DE-40 (DC&SE)

NUST COLLEGE OF

ELECTRICAL AND MECHANICAL ENGINEERING

Cribby – IOT Based Crib for Infants

A PROJECT REPORT

DE-40 (DC&SE)

Submitted by

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DECLARATION

We hereby declare that no portion of the work referred to in this Project Thesis has been submitted in support of an application for any other degree or qualification of this for any other university. If any act of plagiarism found, we are fully responsible for every disciplinary action taken against us depending upon the seriousness of the proven offence.

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First of all, Alhamdulillah, that our FYP is finally made and all Thanks to Allah for giving us the strength and moral to keep pushing forward and helping us on each and every step of the way.

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ABSTRACT

Children in the modern day are affected by many diseases sometime after birth. Diseases which affect children at birth are usually caused by premature birth, complications during birth or due to complications during the development of the fetus. These diseases include behavioral, neural and physical disorders. The facts today show that 75% of neonatal deaths take place in the first week of life. This project focuses on Sudden Infant Death Syndrome (SIDS) which can be prevented once notified about any sudden abnormal change in baby's vitals. CDC tells us that in 2019, there were about 1,250 deaths due to SIDS, about 1,180 deaths due to unknown causes, and about 960 deaths due to accidental suffocation and strangulation in bed. Therefore, monitoring babies has become essential. IOT based crib is a real time monitoring system placed on a baby's crib to help monitor the baby using various sensors. This is made possible by the use of Internet of Things (IOT) technology which is the key to the communication between the sensors being used and the module Raspberry Pi 4. The data from the sensors will be collected on Firebase cloud platform which can later be used by the doctors for analyzation. An android application designed on Flutter to notify the doctors of any abnormality in baby's vitals. The product will be easy to use and thus nursing staff will not be required to take vital readings manually. The potential consumers for this product are pediatrics doctors.

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Chapter 1: Introduction

1.1 Introduction

Monitoring means to observe the growth of a thing over a period in a systematic view. Monitoring baby has been in view from the start and baby incubators are used for this purpose which provide the ideal environment for the pre-mature babies to grow and survive. When the babies are born early before the delivery they are called as premature babies. Such babies are prone to different problems like low birth weight, non-uniform temperature and other unstable vital signs that can lead to many diseases. As we can see that proper monitoring and growth is done for the premature babies while the normal babies are just kept in the hospital for a few days and then sent to home for care and growth. This gave us a unique idea to monitor the growth of the infants in hospitals and notify the doctors in case of any ambiguity. The newborn babies are sensitive, and it is very important to monitor their growth by their basic vitals for future purposes.

So the idea is to use the new technology like Internet of Things (IOT) to monitor the growth of babies by their basic vitals using different sensors and display the data on the lcd screen attached to the crib and also sends the data to the application to the doctor and even to the parents even if there are far away from home in the office thereby decreasing the time needed to perform actions in such urgent situations.

Different sensors are attached to the crib: Humidity & Temperature Sensor for bed wetting mechanism, Body temperature, Heart rate and Respiration rate of the baby for hypothermia, SIDS (sudden infant death syndrome) and weight and height for malnutrition. All the real time data will be sent to the Firebase and analysed at regular intervals. The data will be displayed on the GUI Screen (Raspberry pi LCD Screen). An instant mobile notification that will be generated if any abnormal activity is detected in the Android Mobile Application which has been Developed. It has UI which include the feature of displaying the baby vitals of the baby.

Sudden Infant Death Syndrome (SIDS) also known as crib death, occurs to infants younger than 12 months old. Its causes are not known, but risk can be reduced by letting the baby

sleep on a firm surface. In winter or cold weather, the risk of SIDS increases, because the parents overdress their babies.

The Internet of Things depicts actual objects with sensors, handling skills, programming, and different innovations that associate and trade information with different gadgets and frameworks over the Internet or different correspondences organizations. The IOT encompasses many devices and is growing at a rapid rate, because it is such a broad category.

Generally, the baby cradle (Figure 1) is used in various hospitals and maternity homes for infants to sleep in and for soothing them. Conventional cradles are used in villages or non-urban areas because of their low cost and simplicity. They lack automation and are not electronically equipped. Consequently, conventional cradles should be automated to become more convenient, safe, and efficient in monitoring the baby's situation in real time.

Figure 1: A normal baby cradle

For the most part, the baby crib (Figure 1) is utilized in different emergency clinics and maternity homes for infants to stay in bed and for calming them. Regular supports are utilized in towns or non-metropolitan regions on account of their minimal expense and effortlessness. They need automation and are not electronically prepared. Thus, regular cribs ought to be mechanized to turn out to be more helpful, safe, and effective in monitoring real time.

The proposed framework model is created and tried to demonstrate its adequacy concerning cost and straightforwardness and to guarantee safe activity to empower the child nurturing anyplace and whenever through the organization. At last, the child observing framework is demonstrated to work in checking what is going on and encompassing circumstances as per the model.

1.2 Motivation

Sudden unexpected infant death syndrome (SUID) is a term used to describe the sudden and unexpected death of a baby under one year of age from accidental suffocation. These deaths usually occur during sleep or in the baby's sleeping area. Parents or guardians usually do not see these deaths as they occur. In addition, neonatal hypothermia plays an important role in increasing infant mortality by 80% for every 1°C drop in body temperature. Hypothermia is common in neonates born in the hospital (about 32% to 85%) and at home (about 11% to 92%). The lack of thermal protection measures remains an underappreciated challenge to infant survival in developing countries. Although hypothermia is rarely a direct cause of death, it contributes to a substantial proportion of neonatal mortality worldwide, mainly as comorbidities of severe neonatal infection, birth immature and suffocated. Our proposed system provides an IoT-based solution to solve these problems by collecting basic readings of children such as temperature, saturation rate, heart rate, humidity (bedwetting), store them in a real-time database and display them on the screen. The notification is then sent to the physician on application if the threshold is crossed.

In addition, according to the World Health Organization (WHO) infants, children and adolescents are among those most at risk of malnutrition. The baby cannot grow or gain enough weight in this condition. Our solution can track the weight of the baby, but the height is supposed to be determined in the future perspective of the project. There is no solution to get data from all sensors at the same time but our project deals with it.

