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SMART BASAL BODY TEMPERATURE MONITORING AND INDICATION OF OVULATION USING IOT

Santhosh Thiyagarajan[1], Dr. Priyanka Parthiban[2]

[1]*Student, Master of Technology in Software Systems, Brila Institute of Technology, Pilani(Raj.), India.*
[2]*Yerevan State Medical University, University in Yerevan, Armenia*

Abstract - *One of the long-used way to determine whether ovulation has occurred and the menstrual cycle timing is by the Basal Body Temperature (BBT) charts. It is the most simple and inexpensive method. The past studies by various authors proves that there is a relationship between the BBT and the ovulation. This is due to either the luteinizing hormone(LH) peak or increase in the plasma progesterone. The resting body temperature is measured over a period to determine the ovulation. The growth in the internet technology enables us to make a huge leap in healthcare industry. This paper focus on how a wearable IoT device can be used to collect the BBT data from the users and send it to a microservice architecture enabled cloud clusters where the data can be processed and results are obtained.*

Keywords: Microservice, BBT, IoT, Ovulation.

1. Introduction

Women observe recurring physiological changes known as menstrual cycles during their reproductive age. This menstrual cycle starts on the first day of menstruation period, followed by a pre-ovulatory period referred to as the follicular phase, then followed by ovulation the cycle enters a post-ovulatory period referred to as the luteal phase. This phase will last until the day before the next menstruation onset. Although menstrual cycles generally last 28 days there is a significance variation in the length of this menstrual cycle Variation in menstrual cycle length is mainly attributed to the follicular phase, as the follicular phase shows greater variation in length than the luteal phase. This makes the determination of time of ovulation can be difficult.

Basal body temperature (BBT) also reflects this biphasic aspect of the menstrual cycle; BBT tends to be relatively low during the follicular phase, increasing by 0.3 to 0.5 ◦C after the cycle enters the luteal phase. Since a shift in BBT may be indicative of ovulation, daily BBT records could be used to estimate the day of ovulation and associated fertile interval. After ovulation, the corpus luteum produces the heat-inducing hormone, progesterone. The fertilized ovum is implanted on the lining of the uterus once the progesterone makes the necessary changes during the luteal phase. Progesterone, however, also causes the resting body temperature to rise after ovulation. Because progesterone is only secreted in high levels after ovulation, it is possible to identify ovulation for the day before the temperature rises when temperatures are plotted on a graph.

In this paper, we focus on obtaining the Basal Body temperature through sensor and transmit them to the cloud through ad aurdino circuit, where the data is analyzed and the report is generated using the statistical model and sent to the users. The microservice architecture helps in scalability of the user and data as required. The auto scaling of the microservice architecture enables this system to serve the user need even during the high demand of the service.

2. Related Works

As mentioned in the [1] we may estimate basal body temperature by extrapolating from a plurality of temperature readings during a sleep period. The estimated basal temperature may be used to form an indication of ovulation.

The reliability of the BBT method to determine the ovulation was questioned by various researches [2-6]. This error is due to the different method practiced by the users to measure the body temperature and the interpretation of the BBT graph by the users. The serial real time pelvic ultra-sonography has been described as a rapid, reliable method for monitoring follicular growth, rupture, regression [7].

In [8] author planned to assess how closely BBT charts matched detailed endocrine data in distinguishing ovulatory from an ovulatory cycle, detecting short or inadequate luteal phase cycles, and determining the time of ovulation. In addition, the use of a panel of six expert evaluators provided a measure of possible variability in individual interpretation of identical BBT charts.

System security is increased using two level authentication mechanism with SHA-2 encryption technology. This also increase the robustness of the system exponentially. The sensors need to be powered by renewable energy sources. Theses sensors can be powered by solar energy to provide uninterrupted data collection form the patient. These devices can be turned into a wearable device such as watches so that the user can wear it all the time without any discomfort. The devices can be designed over M2M protocols so that the system can be

able to process huge volume of data to come to a conclusion. Computing power will be limited by a device and the devices cannot be scalable horizontally and it is only possible to scale only vertically [9].

For the system to be horizontally scalable it should be able to process the data in distributed manner. The system should be intelligent enough to detect the data load and auto scale. The smart IoT system coupled with the microservice architecture provides a solution to the scalability of the huge data flow system. [10] The complex computational system needs to be split down into sizeable small components such a way that they can be able to scale on their own. These individual components should serve only one purpose which it should be able to define in a single line. This decomposition can be either data driven or the domain driven. The healthcare system the data is key component hence the system can be decomposed by a data driven architecture. The should be maintained consistently across all the microservice available without any losses.

3. Architecture

The body temperatures are measured through the sensor and with help of the aurdino powered system the data is transferred over the Wi-Fi protocol to the cloud server where the statistical calculations are applied over the period of data to detect the ovulation period and indicate the users.

