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Remote Patient Monitoring using Disease Detection Algorithm

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***Abstract*—This paper includes the development of multi-parameter health monitoring system on Arduino using disease detection. Health is a level of functional and metabolic efficiency of living organisms. The disease detection algorithm uses the metabolic conditions of the person's body to detect certain diseases. The system is developed in Arduino environment using array of sensors and focuses on monitoring the general abnormal conditions of the patient and early detection of disease. The detected diseases are mainly Hyperthermia, Dysautonomia, etc.**

Keywords—Wireless Sensor Network, Health at Home Monitoring, Disease Detection, Arduino.

I. INTRODUCTION

Health is a dynamic process which needs to be continuously monitored. Health sectors have been facing various hospital admission problems due to higher rate of patient admission to hospital. To this aim, a system is proposed for human health care. The system provides regular monitoring of patients metabolic parameters and disease detection using the parametric values obtained. Due to increase in number of sudden deaths caused by chronic heart failure or high blood pressure, it is necessary to provide continuous health monitoring service at home. The proposed work is thus established at health at home platform.

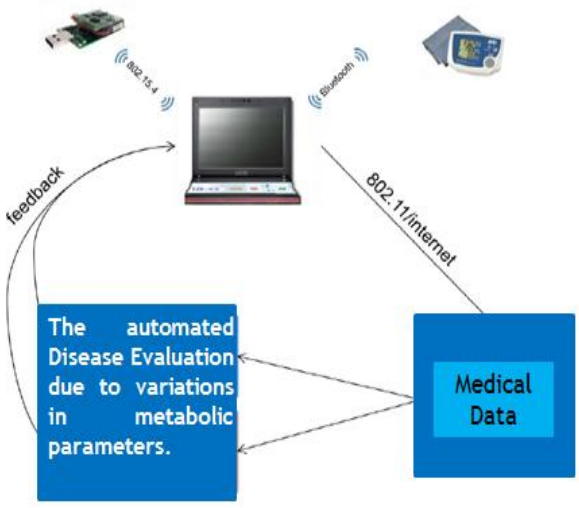

Fig 1: Health at Home system architecture

Health monitoring may be conducted at diverse situations whether at home or as a part of the diagnostic procedure. This may help to prevent a recovery from any minor event, as medical assistance will be provided by the system itself. The normal, abnormal and critical conditions of the patients per parameter value will be helpful to provide the diagnosis of diseases earlier. Critical situations are likely to be successfully managed and cured. When a disease is treated it may be able to prevent or delay problems from disease more likely than the normal traditional method of suffering from after effects of the disease. System is flexible to find a disease or other health parameters abnormality early in its course. Wireless Sensor Network (WSN) provides a wireless network consisting of spatially distributed autonomous individual sensor devices to monitor physical conditions of human beings. The Health at Home system architecture as shown in Fig.1 consists of a laptop home gateway which collects all the sensors data from the patient's body. The medical data or changes in metabolic parameters are then used by DDA for automated disease evaluation. The disease detection algorithm analyzes recorded signals from the sensors in more details with accurate results. On one hand, the sensor device is placed on the patient's body to monitor the metabolic parameters in real time. On the other hand, a Windows laptop will be used to show the analyzed results of the data acquired. Incidentally, the sensor and the application program are very low power. Hence users can monitor their ECG, stress, glucose, acceleration, pulse oximetry, weight, and blood pressure continuously. In this paper we consider the following things:

(a) Development of the disease detection flow using disease detection algorithm. The minimum set of parametric values is used for detection of various diseases.
(b) Development of the sensor modules for parameters, temperature, blood pressure, Spo2, ECG, stress using Arduino board and its acquired results based on implementation of the project.

If proper medical care can be given to the patients at the right time their lives can be saved, for that all we need is a system that continuously monitors all major metabolic parameters. This project can fulfill the mentioned need.

II. LITERATURE SURVEY

Wireless monitoring represents a medical practice that involves remote monitoring of patients. Most of the work is done in the field of health monitoring systems and still large numbers of expertise are working to innovate new ideas in this process. The research on epidemiology of acute heart failure syndromes is carried out and it is estimated that in last many years the hospital admission rate has doubled. The CHF patients will also be doubled in the forthcoming years [1]. The CHF patient's admission to hospitals approaches 45% within the period of 6 months. The changes in vital signs often precede symptom worsening and clinical destabilization. The survey mentions that the health at home monitoring system is beneficial and improves quality of life. Daily monitoring of some biological parameters would ensure an early recognition of chronic heart failure symptoms, which will allow timely intervention [2]. The ambient assisted living program made it easy to improve the provisioning of healthcare services for patients [3].

