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Smart Diabater: Android Based Diabetics System

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Abstract: ***Glucometer is device used by diabetics to measure blood glucose levels. Blood glucose testing is an important part of controlling blood glucose. One important goal of diabetes treatment is to keep the blood glucose levels near the normal range of 70 to 120 mg/dl before meals and under 140 mg/dl one to two hours after meal. Smart diabater is bluetooth enable hardware and it sends glucometer data to mobile application for data management and analysis. This can help to make an effective diabetes management program. Smart phone application shows data in graphical format. Each test result plotted along the time axis according to the time when the test is performed. Also it shows normal glucose level. On the basis of lunch and dinner time it distinguish glucose readings, it calculate average of pre-prandial reading and post- prandial reading average and glucose profile. According to difference between changes in glucose levels it suggests food list.***

Keyword: Diabetics, Glucometer, Bluetooth, Android Application.

1. Introduction

Diabetes is deadly and fifth leading cause of death in the world. In India alone, there are 40 million people suffering from diabetes and up to 346 million people suffer from diabetes worldwide [1]. Diabetes causes due to wrong blood sugar concentration. Electronic devices used to measure blood sugar level. This information of glucose level is important for user and physician. These readings have to be analyzed. Based on the analysis of blood glucose level, person can adjust his/her blood glucose level and thus improves his quality of life, getting closer to healthy life.

Diabetic patients are advised to test their blood glucose levels periodically and in some cases use injections of insulin to maintain healthy levels of glucose in their blood. Doctors recommend that patients keep a record of blood glucose levels for review at routine examinations. The review of handwritten logbooks is time consuming for both the patient and the doctor. With the creation of a device capable of data collection and management, and that is compatible with one touch glucometers. Glucometers give us information of sugar levels but nothing more. Physicians, regularly evaluating patients during periodic visits to the clinic, may be overwhelmed by the amount of recorded data. They often face difficulties when trying to understand what these data mean and identify actual problems or anticipate future risks [6]. The system manages home monitoring data of diabetic patients collected over a specified time period, and allows clinicians to analyse these data from different perspectives.

Blood glucose levels rise depends on food composition, portion size and timing [3]. Blood glucose level is usually tested before and after meal and at bedtime. Regular monitoring of blood glucose level helps to keep it near the normal range of 70 to 120 mg/dl before meal and under 140 mg/dl at two hours after eating [90-10]. The blood sugar level is typically determined by pricking a fingertip with a lancing device and applying the blood to a glucose meter, which reads the value. The test results are then used to help patients make adjustments in medications, diets, and physical activities. There are many meters in the market. Each meter has its own advantages and disadvantages.

1.1 Value of self-monitoring blood glucose pattern analysis in improving diabetes

Self-monitoring of blood glucose (SMBG) is an important adjunct to hemoglobin A1c (HbA1c) testing. This action can distinguish between fasting, pre-prandial, and post-prandial hyperglycemia detect glycemic excursions, identify and monitor resolution of hypoglycemia and provide immediate feedback to patients about the effect of food choices, activity, and medication on glycemic control.

Mobile based glucose data collection and management tools can be developed to perform pattern analysis for identifying patterns in SMBG data [4]. The use of pattern analysis involves: i) establishing pre-prandial and postprandial glucose targets; ii) obtaining data on glucose levels, carbohydrate intake, medication administration (type, dosages, time) activity levels and physical/emotional stress; iii) analyzing data to identify patterns of glycemic excursions, assessing any influential factors, and implementing appropriate actions.

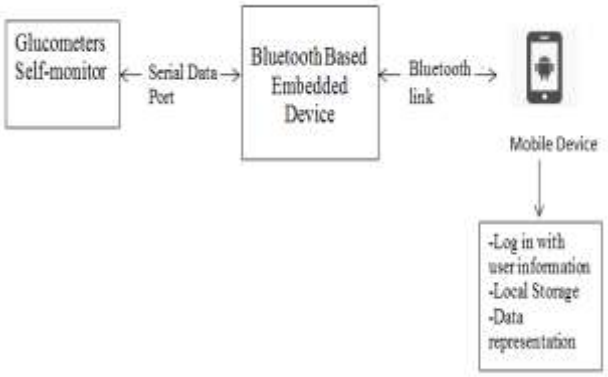
2. Proposed System

Proposed system aims to simplify the lifestyle of diabetics while providing new opportunities for statistical research and analysis of diabetes. Device and its firmware have been

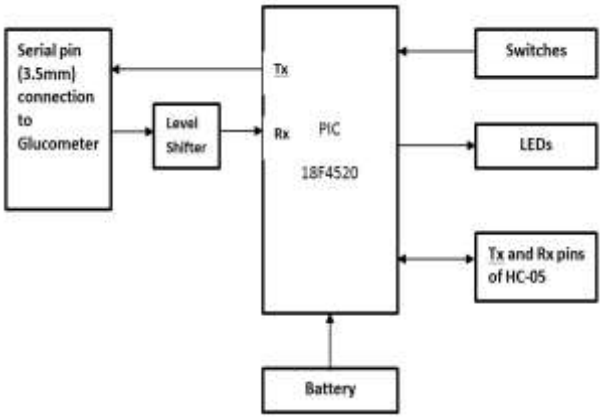
developed for data retrieval of glucometer and send readings to a data management application system for further analysis.