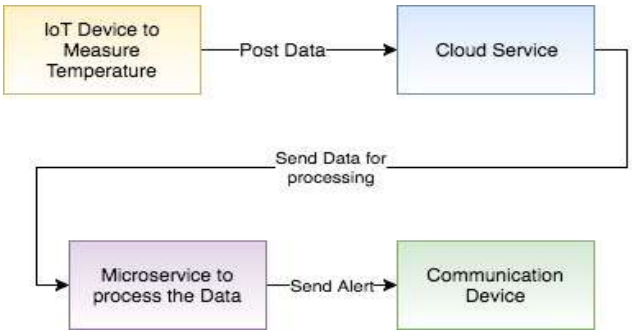

Fig -1: Block Diagram for Overall System

Fig -1 shows the overall block diagram of the system where the data collected using the sensors are transmitted over an IoT devices using the HTTP protocols and received at the computational server end. The computational system takes care of analyzing the data and sending alerts to the respective persons. The alerts can be transmitted as SMS or a push notifications. This enables the users to pay attention to the ovulation period of the menstrual cycle. The data is obtained over the period of time where the graph is plotted to determine the basal shift which indicates the ovulation period. Once basal temperature shift is detected the notification is sent to the user over the SMS service.

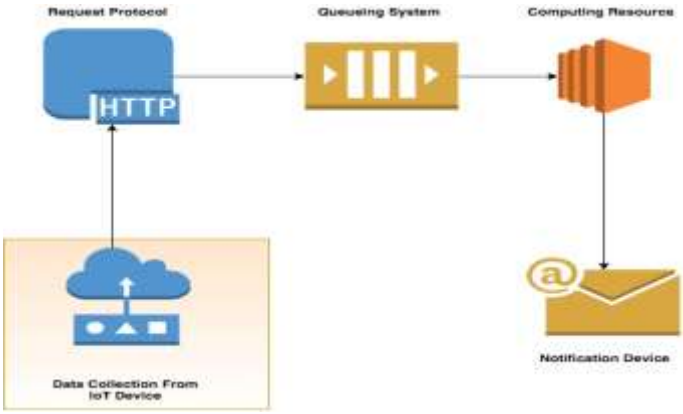

Fig -2 shows the architecture of the microservice.

The data received through the HTTP request are stored on a processing queue. The queue will be listened continuously by an ever-running process which will take the data and process it for the anomaly detection. These instances can be scaled horizontally if there is huge data incoming. Once the anomaly is detected the notifications are sent to the respective persons through SMS/ Push notifications.

The given architecture is capable of adapting the various interfaces on demand by plug-in approach. As we read the data from the persistent queuing system various computation logics can be applied simultaneously on the data and take make various decision based on it.

4. Implementation

The implementation has two parts. First the data has to be collected by the sensors on the regular interval and transmit it to the cloud servers where the data will be analyzed and the results are send back to the users.

4.1. Sensor Circuit

The processing capability of the sensor circuit is powered by an Aurdino Chipset Board. This provides the high processing power to collect the data from the sensors. The LM35 sensor is used to make contact with the human body to measure the body temperature. The ESP86266-01 Wi-Fi Module is used to connect to the available network and transfer the sensor data over internet using HTTP protocol. The LCD Display is attached to the system to show the temperature in real time. The entire system will be powered by an 12V DC power supply.

The circuit connections are made as given in the Fig -4. The 12V DC supply will power the aurdino board and the remaining components will get the power supply from the output of the aurdino pins. The ESP8266-01 is a 3.3V 100 amp powered module so the power distributor is used to maintain the steady current flow to the module. The LCD display is connected to the digital pins of the aurdino board. The LM35 sensor is powered by 5V DC supply from

the aurdino board and the voltage pin is connected to the analog pin in the board. This is used to make the voltage difference based on the temperature of the human body. This voltage difference will be sent out in the middle pin of the sensor.

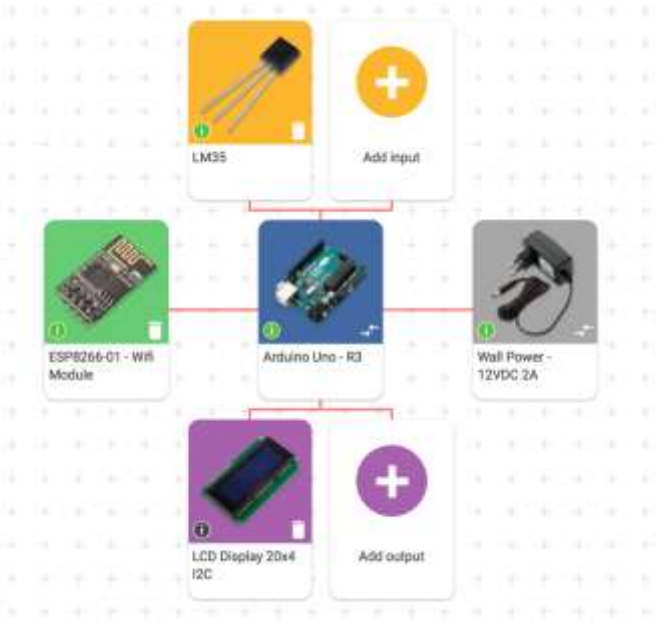

Fig -3: Components Diagram

The programmed in such a way that the voltage difference from the sensor is converted in to equivalent analog value then from the analog value the temperature is measured. Then the data will be transmitted over the network every second to the webserver. This data transfer uses the HTTP protocol over TCP so that the data is secured and transferred without any data loss