According to WHO (World Health Organization), around 17 million people around the world die due to untimely intervention. If proper and timely medication is given to the patient many lives can be saved, continuous monitoring thus is very beneficial [4]. The home based mobile cardiac monitoring solution incorporates a design of an integrated electrocardiogram (ECG) beat detector, similar for the blood pressure of the patients [5]. The device placed at the patient's body allows the patient to be mobile and allows data acquisition through Bluetooth module on the laptop gateway.

In order to monitor the breathing disease called Obstructive Sleep Apnea Syndrome (OSAS) which occurs due to sleep disorder, a phone based system for OSAS monitoring was developed. This disease interrupts normal sleep pattern and also causes hypoxemia and hypercapnia. In this work a smartphone based wireless e-health system has been introduced for monitoring a patient with OASAS. The authors show that the proposed system is very energy efficient due to the use of Bluetooth [6].

III. PROPOSED METHODOLOGY

The development of Health Monitoring System has been motivated mainly by the increasing healthcare costs and by the fact that the world population is ageing. The traditional method of individual parameter monitoring with doctors intervention is commonly featured in health care monitoring till date.

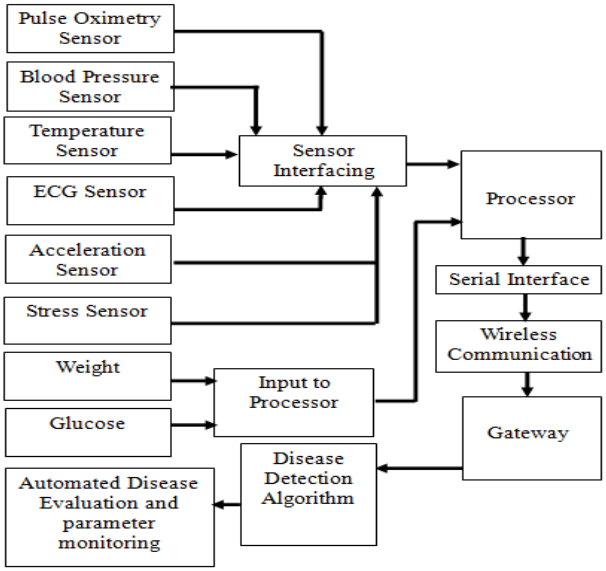

Fig 2: Block diagram for Health Monitoring System

So, to reduce affliction over doctor intervention and to encourage ease of disease detection, a unique platform is developed for health sectors which monitors various vital parameters on health at home gateway and detects various diseases by using a minimum set of metabolic parameters and provides an automated disease detection system.

The work takes into account the health at home platform. The system aims at giving highly flexible patient monitoring with vital sign acquisition and monitoring of the metabolic changes in patients body. The health care system provides cost beneficial feedback. The home gateway receives data; communication takes place point-to-point via Bluetooth module. possible. The Arduino Mega 2560 development board used is a microcontroller board based on the ATmega2560 having 54 digital input/output pins and 16 analog pins, which gives developers wide scope to make a compact and compatible design. Powered with a battery to get started, Arduino has 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, an ICSP header, USB connection and a reset button.

A. Hardware Design

The System is implemented on Arduino Mega 2560 Development board. SpO2. Blood Pressure, Temperature, ECG, Acceleration, Stress (Galvanic Skin Response) sensors are interfaced to the development board along with the output from Weight meter and Glucose meter simultaneously. This complete model is serially interfaced to the Bluetooth from health at home gateway as shown in Fig.2. The data is thus obtained at the gateway and after data acquisition the disease detection algorithm processes results on the graphical user interface. Automated disease evaluation and individual parameter monitoring in real time is possible.