2.1 System hardware

As shown in figure 1 (a) system level diagram transfers glucose readings from compatible glucometers to mobile via bluetooth. Data transfer mechanism is initiated by calling meter data extraction command, which changes according to glucometers.



(a)



(b)

Figure 1: (a) System level diagram (b) Proposed system block diagram

After successful reception of glucose data, embedded device transfer the captured data to mobile for processing. Glucose data display on a mobile in the graphical forms. It makes easy to overview the overall data.

The designed system is compatible with the one touch ultra-glucometers. There are different models of one touch models - Ultra, Ultra 2, Ultra mini, Ultra Easy. One touch glucometer can be connected to PC by cable with DB9 pin on one end and stereo jack 3.5 mm on other end. OneTouch Ultra and Ultra 2 have same communication protocol. One touch ultra 2 has different commands as compared with other models of one touch.

Communication parameter setting for One Touch Ultra/Ultra 2 and Ultra mini:

Baud Rate = 9600 bps, Data Bits = 8
Stop Bits = 1, Parity = none
Flow Control = None, Com Port = port # utilized

Data received from Ultra/Ultra 2 is in the ASCII format such as Date, Time, Glucose reading, and Meter serial number. Different commands were used for communication to get data. As "DMP" command transfers the blood records from the meter's memory in ASCII text format as shown below.

P "WED","07/30/03","01:23:00 "," 101 ", 00 0807

This result can be interpreted as follows:

Date and time is WED, 07/30/03, 01:23:00. Glucose value is 101mg/dl.

Data received from ultra mini is in the form of series of hex such as Date, Time, Glucose readings. Different commands were used for communication to get data. One of data frame received form meter is shown in following table 1, 2.

Table 1: Data received from one touch ultra mini

STX	Len	Link	RM1	RM2	DT1	DT2
0x02	0x10	0x01	0x05	0x06	0xAC	0x86

Table 2: Data received from one touch ultra mini

DT3	DT4	GR1	GR2	GR3	GR4
0x55	0x68	0x4C	0x00	0x00	0x00

This result can be interpreted as follows:

Date and time in hex is 685586AC (from DT4 to DT1) = 16:05 20 June 2025. Glucose value in hex is 4C (from GR4 to GR1) = 76 in decimal. Date Shown is in epoch time stamp.

To transfer readings from embedded device to mobile HC-05 bluetooth module is used. Bluetooth communication is more flexible and robust. Serial port Bluetooth module is fully qualified for Bluetooth V2.0+EDR (enhanced data rate) 3Mbps modulation with complete 2.4 GHz radio transceiver and baseband. These connections are wires for TXD, RXD, VCC and GND pins. TXD pin of the module should be connected to RXD pin of microcontroller, and RXD pin should be connected to TXD pin of the microcontroller. VCC pin is connected to the common ground rail of the circuit.

In this system PIC controller (PIC18F4520) is used for glucometer data retrieval, where programming is done on embedded C. Code written on MPLAB tool (xc8-Compiler) [7]. As shown in following Proteus simulation of circuit fig. 3 microcontroller PIC18F4520 were used. In which serial port communication is done by USART. As need of system one inbuilt UART and software UART were used for communication. In following proteus simulation of circuit UART communication is shown on "Virtual Terminal".

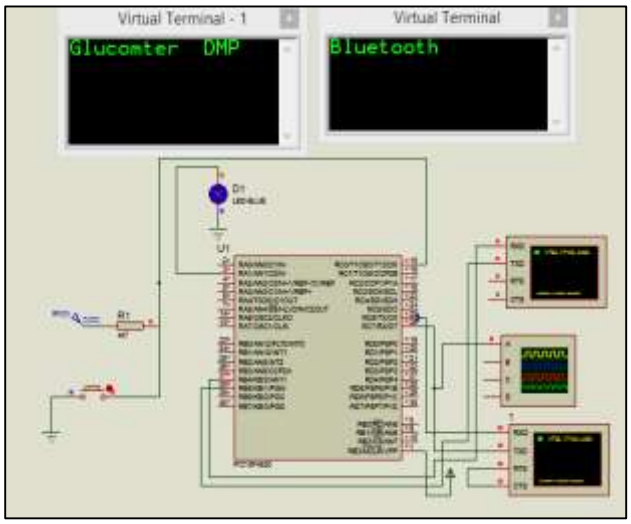


Figure 3: Serial communication using two UART

Figure 4 show system prototype. Working of circuit in such a way, when power is supplied to circuit blue led glows and led

