ADVANCING INFANT INCUBATION THROUGH IOT

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ABSTRACT

An Infant Incubator is the equipment required to maintain appropriate controlled environmental conditions suitable for a neonate (newborn baby) while their vital organs get develop. In preterm births or for some sick full-term babies, it is a lifesaving tool. A neonatal ventilator, blood pressure monitor, and oxygen hood are just a few of the pieces of equipments that are required to assess and treat sick newborns. The Internet of Things (IoT) is a new paradigm that allows electronic devices and sensors to communicate with one another via the internet in order to improve our lives. IoT uses smart devices and the internet to provide innovative solutions to various business, governmental, and public/private industries around the world. In hospitals, it is shown that neonatal staff burnout is prevalent among doctors. To reduce the burden we have designed a user-friendly IoT based infant incubator which will make the monitoring of neonates easier. The goal of this prototype is to design an IoT-based infant incubator that a health professional may access and manage online by using an IoT application. This prototype may gather information on the environment of incubators and store it on a server that is accessible online.

Key words: IoT based, Infant Incubator, Flame Feedback System, DHT22, Fireproof lift, Newborn, Monitoring.

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INTRODUCTION

Background

An Infant Incubator is the equipment required to maintain appropriate controlled environmental conditions suitable for a neonate (newborn baby) while their vital organs get develop. It is a lifesaving equipment used in preterm births or for some ill full-term babies. There are multiple equipments necessarily used to evaluate and treat sick neonates, which are a neonatal ventilator, blood pressure monitor, and oxygen hood.

An Infant Incubator provides a number of functions which include:

oxygenation, through oxygen supplementation by a head hood or nasal canola, or even Continuous Positive Airway Pressure (CPAP) or mechanical ventilation. It also protects the neonates from allergens, germs, excessive noises, cold temperatures, and light levels that might cause harm.

One of the prevalent causes of death in premature infants is Infant Respiratory Distress Syndrome, so for this purpose, CPAP is used, with administering pulmonary surfactant and stabilizing the blood sugar, blood salts, and pressure. Modern neonatal intensive care involves sophisticated measurement of temperature, respiration, cardiac function, oxygenation, and activity. Incubators in simple words are bassinets enclosed in plastic, having climate control mechanism equipment designed to keep the infants warm and limit their exposure to germs.

The working principle of infant incubator is that a fan blows filtered air on a heating filament and a water container. Some amount of oxygen can also be supplied to the incubator. The moistened, heated, and enriched air now flows into the above cabinet containing the baby.

A type of incubator called a transport incubator is used when preterm or a sick baby is required to be moved from one hospital to another or shifting of baby due to any medical emergency. The incubator comes with a small ventilator, IV pump, pulse oximeter, built-in oxygen supply, etc.

LITERATURE REVIEW

In 1891, the physician Alexandre Lion brought the incubator into the public consciousness by establishing permanent exhibitions. The infants were under medical care, but a paying public was able to enter and observe the infants in their glass incubators. In 1896, German Cooney worked with Lion on managing his exhibitions and set up his own display at the Berlin Exposition to demonstrate the treatment of premature infants. This display was a resounding success and led to many more displays in shows around the world. In 1897, the Victorian Era Exhibition at Earl's Court. Cooney moved to the United States and became the first doctor there to offer specialized care for premature infants. Between 1903 and 1943, there were incubator displays with premature infants set up in the Coney Island amusement parks. The infants were managed free of charge to their parents, while visitors paid to see the infants and receive explanations from his assistants.

In 1943, the first neonatal ward in New York was opened, marking the end of the exhibitions. While the idea of placing infants on display is controversial, not least because it entails a violation of privacy, the exhibitions served to educate the public while providing free healthcare for a group often disregarded before the invention of the incubator. This education in neonatal medical management may have contributed to the incubator's wider acceptance and the development of specialized neonatal units [2]. In 1985, Infants are nursed in incubators using either air mode control or skin temperature servo control, data are collected continuously using a computer-linked monitoring system. In 1998, the water permeability of an infant's skin is an important factor in the maintenance of a controlled water and heat balance. Radiant warmers and incubators help maintain the body temperature of the newborn infant. Incubators provide a heated environment to reduce body heat losses. The heat production is performed by force circulation of air warmed by an electrical heater, controlled manually [3]. An active humidification system was proposed to control ambient humidity in the incubator.

In 2002, the relative humidity level of an incubator was measured and controlled [4]. An integrated circuit-type humidity sensor is used to measure the humidity level of the incubator environment. Measurement and control processes were achieved by the Peripheral Interface Controller (PIC) controller. The high performance and high-speed PIC provided the variability of the system. The developed system can be used effectively for the intensive use of newborn and premature infants. The Integrated Circuit (IC) type humidity sensor used in humidity level measurement circuit, since the Measurement and control process was achieved by high performance and high-speed microcontroller, it is possible to provide better performance to control [5].