TABLE I. TECHNICAL DATA OF THE SYSTEM

Component	Specification
Arduino	Microcontroller ATmega2560
Galvanic Skin Response Sensor	1uA,16 Hz
SpO2	100mA,660nm Super Red LED, 5V TTL level
ECG sensor	170uA, single supply operation 2.0 V to 3.5 V, G=100
ADXL Acceleration	3-axis,4mm x 4mm x 1.45mm LFCSP
Blood pressure sensor	+5v, 200mA, RS232,USB-UART
Bluetooth	1.8V, 3.3 to 5V I/O,-80dBm sensitivity
Dallas Temperature Sensor	Unique 1-wire, 8-pin SOIC, -67^{0}F to +125^{0}F

The normal, abnormal, subnormal, critical parametric situations are made known to the care givers or users, which becomes extremely beneficial for prevention. In special cases disease detection for diseases like hyperthermia, dysautonomia and diabetes are also possible.

B. Real Time Parameter Monitoring

Continuous monitoring of a metabolic culture for pH level, oxygen level, blood pressure, body position, Pulse rate and Heart beat monitoring is accomplished by means of the in-situ probes from the sensors. This type of in-situ monitoring system has great potential for the study of metabolic parameters as well as early detection of abnormalities in the metabolic culture.

1) *Sensor Placement:* Wearable Sensor platform comprises in-situ probes placed at different positions of the body. The ECG sensor consisting of three electrodes are placed two at arms and one at right limb. The device is placed at the chest of the patient's body with the help of a strap, which collects ECG, Skin temperature, stress index, acceleration data for accurate activity recognition. The body temperature can be measured at axel, whereas GSR, Blood pressure, SpO2, are placed as shown in Fig.3 Multi Parametric Health Monitoring System sensor placement and positioning. The sensor placement scheme collects the parameters from sensors and sends the data to a gateway platform by means of Bluetooth connections. Bluetooth is a proper solution for sensor communication as most of the mobiles and laptop gateways integrate it and it offers higher data rate than Zigbee. Bluetooth capabilities for sensors are an adequate choice because they provide acceleration together with standard buses (digital) I2C, SPI communication buses for new potential sensors [6].

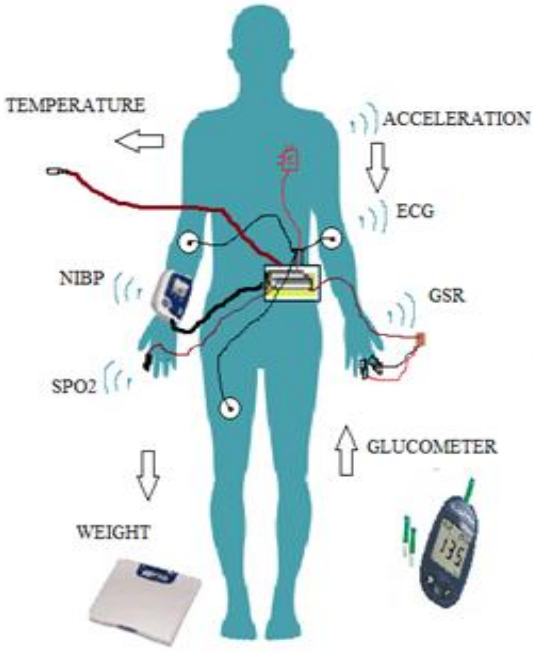

Fig.3 Sensor Placement and Positioning

2) *Disease Detction Algoithm:* The concept of the algorithm depends on the step by step procedure of the calculations, detection of the parametric value and accordingly detects the disease. Starting at initial input, the instruction describe computation, execution, process, and well-defined successive states producing output and eventually terminating at final state as shown in Fig.4 (a) and Fig.4 (b). The parameters and diseases in Table.2 represent the declaration of disease. The diseases like Hyperthermia, Dysautonomia etc. depends on the dynamic metabolic parameters like temperature, oxygen level, stress level, heart beat pulse, weight, blood pressure etc. All these parameters indirectly or directly affect the other parameter resulting in detection of parametric conditions and disease detection. Disease detection is useful in the health care monitoring systems as metabolic parameters are monitored in real time.