of HC-05 also start fast blinking. After pairing bluetooth connection led blinking slow down. This shows pairing is successful. Toggle switch has two position one for one touch ultra2 and ultra mini. Microcontroller read status of switch according to that send command to glucometer. If glucometers communication gets successful green led glows and remain glow.

Figure 4: System prototype

Following fig. 5 shows flow chart of system. It shows working steps of system. At UART initialization step Software UART and USART set at 9600 baud rate. At final step glucose readings transferred to smart diabater mobile application.

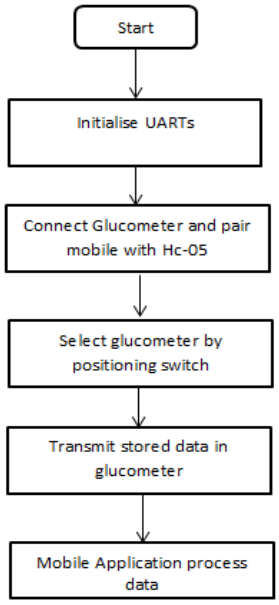


Figure 5: Flow chart of system

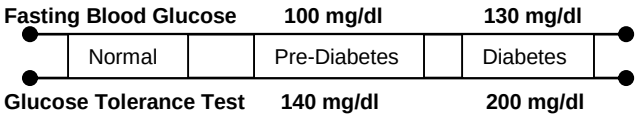
2.2 Android Phone Application

Android application requires information from user such as name height and weight. It calculates Body Mass Index (BMI). It also manages blood glucose data of diabetic patients recorded, and allows clinicians to analyze this data from different perspectives.

Android application performs following actions:

I. Plot patterns of high or low blood sugar and normal glucose level.
II. Create report to share with your doctor.
III. Alert for glucose measurement.

A simple blood test, called the fasting blood glucose (FBG) test. Another test is the glucose tolerance test (GTT), which requires that you drink a sugar solution, followed by a blood test 1-2 hours afterwards. Pre-diabetes is a condition in which blood glucose levels are greater than 100 mg/dl and less than 130 mg/dl. Pre-diabetics are at increased risk for developing type2 diabetes and for heart disease and stroke. If user has pre-diabetes, he/she can reduce your risk of getting diabetes by lowering your blood glucose levels [9].



2.3 Analysis of Glucose Readings

Mobile application differentiates glucose reading before lunch/dinner and after lunch/dinner on the basis of time. As mobile application asks for user's time of lunch/dinner and gives alert to user for glucose measurement before lunch/dinner and after lunch/dinner. According to previous study average of fasting blood glucose and glucose tolerance test is in the range of 100-110 mg/dl and 140-150 mg/dl respectively person is "pre-diabetics". Average of fasting blood glucose and glucose tolerance test is in the range of 130-140 mg/dl and 200-210 mg/dl respectively person is "diabetics".

The difference between the maximum and minimum pre-prandial glucose reading is less than 45 mg/dl it shows "balanced glucose profile" otherwise it shows "unbalance glucose profile". On calculating the difference of pre-prandial and post-prandial last glucose reading if person found is "pre-diabetics" application suggest food list to adjust blood glucose and for "diabetics" it suggest to meet doctor.

Researchers related and classify foods into account both the amount of carbohydrate in the food in relation with impact on blood sugar levels. This measure is called the glycemic load. Glycemic index refer to scale of 1-100. High GI food digested and absorbed fast so rapidly increase in blood sugar. On other hand food which is low GI gradually increase blood glucose [10].

GI > 70	High
GI between 56 and 69	Moderate
GI =< 55	Low

Whole Grains and Cereals:

Oatmeal (49), chick pea flour (besan) chapati (39)

Most vegetables score low on GI scale:

Broccoli, cabbage, lettuce, spinach, mushrooms, onions and red peppers (10-15).

Fruits:
Sweet potatoes (11 for boiled and 42 for baked), Cherries (22), grapefruits (25), plums (37), apples/pears (38), strawberries (40), oranges (42), grapes (46).

3. Results

Following figure 6 shows Registration on smart diabater application.