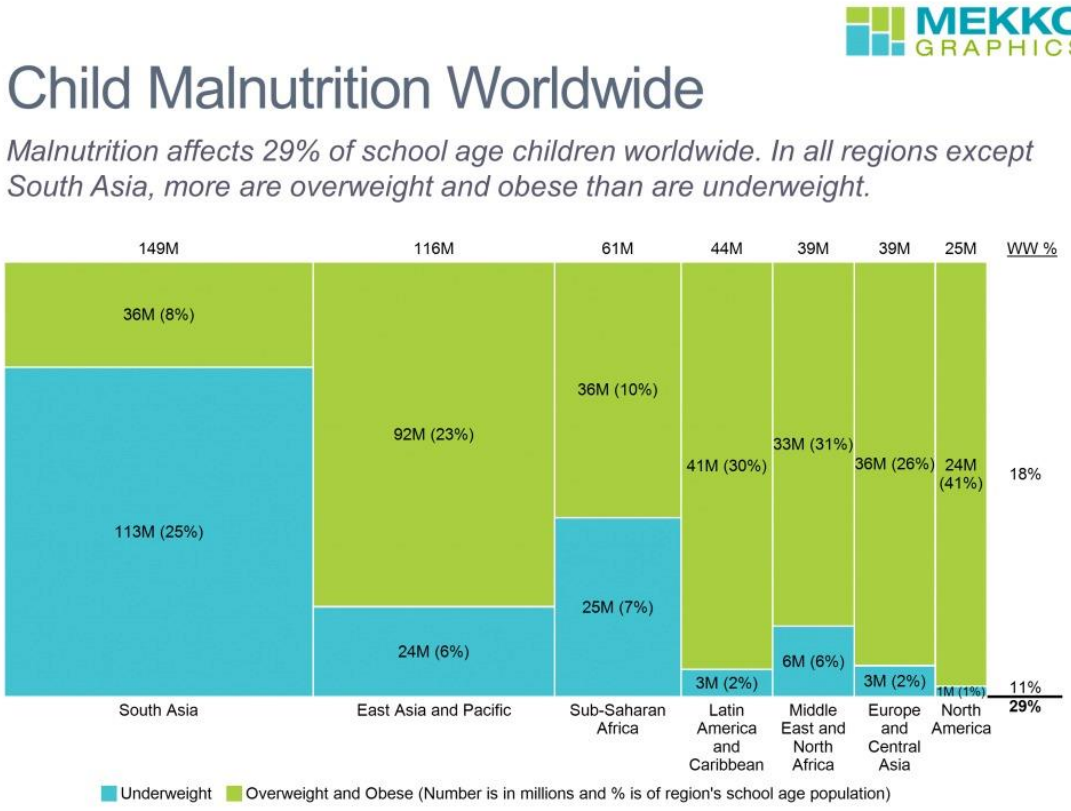

Figure 2: Children suffering from malnutrition

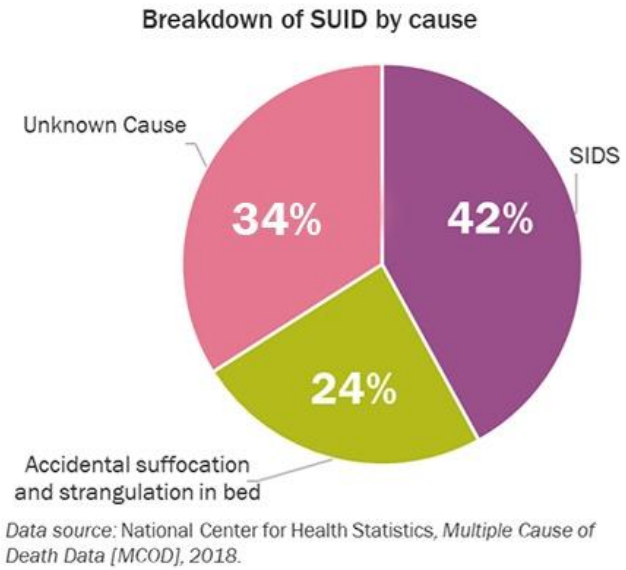

Figure 3: Children suffering from SIDS

1.3 Scope

The aim of this project is to develop a working system capable of monitoring the infant's growth to deal different diseases related to infants like SIDS, Hypothermia, Malnutrition and deals with the mechanisms like bed wetting mechanisms and can further be extended to cry detecting mechanism in future.

The system will be portable in a way that it can be attached to any crib and, and it can used in hospitals and in day cares.

The system is accompanied with a real time android mobile application which displays the vitals of the infants to the doctor, and notifies the doctor in case any threshold is crossed and also contains an lcd screen which will be attached to the crib and displays the vitals on the GUI

The scope of the project can be defined in terms of the following objectives:

- Development and testing of a portable monitoring system
- Development of a real time data driven mobile application
- Development of a LCD Screen GUI

1.4 Structure

Following is the structure of the report ahead:

- Chapter 2, it mainly deals with the explanation of Diseases Affecting Infants and literature review undertaken to establish grounds for better understanding of the usage of IOT
- Chapter 3, it deals with the innovative side of the project, exploring related therapies and products and establishing how the project is different from existing products
- Chapter 4, it deals with the design and development of the crib, the mobile application along with highlighting how the main integration is taking place
- Chapter 5, it deals with product trials undertaken to establish the working effectiveness of the system
- Chapter 6, it consists of concluding the report and exploring future possibilities and directions in which the project can be taken

Chapter 2: Diseases Affecting Infants

2.1 Sudden Infant Death Syndrome (SIDS)

[1] Sudden infant death syndrome (SIDS) is the unexplained death, usually during sleep, of a seemingly healthy baby less than a year old. Although the cause is unknown, it appears that SIDS might be associated with defects in the portion of an infant's brain that controls breathing and arousal from sleep. Physical factors include:

- Low birth weight. Premature birth or being part of a multiple birth increases the likelihood that a baby's brain hasn't matured completely, so he or she has less control over such automatic processes as breathing and heart rate.
- Respiratory infection. Many infants who died of SIDS had recently had a cold, which might contribute to breathing problems.

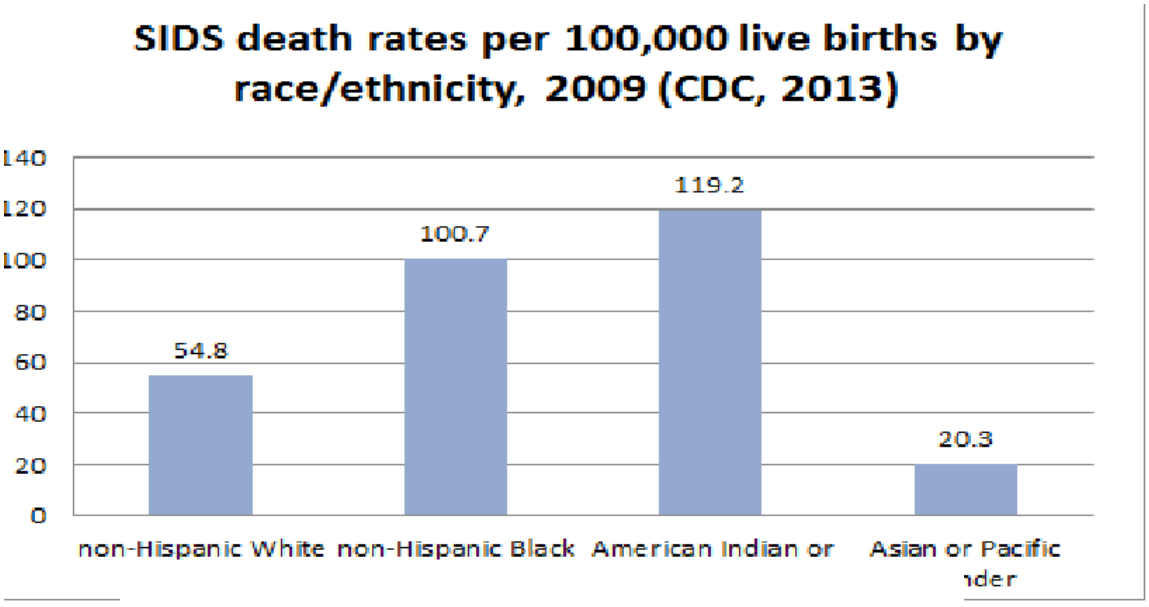

Figure 4: SIDS death rates 2009 (CDC,2013)