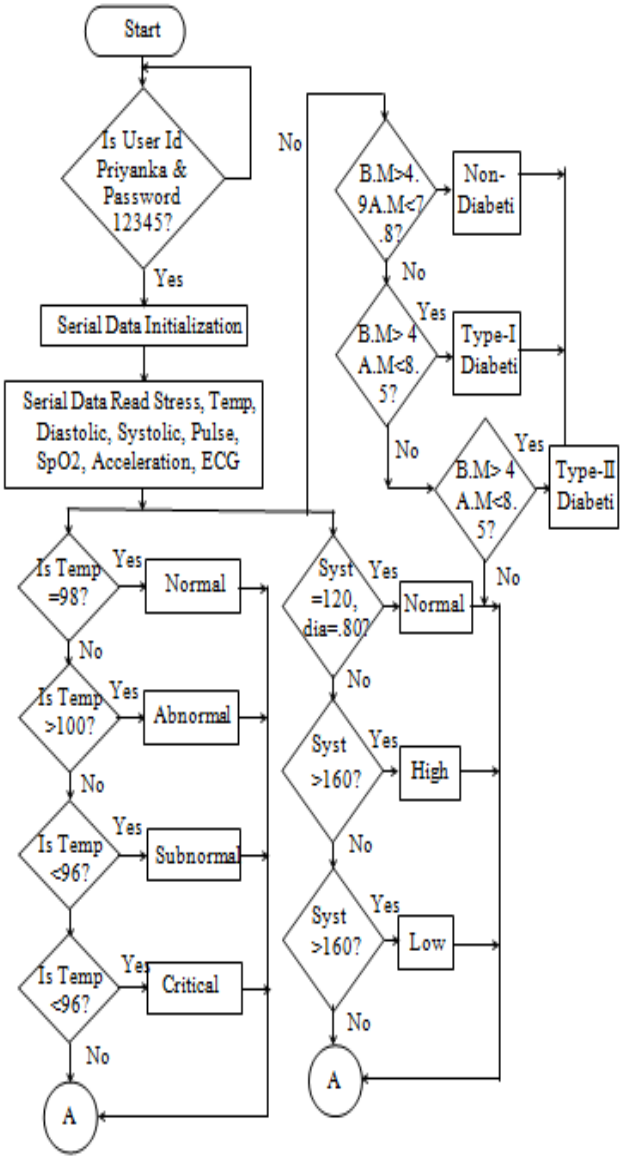

Fig. 4 (a) Flow chart of Disease Detection Algorithm

The system first requires a login after which the serial data is initialized and data is read serially for stress, temperature, diastolic, systolic, pulse, spo2, acceleration and electrocardiogram. The read data is compared with the medical database and its normal, abnormal, subnormal, critical levels are detected for each parameter as shown in Fig.4 (a). The flow continues to the Fig.4 (b) as given below.