Figure 6: Registration on smart diabater application

Following glucose readings in table 3 of user profile has lunch time at 12:00 PM and dinner time at 8:00 PM. System distinguishes readings on the basis of lunch time/ Dinner time. On averaging the pre-prandial and post-prandial readings is shows person found is pre diabetics.

Mobile application process received those data and plot graph. For following glucose readings fig. 7, 8 shows plotted graph and analysis screen smart diabater mobile application.

Table 3: Time and glucose readings

Date & Time	Glucose readings(mg/dl)
05/07/15,14:12:35	149
05/07/15, 11:48:35	109
05/06/15, 14:19:15	142
05/06/15, 11:46:05	106
05/05/15, 14:49:35	153
05/05/15, 11:45:35	118
05/04/15, 14:10:15	146
05/04/15, 11:40:05	103

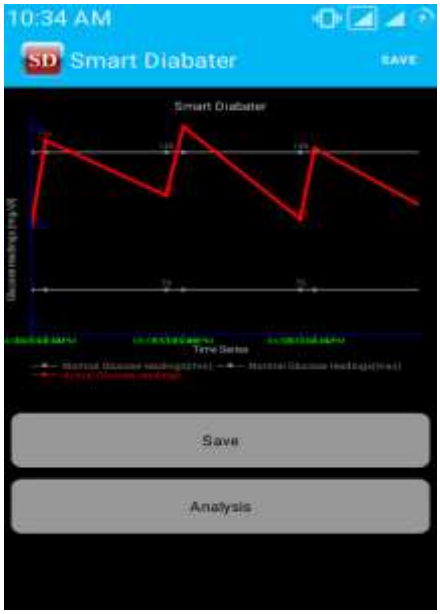


Figure 7: Graph of glucose readings

As for above data pre-prandial readings average is 109 mg/dl. It shows pre-diabetic condition and balance glucose profile so mobile application suggest following food list.

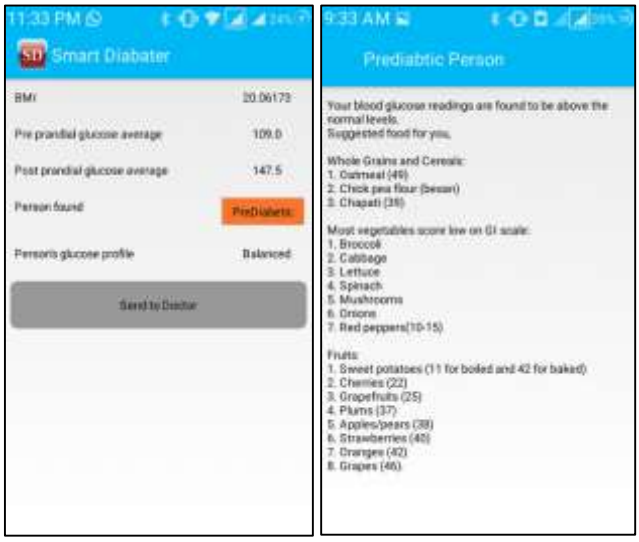


Figure 8: Analysis of readings and food list

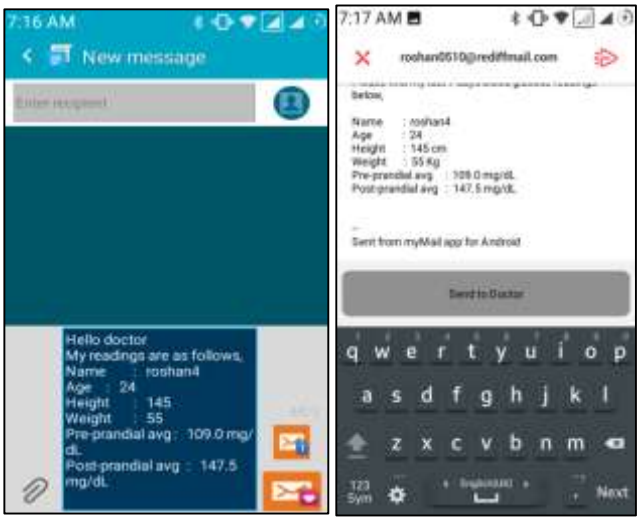


Figure 9: Sharing report with doctor by SMS or email

Figure 9 shows application screen of analysis sharing by SMS and email. In which user can glucose reading by attaching readings text file in email.

4. Conclusion

Smart Diabater is mobile base glucose data management system. System presented in this paper gives better visualization, summarization of set of home monitoring glucose data. This helps to know patient's diabetes stage and diabetic profile. As given in results mobile application calculates average of glucose readings and knows diabetic stage and it analyze readings and gives glucose profile. So clinicians can easily understand patient health condition and give correct medication. Android application also suggests food list this to help user to maintain diet thus improves diabetic patient's health.

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