2.2 Hypothermia

[2] Hypothermia is defined by the World Health Organization as a core temperature < 36.5° C (97.7° F). In premature infants, hypothermia increases morbidity and mortality. Hypothermia may be purely environmental or represent intercurrent illness (eg, sepsis). Maintaining an appropriate environmental temperature in the delivery room or operating room is critical in preventing neonatal hypothermia. Hypothermic infants should be rewarmed, and any underlying condition must be diagnosed and treated.

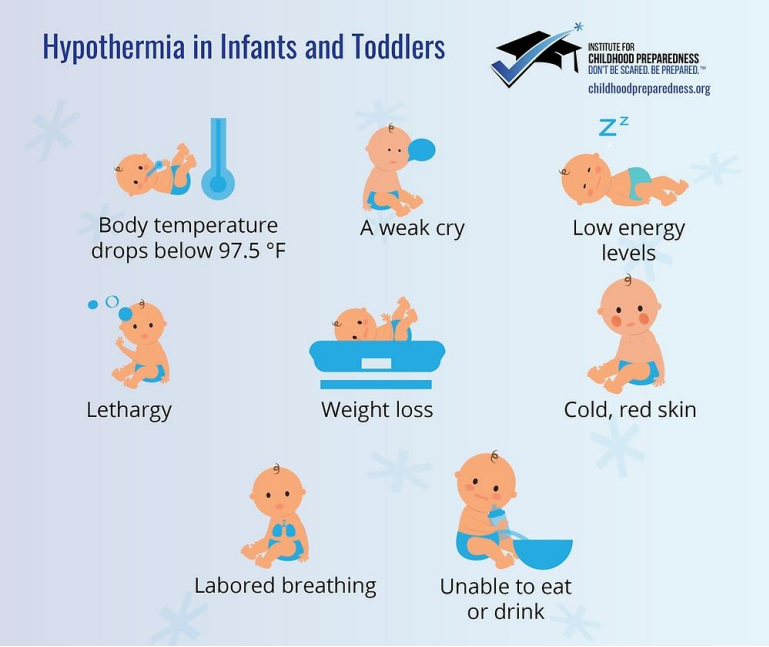

Figure 5: Hypothermia in infants

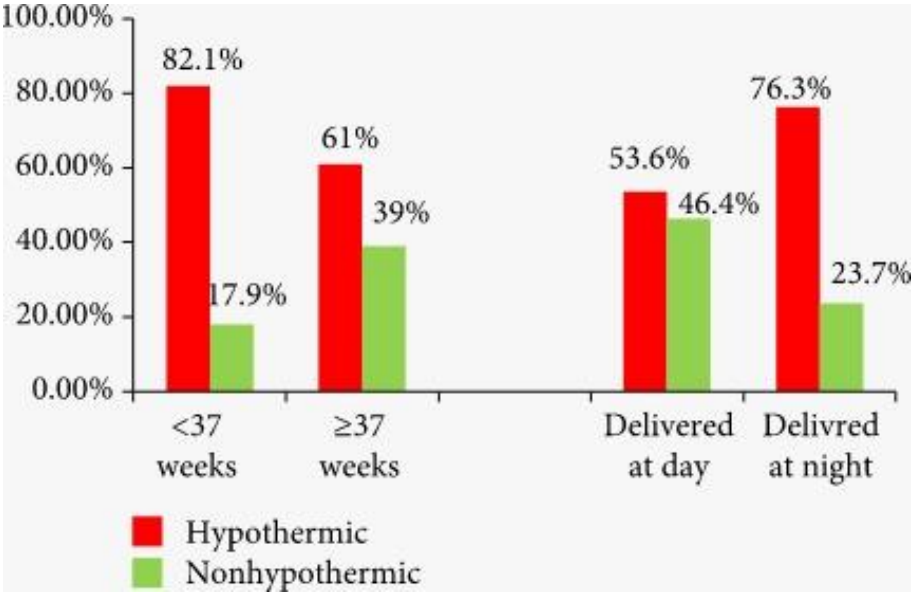

Figure 6: Children suffering from hypothermia

2.3 Malnutrition

[3] Malnutrition (poor nutrition) is a hidden epidemic that affects more and more people every year. It can strike even the youngest members of our population: babies and children.

Infants, children and teens are among those who are most at risk of malnutrition, according to the World Health Organization (WHO). WHO advises making the most of your child's nutrition within the first 1000 days — from conception to the child's second birthday.

2.4 Literature Review

Few researches show the different systems for monitoring babies by using different technologies.

[4] This paper uses the new technology called IOT (Internet of Things) which came into being because of the internet and enabling it to control different devices. One important idea is to monitor the babies at home using mobile phone for the working parents that are busy in their schedules.

This paper includes the smart cradle system which supports video monitoring and also includes the cry detecting mechanism and in response to it, it controls the swinging mechanism of the cradle. If the crying of baby continues for a longer time, it alerts and notifies the parents via phone and notifies them that the baby needs personal attention. The cradle has an automatic toy attached to it that rotates to reduce the baby cry possibility.

[5] This paper presents the idea of a baby monitoring system for toddlers so that they can properly be cared and monitored. This monitor includes motion sensors, sound, and cry detection mechanism. It gives the output as video which is displayed on the monitor so that parents can view it when they are far away from baby. it gives an easier and convenient way of monitoring the babies for busy parents. The hardware module includes raspberry pi module and PIR sensor to detect positions, condenser mic and pi camera for baby sound.

[6] While babies are kept in the nurseries, they are monitored for their basic vitals so the cry detecting mechanism is also included in this system to improve the quality of health care for babies. The hardware module includes (DSP) chip TMS320DM643 and multimedia audio codec chip TLC320AIC23B, which are used for real time recognition of baby's crying. After the baby's crying signal is gathered by the pickups, it will be handled by the sound decoder chip and afterward sent it to the DSP chip where it will be pre-processed and removed for the characteristic's boundaries by advanced autocorrelation work calculation. It will be perceived precisely by the strategy for dynamic time regular (DTW), and afterward the outcomes are shipped off the host PC through the sequential port. It is demonstrated that the exactness of the child crying state can be perceived as high as 97.1%, this study is vital in the field of baby care.

