Monitoring of Incubator using IoT

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Abstract - *The neonatal incubator is an apparatus that provides a closed and controlled environment for the sustenance of premature babies. But recently, many premature babies have lost their lives due to lack of proper monitoring of the incubator that leads to accidents (leakage of gas and overheating causing short circuits and eventually, the bursting of incubators). This project deals with the cost-effective design of an embedded device that monitors certain parameters such as pulse rate of the baby, temperature, humidity, essential amount of gas and light inside the incubator. The details are sent as a message to the doctor or nurse through IoT, so that proper actions can be taken in advance, to maintain the apt environment inside the incubator and ensure safety to the infant's life. So, the objective of this project is to overcome the above-mentioned drawbacks and provide a safe and affordable mechanism for monitoring the incubator.*

Keywords: Internet of Things, neonatal incubator, safety, parameter monitoring, affordable.

1. INTRODUCTION

[10] According to a recent study, premature birth or low birth-weight were two major reasons for about 370,000 neonatal deaths in India during 2015. The largest proportion of deaths among these two reasons belonged to neonates or premature babies. Also, a rise in neonatal deaths linked to premature birth and low birth-weight has been observed, from 12.3 per 1,000 live births in 2000 to 14.3 per 1,000 live births in 2015.

The increase in neonatal deaths from premature birth and low birth-weight was found to be non-uniform across India such that the death rates were more in rural areas and poorer states but lesser in urban areas and in richer states. Moreover, premature births and low birth-weight babies may require more investments in incubators and intensive care units in order to provide appropriate neonatal care. [9] According to another study, every year more than 20 million babies are born prematurely or with low birth weight and an estimated 450 of them die each hour. There have also been incidents of death of premature babies due to accidents which have been categorized as a technical fault in the incubators.

The existing system proposes the use of a temperature sensor to sense the temperature of the incubator which is connected to the Node MCU. Any increase in the temperature beyond the specified range turns the alarm on and the heater in the incubator gets turned off through the usage of a mobile app. The temperature readings can be continuously viewed by programming the Raspberry Pi. This enables the staff to receive notification during an emergency so that necessary preventive actions can be taken. This only ensures the maintenance of temperature inside the incubator. But there are other parameters which require being monitored and controlled to provide safety to the infant.

So, the main objective of this project is to overcome the above-mentioned drawbacks and provide a safe and affordable mechanism for monitoring the incubator which will help in reducing the mortality rate of neonates. The proposed system involves the use of Node MCU integrated to various sensor units such as pulse, gas, light, temperature, and humidity sensors. This system uses ubidots cloud to collect the sensed data and send emergency notifications to the doctor or nurse when there exists any variation in specified condition. The readings of the sensor are continuously monitored with help of IoT and can be controlled, thereby providing efficient and safe working of an incubator.

2. BLOCK DIAGRAM

Fig- 1 The system consists of the following requirements:

a. Node MCU
b. Temperature and humidity sensor – DHT11
c. LPG gas sensor – MQ6
d. Light sensor – LDR
e. Pulse sensor – M212
f. Ubidots cloud

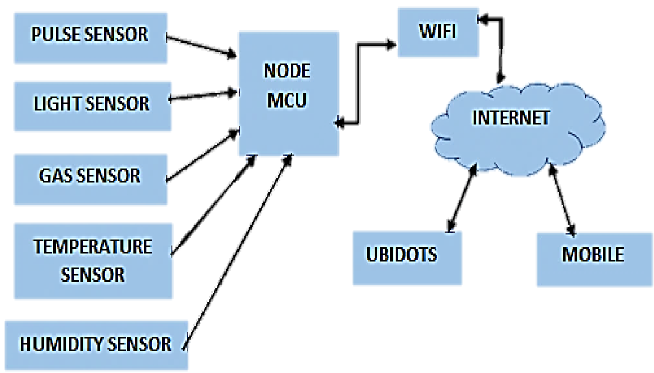

Fig -1: Block diagram

2.1 Node MCU

It is a firmware that runs on ESP8266 (microchip) with support of Wi-Fi network and built in flash memory. It is an open source IoT platform, considerably preferred over other boards because of its low cost, low power consumption and reduced size of the board along with integrated support of Wi-Fi. It is a single-board microcontroller with XTOS as its operating system. It consists of 128kBytes of memory and 4Mbytes of storage capacity, powered by USB.

