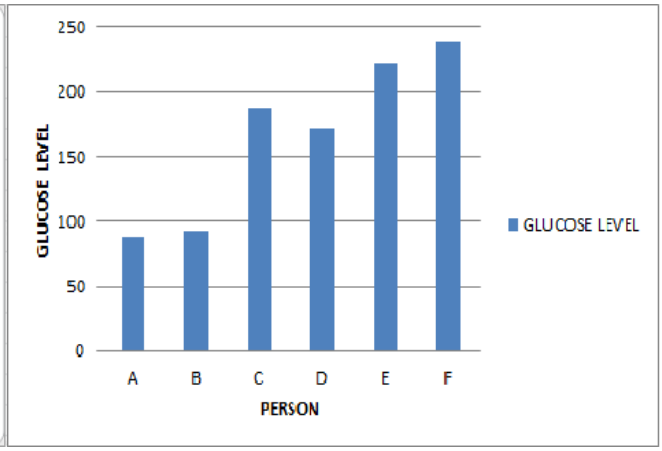

Fig. 6: Sugar value for age group 40-70

. The values for different age group where noted. The results were stored in ThingSpeak. The values were also stored as a graph. Figure 8 shows the IoT output of Glucose level. Figure 9 shows the IoT output of stress level using the proposed system.

PERSON	GLUCOSE LEVEL
A	83
B	87
C	88
D	81
E	94
F	83
G	88

TABLE III: Comparison of existing and proposed system

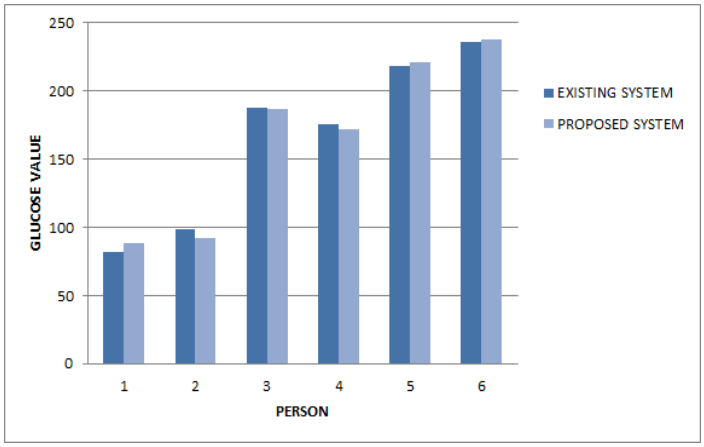

Fig. 7: Comparison of existing and proposed system

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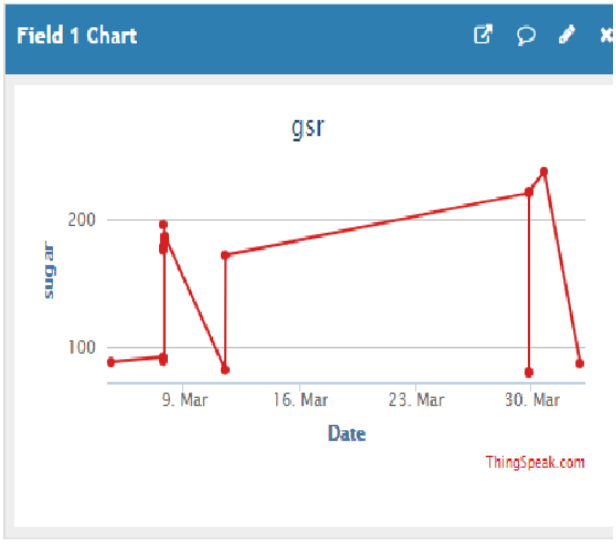

Fig. 8: IoT output of Glucose level

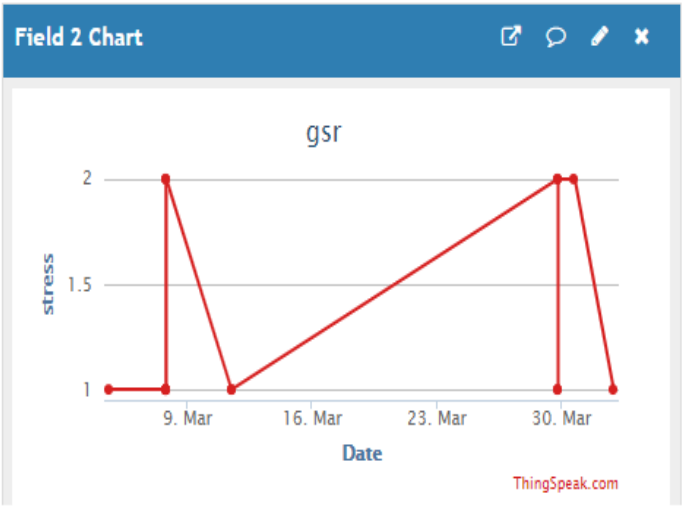

Fig. 9: IoT output of Stress level

V. CONCLUSION AND FUTURE WORK

The proposed system deals with a non-invasive method for monitoring the glucose level of a person. Since non-invasive method is used for monitoring the glucose level it will be much useful for people and can monitor glucose level without any help. Once of the painless method is used here. Sweat is the non-invasive method used. Stress and hydration level can be monitored using the same sensor. The proposed system has importance in medical as well as sport field. Cost of the IoT module helps to store data in cloud for future reference. Based on the concept of IoT is used for storing results in cloud. With the increasing improvements in machine learning technologies, IoT technologies and non-invasive methods such projects would have more value-added and receive more attention and support

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