$$Temp = sensordata * \left[\frac{5V * 1000}{1024}\right] /10$$

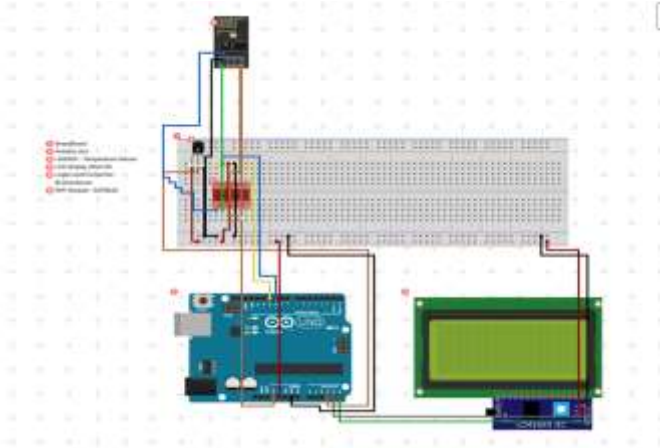

Fig -4: Circuit Diagram

The analog data from the sensor is multiplied with the input voltage to sensor data ratio, this give the temperature measured by the sensor. This data will then be transmitted over the network to the webserver from the ESP8266-01 module.

The temperature measured is also sent to a programmed LCD display to track the patient in the real-time. This enables the users to know their daily basal temperature.

4.1.1. Measuring body Temperature

The temperature has to be measured on the daily basis during the same interval of time. The sensor circuit is programmed to measure the body temperature on the specified time intervals. Basically, the ideal time will be early morning immediately after waking up. The LM35 sensor will be used to measure the body temperature through the skin. Once the temperature is recorded the data is transmitted to the server through the Wi-Fi module attached to the aurdino circuit.

4.2. Cloud Server

The data once received in the server will be queued up for the processing. The queue helps the sever to balance the load and make surer none of the data goes not processing. If there is a huge flow of data simultaneously to the server it will be queued up and processed in a FIFO order.

The server stores the data on the daily basis and plots a chart with temperature to the date. This chart helps to identify the basal temperature shift.

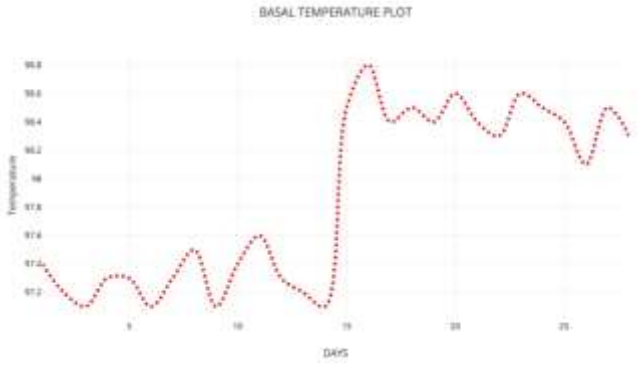

Fig -5: Circuit Diagram

Once the data is gathered in the server the graph is plotted and following phenomenon is observed. If the ovulation is happening, is observed a biphasic pattern that signals ovulation. In biphasic graph, there will be two parts or phases. The first part plotted of lower temperatures, during the time that the eggs are producing

and the hormone estradiol is high. That is known as the proliferative or follicular phase. The second, post producing (postovulatory) part of the cycle consists of relatively high temperatures, during the time that progesterone dominates, creating a bodily environment ideal for the establishment of a pregnancy. That phase is known as the secretory or luteal phase.

The Fig-5 graph is plotted against the days and temperature. The graph shows the 28 days of the cycle, the days are plotted against the X legend and temperature is plotted against the Y legend. This graph shows a biphasic behavior, where over the period of 28 days of the menstrual cycle the first half the temperature is observed to be with in 97.6 and on the second phase of ovulation the basal temperature is raised to 98.7 this shift indicates the luteal phase of the cycle.

5. Conclusion

The evolution in the technology has open the doors of various possible enhancement in the medical filed. The prediction of the ovulation period is the one of the critical thing in the IFV (Test Tube Baby) process and it is also a demanding thing in the day to day life. In future, the world will be controlled by Internet of things, thus monitoring the health enables the user to maintain good health on the go and it also enables the doctors to monitor the patient remotely with ease. This basal body temperature monitoring using the IoT opens up a huge gateway in the medical filed to and made ease for the user to maintain their personal hygiene with the power of technology.

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