2.2 Temperature and humidity sensor – DHT11

It is a low-cost digital temperature and humidity sensor that measures temperature and relative humidity in the atmosphere, providing digital signal output. Here temperature is measured with the help of a surface mounted thermistor (NTC temperature sensor) and relative humidity is measured with the help of a moisture holding component between two electrodes. So, DHT11 measures the electrical resistance between the two electrodes by detecting the water vapour content.

2.3 LPG gas sensor – MQ6

It is highly sensitive LPG gas sensor that mostly detects the presence of propane and butane concentrations in air anywhere from 200-10000ppm. When the presence of any flammable gas is detected, the conductivity of the sensor increases producing analog resistance output. Its response time is very fast, which is less than 10 seconds.

2.4 Light sensor – LDR

It works on the principle of photoconductivity, where the conductivity of the material is increased when the light is incident on the material. When light (photons) are absorbed by the material, electrons in the valence band move towards the conduction band resulting in more number of charge carriers. So, when circuit is closed current flows through the device and the resistance decreases producing an analog output voltage signal.

2.5 Pulse sensor – M212

It consists of a LED light that is used to measure the pulse rate. Based on the volume of blood in the capillaries, the light gets reflected as the sensor is placed on the body. So, the amount of reflection taking place during heartbeat will be less than that with no heartbeat. Also the volume of blood inside the capillaries decreases in between heartbeats, which affects the transmission of light through the tissues. This variation in transmission and reflection of light gives the analog pulse output from the sensor.

2.6 Ubidots cloud

It is an easy and affordable means of IoT data analytics, which changes the sensor data into information. It is a storage platform that also provides access to shared pools of data, which is often accessible only over internet.

3. WORKING

The system consists of Node MCU which is connected to the incubator. The various sensors used to sense the parameters associated with the monitoring and control of an incubator are integrated with the Node MCU. The Node MCU is programmed to obtain the readings of these sensors and display it thus enabling in the monitoring of the readings. The values of these sensors are updated in the cloud using the ubidots platform. The temperature and humidity sensor (DHT11) senses the temperature of the surroundings and the humidity present in the surrounding environment of the neonate.

Similarly, the gas sensor (MQ6) and light sensor (LDR) detects the presence of any gas leak and extra light penetrating the interior area of the incubator. If the temperature and humidity values exceed the specified range (36.5-37.2°C) or when the presence of gas or light is detected by the respective sensors monitored by a computer then, a message or an email is sent to the baby's doctor and nurse with the help of the ubidots platform. The Node MCU is also programmed to get the analog readings from the pulse sensor (M212) to monitor the heartbeat of the infant.

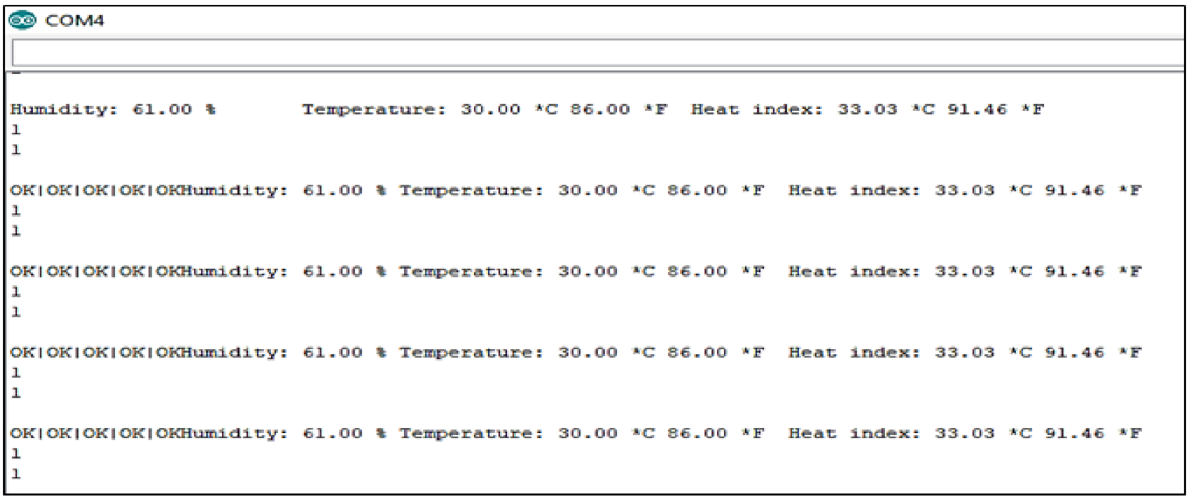

Fig -2: Output in serial monitor

Fig. 2 The continuous readings of these parameters such as temperature, humidity, gas, light and pulse can be monitored on the ubidots platform. Also, the values of these parameters can be altered immediately if any parameter exceeds their reference values, by the doctor or nurse viewing it at that moment. This ensures the ambient atmosphere being maintained for the neonates. Moreover, any variation in the parameters is intimated in order to help the hospital staff to take immediate action and thereby, save an infant from an imminent danger.