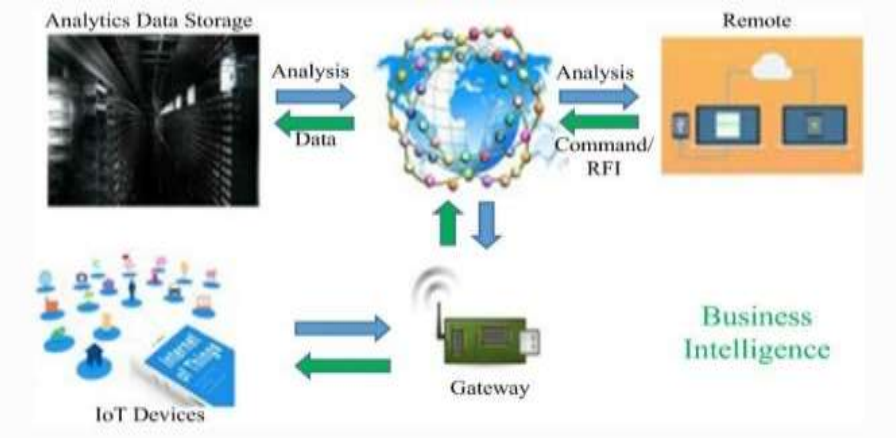
If a premature child is exposed to an unprotected environment outside the womb, the initial moments of his life could be critical [6]. Therefore, advancements in the infant incubator were necessary. According to research published in 2003, a binary frequency shift-keyed (BFSK)

ultrasonic temperature measurement technique based on sound speed was developed by combining the approaches of the phase-shift method and the time-of-flight (TOF) method. This lab prototype accurately measures the temperature to within ±1 degree centigrade. The main advantage of their ultrasonic velocity measurement system is quick and precise monitoring of the temperature in an infant incubator [7]. Along with that, there is an infant Intensive Care Unit that has developed and implemented a web-based real-time operation, administration, and monitoring system for evaluating temperature and humidity within infant incubators through the Internet which improves convenience and ensures real improvement in reaction to events that require intervention. [8]

In a 2012, paper, an efficient Field programmable gate array (FPGA-based) temperature monitoring and control system is built and constructed to detect and regulate the temperature of an incubator utilizing an LM35D sensor and associated peripherals. The designed system's performance is evaluated, and it consumes relatively less power and has a 5x faster computing performance when compared to conventional systems [9]. In 2014, a portable, easily powered, low-cost incubator was developed that can be used in a third-world population. The incubator's structural design prioritized the portability and reliability of the invention. The vestibule of the incubator was made up of a pop-up "tent" style. Collapsible, lightweight supports supported a tent-like cover made of clear, washable plastic as well as two heaters. The two DC heaters were powered by mains electricity when available, as well as a battery charged by a solar panel. Because it is an easily accessible, life-saving device, this design has the potential to reduce infant death rates in third-world countries [10].

Internet of Things (IoT)

The Internet of Things (IoT) is a new paradigm that allows electronic devices and sensors to communicate with one another via the internet in order to improve our lives. IoT uses smart devices and the internet to provide innovative solutions to various business, governmental, and public/private industries around the world [11]. IoT, as a whole, is a technological advancement that combines a wide range of smart systems, frameworks, intelligent devices, and sensors. Additionally, it utilizes quantum and nanotechnology to a degree that was previously unthinkable in terms of storage, sensing and processing speed [12].



MATERIALS AND METHODS

A Flame Sensor module, also known as a Fire Sensor module, is a compact electronic device capable of detecting fire or other bright light sources. In general, this sensor picks up IR (Infrared) light with a wavelength of 760 nm to 1100 nm that is released by the fire flame or other light source.

Temperature and Humidity Sensor (DHT22)

The DHT22 is a simple and inexpensive digital temperature and humidity sensor. It measures the surrounding air with a capacitive humidity sensor and a thermistor and outputs a digital signal on the data pin (no analog input pins needed). It's fairly simple to use, but data collection requires precise timing.

12V Fan

DC fans, also known as direct current fans, are powered by a fixed potential, such as the voltage of a battery. DC fans typically operate at voltages of 5, 12, 24, and 48 volts.

12V Adaptor

An electrical adapter changes the input voltage from 120V to 12V, making it acceptable for a radio or other small electronic equipment. The incoming electrical surge may fry the device's internal components if voltage regulation wasn't provided by an adaptor.