[7] As individuals, we start interfacing with the world by communicating our fundamental requirements through crying. Guardians endeavor to distinguish and ideally locate these necessities before crazy crying sets in. However, first-time guardians generally come up short, and this prompts dissatisfaction and sensations of vulnerability. In this unique circumstance, our work centers around making a programmed framework ready to recognize different newborn child needs founded on crying. We remove different arrangements of paralinguistic highlights from the child cry sound signs and we train different rule-based or factual classifiers. We assess and top to bottom contrast the outcomes and acquire up with 70% precise to the assessment dataset.

[8] Body temperature of the child is significant component that will inform the correct ailment regarding a child. Guardians and parents are not mindful of exceptional expansion in body temperature in a shorter time frame and febrile seizure might happen that could prompt epilepsy. In Malaysia, gadget that could screen the newborn child internal heat level's is now accessible. Nonetheless, the gadget couldn't consistently be utilized for an extended periods of time and make inconvenience to the children because of its size of gadgets. In this way, a little, lightweight gadget that persistently screens the internal heat level and serenely utilized by child is created. It straightforwardly helps guardians by cautioning them at whatever point the child's internal heat level expanded higher than typical a degree. This framework screens the vital parameter which is the internal heat level by utilizing a wearable sensor. The data then, at that point, moved to the parents through a remote network. The framework is stretched out for communicating with the cell phones to empower remote checking. Design of the framework comprises of a wearable sensor for observing the crucial boundary and a sound ringer where the part be all constrained by a solitary microcontroller, the ESPressoLite V2.0 in view of ESP8266 and provided by the lithium particle polymer battery. Even though the framework is seriously zeroing in on temperature monitoring only but, it very well may be additionally extended or move up to screen other crucial vitals, for example, pulse, oxygen immersion, breath rate or some other boundary.

The paper in [9] proposed a baby cradle system with sound cancellation mechanism. It reduces the noise pollution and relaxes the baby by using lullabies. This system can also

adjust the room’s light according to baby’s comfort. It also includes certain features such as it uses IOT network to monitor the baby for real time monitoring and supports vision using camera.

A system named “E-Cradle” was introduced by Goyal and Kumar [10] which uses cry detection mechanism to detect the crying of the baby and starts swinging. The other mechanism is the wetting mechanism which generates the alarm. The swinging mechanism was automated and can be controlled and notifies the parents in case when baby starts crying. It uses a buzzer alarm to notify the parents when they are near the cradle and babies can not be monitored when parents are away, and the alarm can frighten the baby.

[11] proposes another baby monitoring system which is similar to [10] and includes both cry detection mechanism and wetting mechanism and generates an alarm when the baby starts crying or when the mattress is wet. It uses a video camera above the cradle to record the baby. It notifies the parents via text message.

Another system was proposed by [12] which used Arduino to detect the infant crying. Single row design was opted for this system to control the damping mechanism and introduces swinging mechanism when the crying is detected. This system is an energy saving device since it does not use electricity to swing the cradle and records everything and stores it on SD card. This system does not allow parents to monitor their child when they are away and also the data does not update the data for future analysis.

In [13], Kaur and Jasuja proposed a framework that can screen the heart beat rate and internal heat level of the individual. Devoted sensors are set alongside Raspberry Pi and IoT is used to screen the ailment and store the got information to Bluemix cloud. The information put away are shipped off a specialist for analysis and to recognize irregularities. The KG011 sensor is utilized to quantify the pulse, and the DS18B20 sensor is utilized to gauge the temperature. However, this framework is unacceptable for babies, on the grounds that their bodies' invulnerable framework is more fragile than that of grown-ups. This wearable framework could produce some radiation that could hurt the babies and cause a few incidental effects.

Saadatian et al. [14] proposed a versatile mobile based framework that updates guardians about the newborn children's status. The framework estimates the temperature, movement, and pulse, and afterward sends the information to a server to be examined. The broke down information will then be shipped off the guardians and produce alert assuming any irregularity is found. The guardians will get a warning medical aid data for guaranteed activity, and a close by center will be told by the framework. The framework was tried on grown-ups during the model stage by gathering information for investigation. The created framework involves Bluetooth as a correspondence innovation, which is restricted in reach and information rate. Such a framework is just material for brief distance child gadgets. The framework doesn't uphold the IoT arrangement, controller, and vision checking as in our proposed framework.

In [15], a checking framework was created for a hatchery. A heartbeat sensor is joined to a baby to quantify the newborn child's heartbeat rate, and a humidity sensor is utilized to gauge the humidity level. The recorded information will be shipped off the PC through Arduino microcontroller, where the information can be alluded by the Neonatal Intensive Care Unit (NICU) faculty for indicative purposes. A caution framework is intended to send a caution at whatever point the information readings arrive at a risky level to forestall the event of a perilous circumstance. However, the information recorded were just moved straightforwardly to the PC. This approach can be improved by adding a Wi-Fi module to send information through the web to screen the newborn children's circumstances anyplace and whenever.

Reference [16] introduced an ARM embedded project for child monitoring. The creator proposed a framework comprising of embedded framework with a Linux kernel, CMOS picture sensor, and control framework. The framework is utilized to screen the child's exercises and room climate through an internet browser. On the off chance that the framework recognizes a child's cry, it will caution the guardians by communicating the sound signal to the guardians' room. The newborn child's internal heat level is estimated by a TMP75 temperature sensor along with a remote module to send temperature readings to the module. A bi-directional triode thyristor is utilized as power regulation part in light control unit. A LCD show module is utilized to show the deliberate readings. This

undertaking can be further developed by planning a support introduced with control framework, which would permit the support to swing all alone when the child cries.