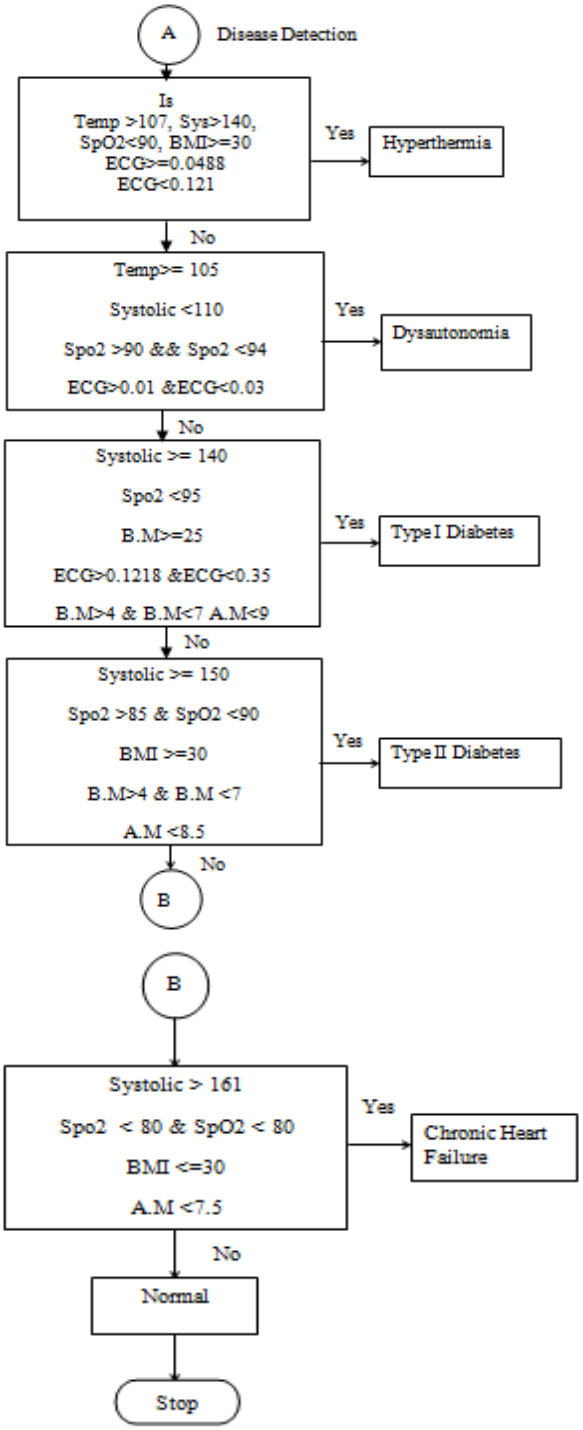

Fig.4 (b) Flow chart of Disease Detection algorithm

All the read values are compared and their conditions are observed. The values for the particular disease are compared within the medical database. If the found comparison is in the range of the minimum set of metabolic parameters, the disease is detected. Detection of hyperthermia prevents stroke. Similarly detection of the diseases dysautonomia, heart attack, diabetes etc. is also detected.

IV. IMPLEMENTATION

The design is approximately 13cm long and 20 cm wide (at the base), and 3.5 cm high. It is encased within a fiber body and placed over patient's waist line using a strap. The model is powered by the NiMH battery (or a power bank) providing over 24 hours of continuous operation. The blood pressure, temperature, accelerometer.SpO2, GSR (stress) sensors are interfaced with Arduino development board as shown in Fig.5.

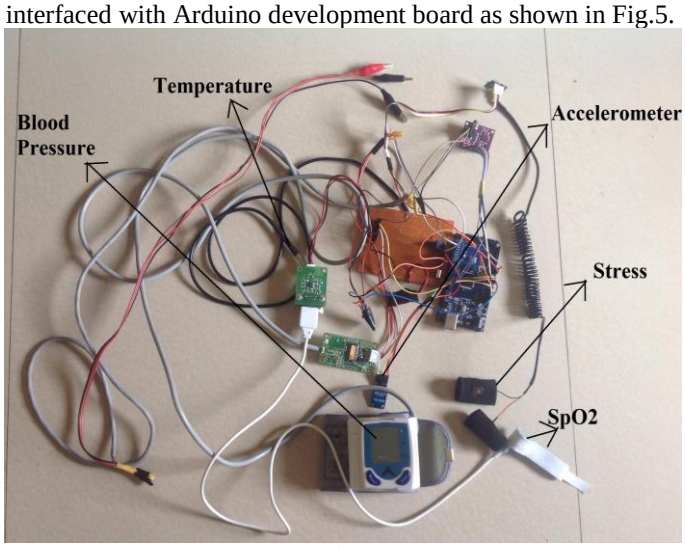

Fig. 5 Sensor Interfacing with Arduino

The Implementation of hardware consists of six different modules combined together to get a compact design of the model, making the system handy and flexible for use. The accelerometer sensor is placed inside the fiber body so that when the device is placed on the patient's body, the body position of the patient may be known such as sitting/standing, bending, sleeping.

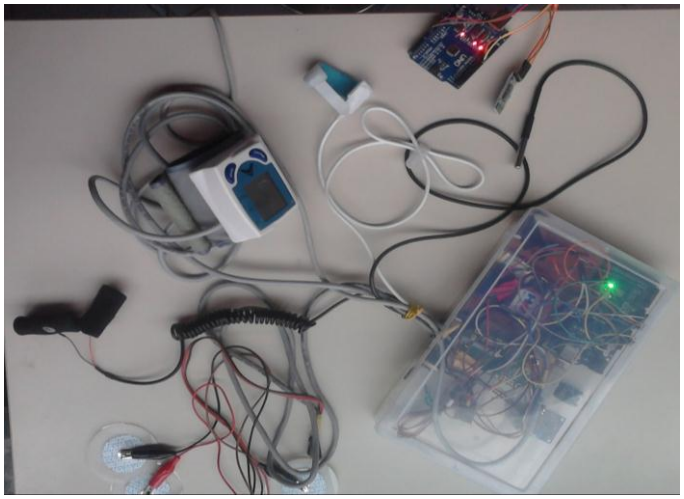

Fig.6 Implemented Hardware for the system.