L293D shield

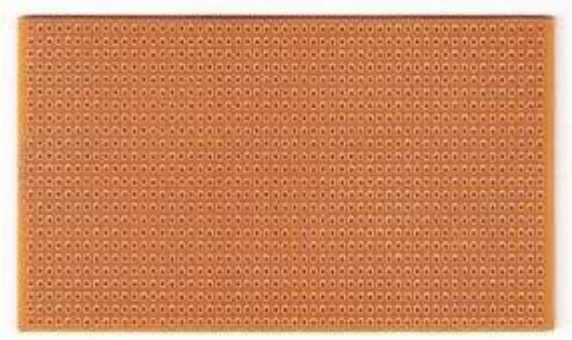
The L293D shield is a driver board based on the L293 IC that can simultaneously operate two stepper or servo motors and four DC motors. This module's maximum current per channel is 1.2A, and it is inoperable at voltages of more than 25 volts or less than 4.5 volts.

Solenoid valve

Solenoid valves are control devices that, depending on whether they are electrically activated or deactivated, shut off or permit fluid flow. An electromagnet serves as the actuator. When energized, a magnetic field builds up which pulls a plunger or pivoted armature against the action of a spring.

3.1.7 Veroboard

A Veroboard is a type of circuit board in which some of the electrical connections are formed by strips of copper on the underside of the board.



3.1.8 Buzzer

The buzzer is a device that produces sound by converting audio signals into sound signals. It is typically powered by direct current (DC). It is

widely used as a sound device in alarm clocks, computers, printers, and other electronic products.

3.1.9 NodeMCU ESP8266

NodeMCU is regarded as an open-source platform with the ESP8266 that enables the connecting of various items and enables data transfer using the Wi-Fi protocol. Additionally, by releasing several of the most important microcontroller components, such as GPIO, PWM, ADC, and others, it can address many of the project's needs on its own.

3.1.10 2 Channels Relay Module

The 2 Channels Relay Module is a board that can control high voltage, high current loads such as a motor, lamps, AC load, and solenoid valves. It can communicate with microcontrollers such as Arduino, PIC, and others.

3.1.11 Blynk Software

Blynk is a cloud-based Internet of Things platform made for iOS or Android smartphones that allows users to remotely operate Arduino, NodeMCU, and Raspberry Pi devices. By gathering and delivering the appropriate address on the available widgets, this program makes it very simple and helpful to develop a graphical interface or human-machine interface (HMI).

3.1.12 Jumper wires

Jumper wires are simply wires with connector pins on either end, which enable you to connect two places without soldering. With breadboards and other prototype tools, jumper wires are frequently used to make it simple to change a circuit as required.

3.1.13 Acrylic sheets

Acrylic is a translucent plastic with high durability, rigidity, and optical clarity. Acrylic sheet is simple to fabricate, adheres well to solvents and adhesives, and is simple to thermoform. Compared to many other transparent plastics, it offers better weathering characteristics. The clarity, brilliance, and transparency of acrylic sheets are similar to those of glass.

3.1.14 Zener diode

A Zener diode is a specific kind of diode made to consistently permit current to flow "backwards" when a specific reverse voltage, called the Zener voltage, is attained.

3.1.15 Air quality sensor (MQ-135)

The MQ-135 Gas Sensor can identify dangerous gases and smoke, including ammonia (NH3), sulphur (S), benzene (C6H6), and CO2. This sensor, like the others in the MQ series of gas sensors, has a pin for both digital and analogue output. The digital pin turns high when the amount of these gases in the air exceeds a predetermined threshold.

3.1.16 Arduino MEGA

The Atmega2560 AVR microprocessor serves as the foundation for the open-source Arduino Mega development board. This microcontroller has eight bits. It makes use of microchip technology ATmega16U2. Users may programme this board using the wiring/processing language. It has a 16 MHz crystal oscillator, 54 digital input/output pins, 16 analogue inputs, 4 hardware serial ports (UARTs), a USB connector, a power jack, an ICSP header, and a reset button. It has everything required to support the microcontroller.

3.1.17 Heating element

A heating element converts electrical energy into heat through the process of Joule heating. The element heats up as a result of resistance that the electric current passing through it encounters. A thermostat, TRIAC, relay, or other electrical temperature control device is used to control the heating element.

3.1.18 Humidifier

A humidifier is a device that delivers moisture to the air to avoid dryness, which can irritate several body organs. To prevent corrosive harm to the incubator, only distilled water should be used to fill the humidifier.

3.1.19 IR distance sensor

An infrared sensor (IR sensor) is a radiation-sensitive optoelectronic component with spectral sensitivity in the infrared wavelength range 780 nm-50 μm. IR sensors are now widely used in motion detectors. It does distance or proximity sensing by emitting IR waves and calculating the angle of reflection. Such infrared sensors only have to meet relatively low requirements and are low-cost mass-produced items.