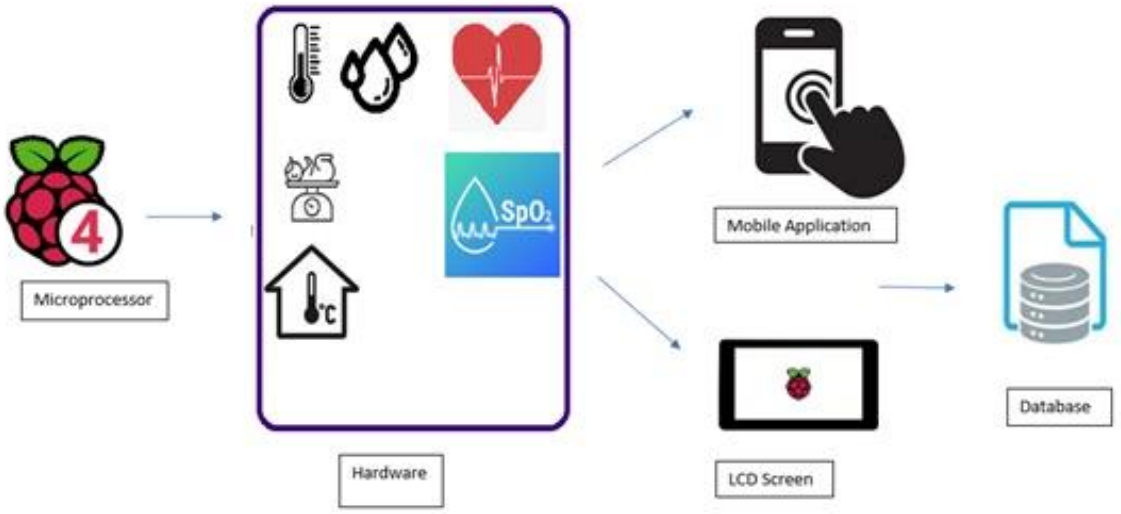

Figure 7: System level diagram

Chapter 3: Related Products and Therapies

3.1Related Products

Arduino Based Infant Monitoring System

The research paper presents a system to monitor infants in an incubator and record related data into a computer. The NICU staff can then view the data collected by the system. The study involved the design of a monitoring system consisting of an incubator equipped with a humidity sensor to measure humidity levels and a pulse sensor that could be attached to an infant placed inside the incubator. to monitor the child's heart rate. The result of the measurement is the pulse rate and humidity level sent to the PC via the Arduino microcontroller. This allows doctors to closely monitor the infant's condition via the local network.

Infant Monitoring System Using Multiple Sensors

This research paper has proposed a wireless Bluetooth approach for infant monitoring system using multiple sensors. Each sensor can be connected to the processing board via a wireless module, and the multi-sensor system can be deployed on a child's mattress to measure temperature, or even in a child's clothing to pulse and heart rate measurements.

An Automated Baby Monitoring System

The child monitoring system ensures safety by monitoring its location at all times and it also reads data from respected sensors i.e. force sensor, temperature sensor and sound sensor. The data read by the sensors is processed by the Raspberry PI and if abnormal values are found, the PI camera will take pictures and alert the parents via mail and the resulting images will be processed and analyzed. by CNN to predict the baby's position at birth. using a predefined template. The data will also be updated in the cloud.

REWEBA

Remote Well Baby (REWEBA) is an early warning device that digitally monitors and provides data on a child's respiratory rate, mass index and skin-related indicators for doctors to take timely

action. It integrates machine learning, IoT, analytics, and other technologies to provide state-of-the-art newborn screening, mirroring the hospital postnatal screening process.

“Infant mortality is highest in Sub-Saharan Africa, exposing a shortfall in healthcare services. REWEBA is the unique remote healthcare system that allows parents to watch their children’s growth from the comfort of their own homes while simultaneously offering doctors direct access to intervene quickly,” Khushi Gupta (one of the team members) said.

Figure 8: REWEBA Project

Sudden infant death syndrome detector

The system includes an optoelectronic transceiver and electronic circuitry capable of detecting the infant's breathing, heart rate and other movements. Includes an active alarm circuit. When the body is not active or breathing, the alarm will prompt the child to wake up. If there is no response, an audiovisual alarm will be triggered.

MonBaby Baby Breathing, Body Movement & Temperature Monitor

MonBaby is a popular choice among parents on a budget. The device latches onto your baby's clothes so you read breathing patterns and know when your baby rolls over, what to trigger an alarm.

Parents say this monitor is a good value for money and is easy and convenient to use with your smartphone. However, there are a few limitations. For example, the battery life is only about 10 days (there is a slightly more rechargeable version, however), and the Bluetooth connection can be quite weak. Meanwhile, our solution only depends on WiFi and direct power is provided to avoid any inconvenience.

Figure 9: MonBaby Application

Figure 10: MonBaby Device

Wellue BabyO2 Baby Oxygen Monitor

The Wellue Baby02 package offers the same monitoring capabilities as other systems, but for half the price. You can monitor your baby's oxygen level and heart rate using a combination of a device that wraps around your baby's feet and legs. It includes an application, as well as computer software if you need to print and share data with your doctor for any reason. However, reviewers mention that skin temperature can affect readings. For example, many people say that if their child's feet are cold, the screen won't read well. Others shared how the device connects to the baby, leaving it vulnerable to being moved around and giving false alarms. Also in this case our system is responsible for displaying not only the baby's body temperature but also the ambient temperature so that false notifications are not sent to the app.

Figure 11: Wellu Device

All of the above suggested studies and devices are mainly used for single problems, but none provide a universal solution for SUIDs, hypothermia and malnutrition. Our system meets those requirements and provides the right solution.

Table 1: Researches on related products

	Features and Characteristics							
System name	**Live Video/Audio Streaming**	**Audio Record**	**Temp & Humidity**	**Awake / sleep**	**Cry Detection**	**Arabic Lang.**	**Mobile Appl.**	**Heartbeat**
Research 1: Knight's Wireless Baby Monitor [2014]	Yes	Playing only	Temperature for baby Not for Room	Sleep only	No	No	Yes	Yes
Research 2: Integrity Baby Monitoring System [2014]	Audio only	Yes		No	Yes	No	Screen only	Yes
Research 3: Baby Monitoring System (Middle East Technical University) [2016]				only			es	Yes
Research 4: Infant Monitoring System using Multiple Sensors [2016]	No	Yes	V	Yes	Yes	Yes	Yes	Yes
Research 5: Automated Child Monitoring	Yes	Yes	No	No	Yes	Yes	Website	Yes

System [2016]								
Research 6: Advanced Baby Monitor [2017]	Video only	Yes	Yes	Sleep only	Sound only	Yes	Yes	Yes
Research 7: Arduino Based Infant Monitoring System [2017]	No	Yes	Humidity only	Yes	Yes	Yes	PC	Yes
Research 8: A Real-Time Infant Health Monitoring System for tough Hearing Parents [2017]	No	Yes	Yes	Yes	Sound only	No	Smart watch	No

Chapter 4: Cribby – IOT Based Crib for Infants

4.1 Internet of Things (IOT)

The Internet of Things (IOT) refers to the network of physical objects that are connected with sensors and other technologies to exchange data with devices over the internet. IOT includes many devices from simple household to industrial and it is growing at a greater rate. A forecast states that by 2025, 75 billion IoT devices worldwide will be available and wirelessly connected to the Internet.

Internet of things (IOT) forms the fundamental basis of the entire working of the system. Following are the salient features of the technology

- Connectivity between different sensors and modules using Wi-Fi
- Can easily be scaled up and scaled down
- Dynamic nature which leads to making business decisions
- Integrating different mechanisms and models to work together
- Real time analyzing of data
- Perform autonomous functions

In this study, IoT is integrated into our baby monitoring system to achieve a rapid response time and to provide a greater sense of security for parents

4.2 Hardware

The hardware portion of the device consists of wooden box containing the PCB circuit, sensor for the basic vitals, an LCD screen which will be installed on the crib and load cells attached between two wooden board and placed beneath the mattress to measure the weight of the baby.