The minimum and maximum values that came from the accelerometer while standing still may need to be changed to hold the calculated values. The analog read values at x, y and z-axis are converted to -90 to +90 degree. To calculate 360º values at an2 convert radian to degree.

x= RAD_TO_ DEG *(at an2 (-y Ang, -z Ang) + PI) {1}

y= RAD_TO_ DEG *(at an2 (-x Ang, -z Ang) + PI) {2}

z= RAD_TO_ DEG *(at an2 (-y Ang, -x Ang) + PI) {3}

Similarly various stress levels can be detected by using the Galvanic skin response sensor namely hungry, tensed, and relaxed. The temperature sensor implementation is a type of parasite powering. The unique 1-wire concept from Dallas makes the sensor shock resistant, when used over body (at axel or beneath tongue). The simulation results obtained on the Arduino is shown in fig. 6.

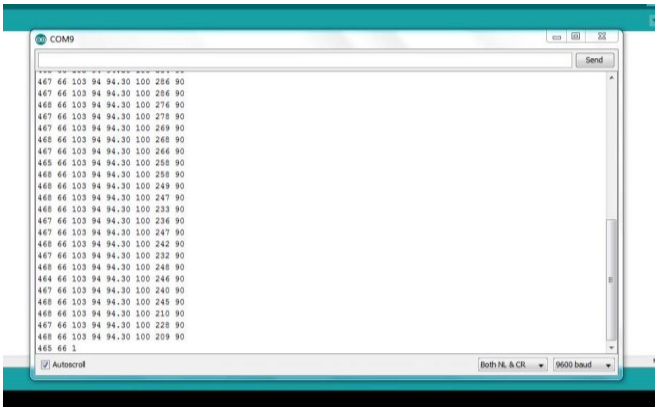

Fig.6 Simulation Results

The simulation results obtained in real time are displayed on the home gateway in the sequence as Stress level, pulse, systolic, diastolic, temperature, glucose after meal, glucose before meal and oxygen level. GUI is designed as per user requirement. The start push up button makes the system ready to use. After login all the sensor data is obtained on the GUI and individual parameter conditions are displayed. If all the parameters provide critical threshold values related to a disease, disease will be detected else it will show person as normal. Fig.7 shows the results hardware implementation on GUI for the Monitoring System.

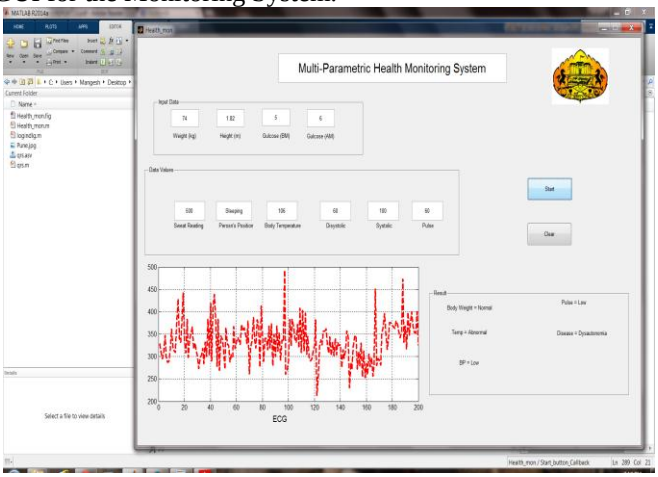

Fig.7 Disease detection for Dysautonomia

The disease detection for Dysautonomia along with other diseases and real time monitoring of patients with normal metabolic conditions is accomplished. For normal patient monitoring the result is as shown in fig.8.

Fig.8 Normal Patient Monitoring

V. CONCLUSION

This paper presents design and implementation of Multi-Parametric Health Monitoring System and the development of Disease Detection Algorithm. The Laptop gateway is integrated with the monitoring system to acquire data of different sensors. The real time monitoring is done with the help of the DDA and metabolic changes or abnormalities if any are obtained. Disease detection is possible for dysautonomia, hyperthermia, diabetes, obesity and person normal conditions. This system examines minimum set of metabolic parameters for detection of maximum diseases. In future full migration on android is possible.

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