3.1.20 Axle

An axle is a central shaft for a rotating wheel or gear.

3.1.21 Shaft coupler

A shaft coupler is a mechanical part that transmits power by joining the drive shafts and driven shaft of a motor. The mechanical flexibility supplied by a shaft coupler offers tolerance for shaft misalignment.

RESULTS AND DISCUSSIONS

It is observed that when a temperature is preset to 30°C as shown in Figure 4.2 then initially the temperature gradually increases as shown in Figure 4.3 then it is maintained at 30°C as shown in Figure 4.4.

In this way the temperature can be controlled and monitored and a graph of temperature is plotted on the Blynk remote application as shown in Figure 4.1.

Figure 4.1: Temperature presettings at 30°C

Figure 4.2: Initial temperature of an incubator

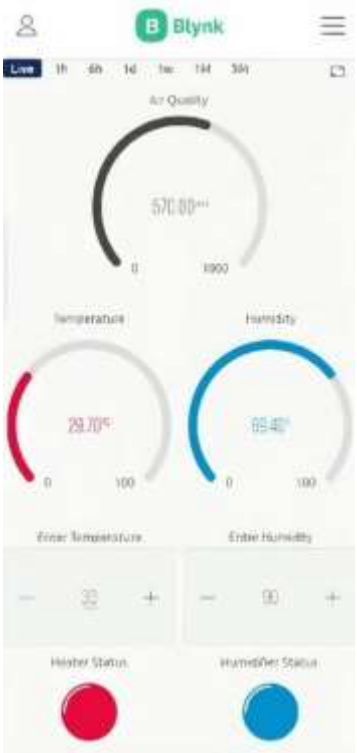


Figure 4.3: Gradual increment of temperature in an incubator

Figure 4.4: Temperature achieved to 30°C

4.2 Humidity monitoring and controlling:

It is observed that when a humidity is preset to 90% as shown in Figure 4.6 then initially the humidity gradually increases and then it is maintained at 90% as shown in Figure 4.7.

In this way the humidity can be controlled and monitored and a graph of humidity is plotted on the Blynk remote application as shown in Figure 4.5.

Figure 4.5: Humidity presettings at 90%

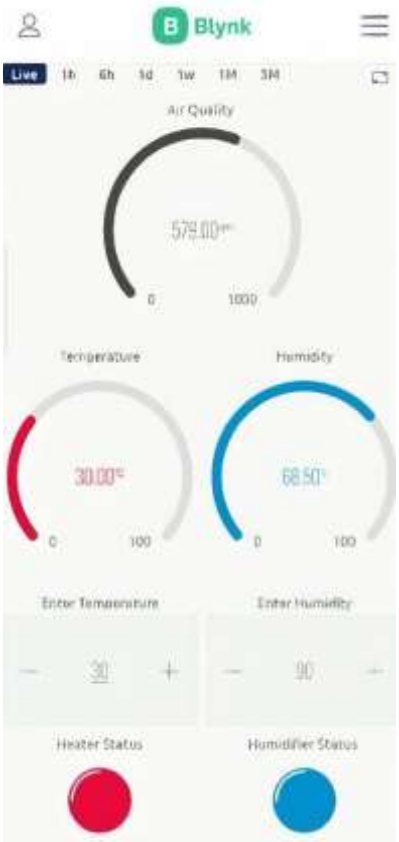


Figure 4.6: Initial humidity of incubator at 65.50%

Figure 4.7: Humidity achieved to 90%

Additionally, the continuous monitoring of air quality is also shown on the IoT remote which

shows the CO_2 levels of the baby inside an incubator. The final output of this project could be an assistive controlling and montoring of the paramters such as humidity, temperature and air quality which can enhance the capability of the incubator.

Conclusion

This IoT-based infant incubator is a low-cost, safe, and easy-to-use smart device that can enhance quality of life. The flame feedback system can resolve the problem of life threatening incidents in the near future. By operating the entire unit at low voltages, the probability of tragic hazards and short circuits can be decreased. Additionally, it is adequate to provide support during energy crises. The remote IoT application has advantages since it improves operational effectiveness, enables real-time monitoring, and can enhance the end-user experience.

Recommendation

The neonatal incubator regulates the environment for newborns by regulating and monitoring temperature and humidity. Future developments include ECG monitoring, circuitry that enables manual operation of the equipment, and the integration of a phototherapy system into the equipment itself rather than a separate attachment. Solar cells could also take the place of an expensive and unreliable electricity source in rural areas and a separate application can also be developed to make it more accessible.

These aspects can be used to progress society in the future.

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