Crib Design

The design of the crib went through a few cycles of planning and testing. The testing depended on simplicity of assembling and usability principal for fast prototyping and client testing to acquire criticism and modify plans rapidly and effectively.

Figure 12: 3D Model of Crib

Assembly Design

The primary function of the internal hardware is to use IOT to connect different sensors and send their data to a central server. Due to the non-availability and unsuitable specifications of existing systems a custom design was made and fabricated.

The entire assembly consists of PCB circuit on which the sensors are mounted, LCD screen which is installed on the crib to show the vitals and the insulated sensors that will be attached to the infant's body to measure the vitals. The sensors are connected to raspberry pi which basically gets the data of all the sensors and transfer it to the lcd screen and to the database.

4.3 Software

The system also includes a real time data driven android mobile application. The application contains a login sign up page for the doctors and it also includes the dashboard which shows the data of the sensors on it. It also includes a service in which it alarms the doctors whenever there is any ambiguity in the sensors data by sending a notification on the mobile phone.

Firebase

The firebase is a real time database that is cloud hosted and it stores and syncs data between users in real time. Firebase is a backend development tool for applications. The data is stored as a JSON file and is sent to the application. Whenever a user signs in to the application, a

unique user id is obtained and stores the data related to that user and sends it to the application.

Figure 13: Client to Firebase

Mobile Application

The mobile application shows the data of the sensors to the user. The various features of the application and use cases are described below:

Sign-up Screen

Sign-up screen registers the user through email ID and stores it in Firebase for Log-in evaluation.

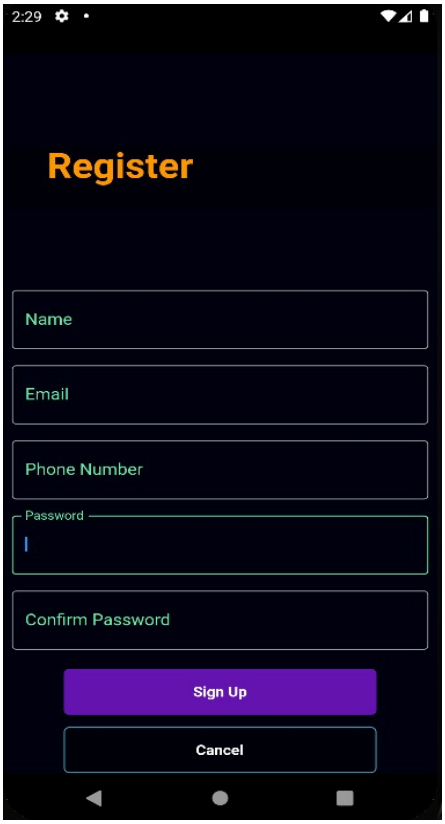

Figure 14: Mobile app sign-up screen

Login Screen

The login screen is the first screen which is showed when the application is started. It prompts the user to either sign-in with if the person is an existing user or new to the platform.

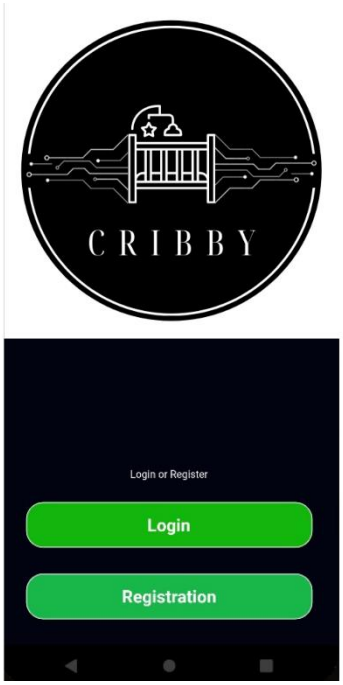

Figure 15:Mobile app main screen

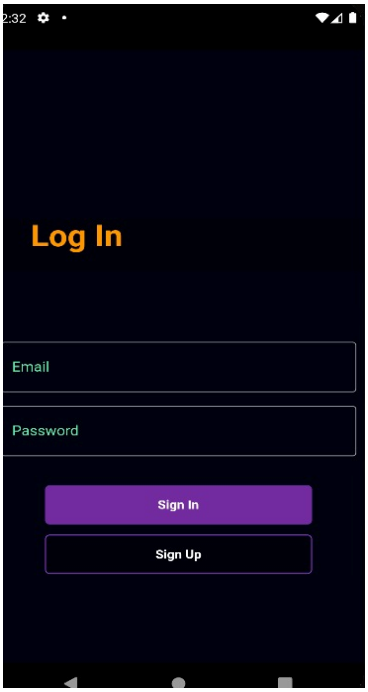

Figure 16:Mobile app sign-in screen

Home Screen

The home screen is where a user is taken after sign in. It is basically the dashboard that shows the data of all the sensors. Being the first screen that a user sees upon sign in it is visually pleasing and contains the necessary information that is required such as the Body temperature, humidity, weight, heart rate and saturation rate.

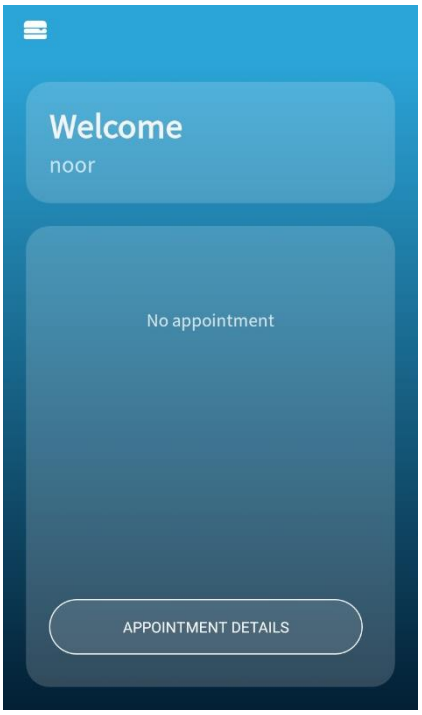

Figure 17: Mobile app home screen

4.4 Tools and Components Used

Hardware Components

The internal hardware components of the device make up the circuitry responsible for the data to be sent to the database and to the application for monitoring the infant. Additionally, the Wi-fi communication of the device with the mobile application is also handled here. Following are the hardware / electronic components used in the device:

Raspberry Pi Module 4

Raspberry Pi 4 Model B is the most recent item in the business. It offers historic speeds up, interactive media execution, memory, and availability contrasted with the earlier age, while holding in reverse similarity and comparative power utilization. The double band remote LAN and Bluetooth have secluded consistence confirmation, permitting the load

up to be planned into finished results with essentially decreased consistence testing, working on both expense and time to showcase.