4. CONCLUSIONS

When the sensors are used such that they supplement the IoT in the necessary application, the technology becomes an illustration of the more general class of cyber-physical systems, which also comprises of technologies such as smart grids, virtual power plants, smart homes, intelligent transportation and smart cities.

Thus, IoT helps in sensing various objects, remote controlling of those objects and creates an ease in directly integrating the physical world into computer-based systems.

This results not only in improved efficiency and accuracy but also in economic benefit and reduced human intervention. Fig. 3 The ease of access to data is ensured by the use of the ubidots platform which is a means of data analytics in IoT. Also, the sensors used in this project are affordable and can be easily obtained if replacement is necessary as a part of periodic maintenance.

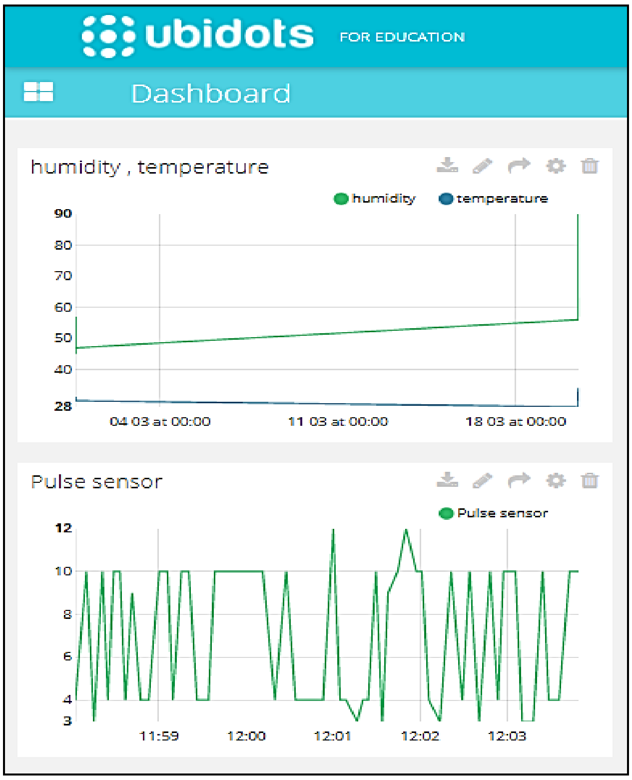

Fig -3: Parameter monitoring in ubidots

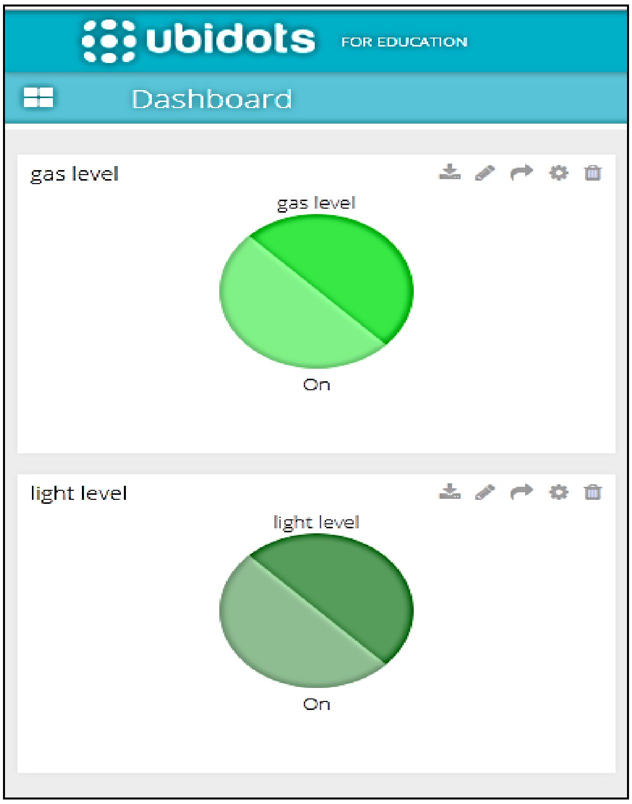

Fig -4: Parameter monitoring in ubidots

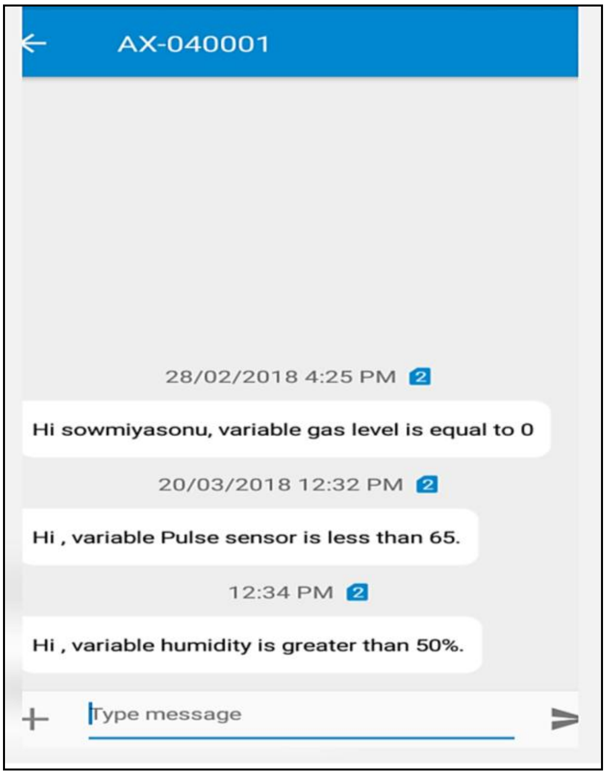

Fig -5: Messages received in mobile phone

Fig. 5 This helps in using the IoT to receive messages for monitoring the neonatal incubator in the most economical way.

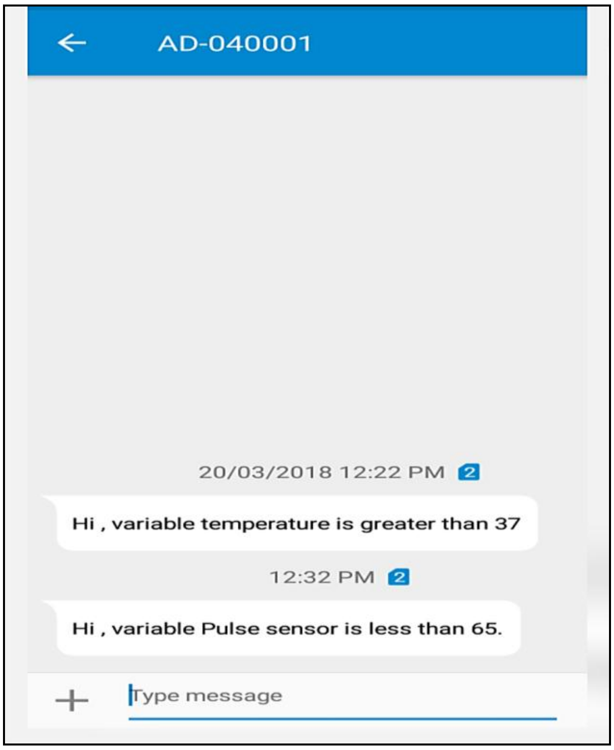

Fig -6: Messages received in mobile phone

5. FUTURE SCOPE

IoT is a way of tagging the objects with machine-readable identification tags. These tags can be coupled with different sensors to collect more information about the conditions of the objects and those present around them. Similarly, various companies which use computers, would keep track of the stock available and the resources, and maintain them at optimum levels using this tagging method. This not only saves a lot of time but is also extremely beneficiary in the financial aspect. But, there is not yet an established standard for tagging and monitoring with sensors. A uniform concept like the USB or Bluetooth is required which is not a very difficult task.

Though this project ensures that all other vital parameters are monitored in the neonatal incubator, there is an issue of exposure to high noise levels in the Neonatal Intensive Care Unit (NICU). In order to reduce noise exposure, strategies aimed at modifying the behaviour of NICU personnel, along with structural improvements in incubator design are required. Also, the impact of electromagnetic fields (EMFs) on infant health is still unclear. However, future incubators should be designed to minimize the EMF exposure and noise exposure of the neonate.

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