This item's key elements incorporate a superior execution and includes:

- 64-bit quad-center processor,
- equipment video unravel at up to 4Kp60,
- up to 4GB of RAM,
- double band 2.4/5.0 GHz remote LAN,
- Bluetooth 5.0, Gigabit Ethernet,
- USB3.0

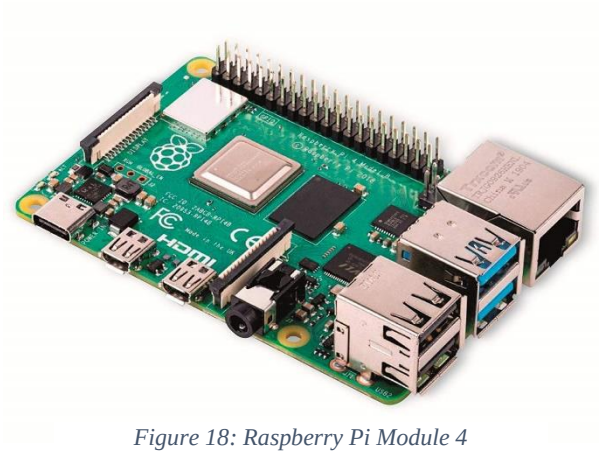

Figure 18: Raspberry Pi Module 4

DHT22 Temperature and Humidity Sensor

- Operating Voltage: 3.5V to 5.5V
- Operating current: 0.3mA (measuring) 60uA (standby)
- Output: Serial data
- Temperature Range: -40°C to 80°C
- Humidity Range: 0% to 100%
- Resolution: Temperature and Humidity both are 16-bit
- Accuracy: ±0.5°C and ±1%

The DHT22 is a regularly utilized Temperature and moistness sensor. The sensor accompanies a devoted NTC to quantify temperature and a 8-digit microcontroller to yield the upsides of temperature and mugginess as sequential information. The sensor is likewise production line aligned and consequently simple to communicate with other microcontrollers.

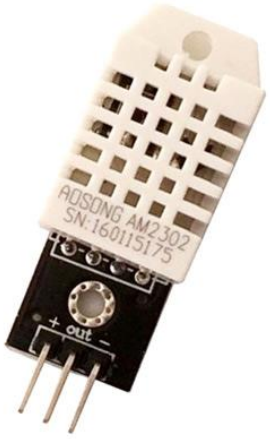

Figure 19: DHT22 Temperature and Humidity Sensor

DS18B20 Temperature Sensor

- Programmable Digital Temperature Sensor
- Communicates using 1-Wire method
- Operating voltage: 3V to 5V
- Temperature Range: -55°C to +125°C
- Accuracy: ±0.5°C
- Output Resolution: 9-bit to 12-bit (programmable)
- Unique 64-bit address enables multiplexing
- Conversion time: 750ms at 12-bit
- Programmable alarm options
- Available as To-92, SOP and even as a waterproof sensor

The DS18B20 is a 1-wire programmable Temperature sensor from maxim integrated. It is broadly used to gauge temperature in hard conditions like in substance arrangements, mines or soil and so forth. The choking of the sensor is rough and furthermore can be bought with a

waterproof choice making the mounting system simple. Every sensor has a novel location and requires just a single pin of the MCU to move information so it a generally excellent decision for estimating temperature at different focuses without compromising a lot of your computerized pins on the microcontroller.

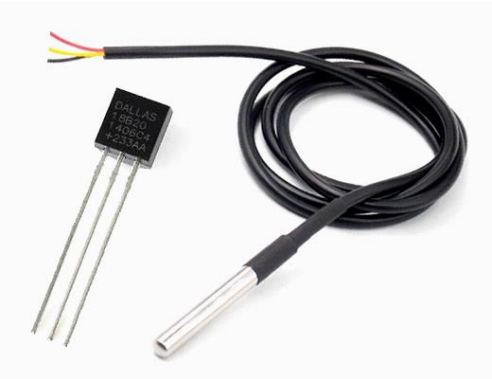

Figure 20: DS18B20 Temperature Sensor

MAX30100 Pulse Rate and Saturation Rate Sensor

The MAX30100 is an integrated pulse oximetry and heartrate monitor sensor solution. It combines two LEDs, a photodetector, optimized optics, and low-noise analog signal processing to detect pulse oximetry and heart-rate signals.

- Operating Voltage: 1.8v – 5.5v
- Interface Type: I2C Serial Interface
- Module Dimensions: 18.8mm (L) x 14.4mm (W) x 3.0mm (H)
- Module Weight: 1.2g (Header + module)

Figure 21: MAX30100

HX711 Amplifier

- Differential input voltage: ±40mV (Full-scale differential input voltage ±40mV)
- Data accuracy: 24 bit (24 bit A / D converter chip.)
- Refresh frequency: 10/80 Hz
- Operating Voltage: 2.7V to 5VDC
- Operating current: <10 mA
- Size: 24x16mm

This module uses 24 high precision A/D converter chip HX711. It is a specially designed for the high precision electronic scale design, with two analog input channels, the internal integration of 128 times the programmable gain amplifier. The input circuit can be configured to provide a bridge type pressure bridge (such as pressure, weighing sensor mode), is of high precision, low cost is an ideal sampling front-end module.

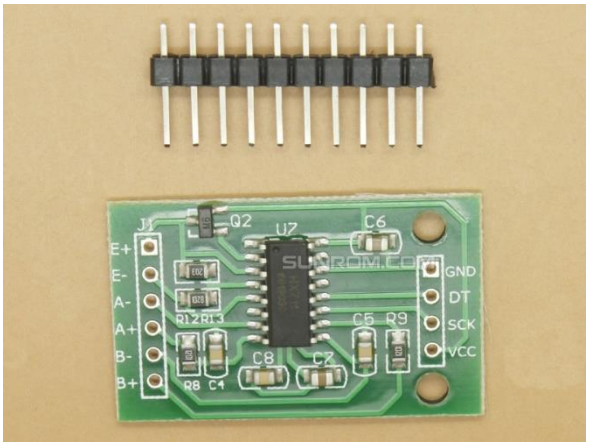

Figure 22: HX711 Amplifier

Load Cells

Load cells are a component used in scales and weighing systems, and are the sensor that detects the weight of the object on the scale or in the system.

Load cells are used for any application that involves weighing. Load cells are used as a component of scales including bench scales, floor scales, truck scales and more. Load cells are also used to turn structures into scales – such as tank scales used for tank weighing.

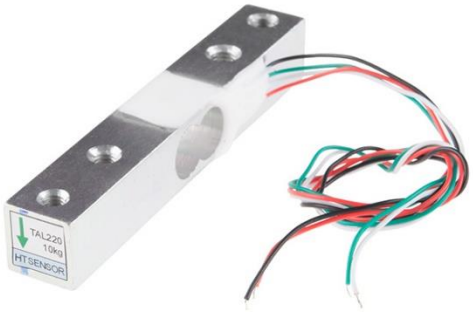

Figure 23: Load Cell (10kg)

Model	SSC-ICA2H
Supply Voltage:	8.5-28 VDC
Operating Current:	23mA
Output Signal:	0.1-5.1 VDC
Linearity	0.02% of Full Scale
Bandwidth	DC to 1 ,000 Hz
Bridge Excitation	5VDC

Figure 24: Load Cell Specification

Raspberry Pi LCD Screen

Raspberry Pi OS provides touchscreen drivers with support for ten-finger touch and an on-screen keyboard, giving you full functionality without the need to connect a keyboard or mouse.

The 800 x 480 display connects to Raspberry Pi via an adapter board that handles power and signal conversion. Only two connections to your Raspberry Pi are required: power from the GPIO port, and a ribbon cable that connects to the DSI port on all Raspberry Pi computers except for the Raspberry Pi Zero line.

Display size (diagonal): 7 inches

Display format: 800 (RGB) × 480 pixels

Active area: 154.08mm × 85.92mm

Touch panel: True multi-touch capacitive touch panel with up to 10 points of absolution

Figure 25: Raspberry Pi LCD Screen

Software Tools Used

The software tools used were primarily for developing the mobile application and programming the hardware along with a backend cloud database system. 3D modelling of the enclosure was also done via software tools as described below:

Proteus

Proteus is a Virtual System Modeling and circuit recreation application. The suite joins blended mode SPICE circuit recreation, enlivened parts and microchip models to work with co-reproduction of complete microcontroller based plans. Proteus likewise can reenact the communication between programming running on a microcontroller and any simple or computerized gadgets associated with it.

Figure 26: Proteus IDE

Visual Studio Code

Visual Studio Code is an open source text editor and developing tool made by Microsoft. It has rich functionality and can be configured to create a developing environment for all any types of applications and coding. It has support for debugging and also contains inbuilt Git support along with syntax highlighting and Intellisense.

Figure 17: Visual Studio Code logo

Thonny

Thonny is another IDE (incorporated improvement climate) packaged with the most recent form of the Raspbian with PIXEL working framework. Utilizing Thonny, it's presently a lot more straightforward to figure out how to code. Thonny accompanies Python 3.6 underlying, so you don't have to introduce anything

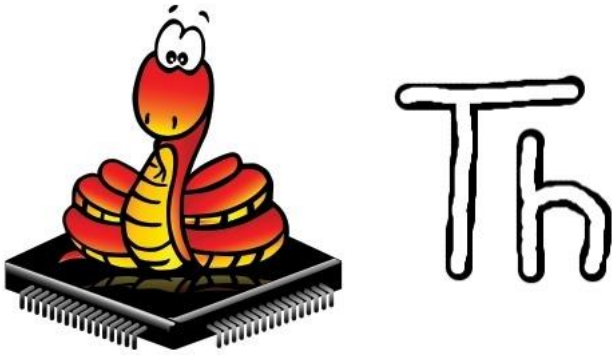

Figure 28: Thonny Logo

Firebase

The firebase is a real time database that is cloud hosted and it stores and syncs data between users in real time. Firebase is a backend development tool for applications. The data is stored as a json file and is sent to the application. Whenever a user signs in to the application, a unique user id is obtained and stores the data related to that user and sends it to the application

Figure 29: Firebase logo

PyQT5

PyQt is broadly utilized for making enormous scope GUI-based programs. It gives developers their preferred opportunity to make GUIs while likewise giving a ton of good pre-fabricated plans. PyQT gives you gadgets to make complex GUIs.

Figure 30: PyQT5 Logo

Blender

Blender is a free and open-source 3D creation suite that upholds basically every part of 3D turn of events. With a solid groundwork of displaying capacities, there's likewise vigorous finishing, fixing, movement, lighting, and a large group of different devices for complete 3D creation. This product is extraordinary whether you need to manage static models or get into the universe of movement.

Figure 31: Blender Logo

4.5 Product Trials

Product trials are necessary for the validation of any medical system. Product trials are experiments or observations done in research. This helps to generate data on safety and efficacy of the system. Product trials and their results are also key to getting the device approved from governmental regulatory authorities. Such trials enable us to develop a close looped system where validation is essential.

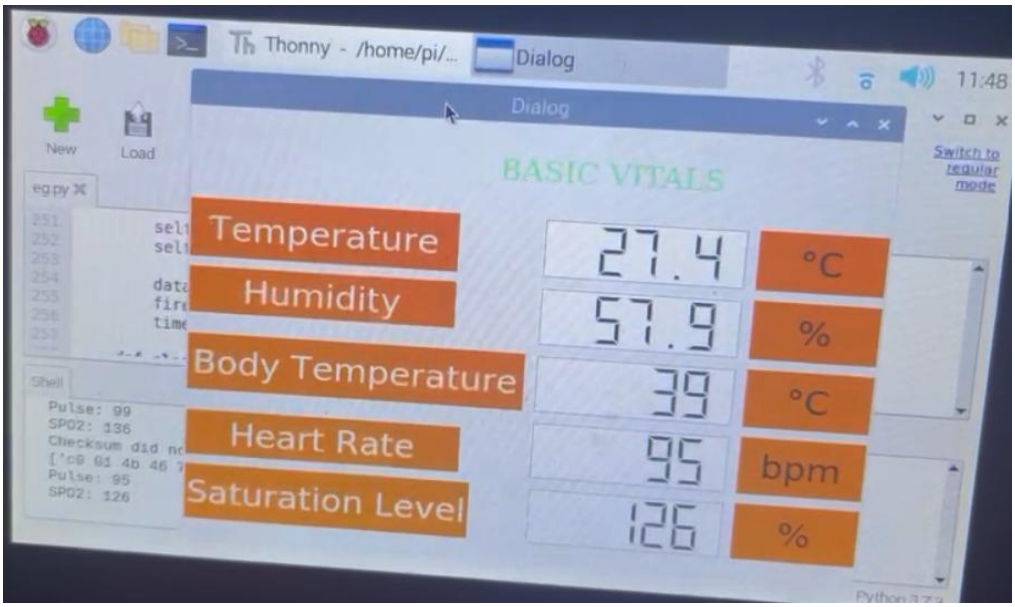

Figure 32: PyQT5 GUI on LCD

At the current moment, we are conducting product trials on adults to do the initial testing of sensors, the GUI testing of LCD screen and the application testing. The future testing will be done on the infants and the feedback from them will help us determine usability issues and design problems while also enabling us to get data regarding their treatment and develop a better knowledge base.

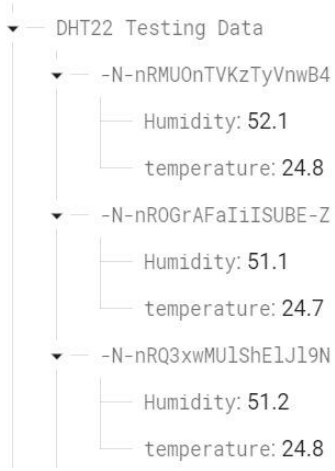

Figure 33: DHT22 readings stored in Firebase

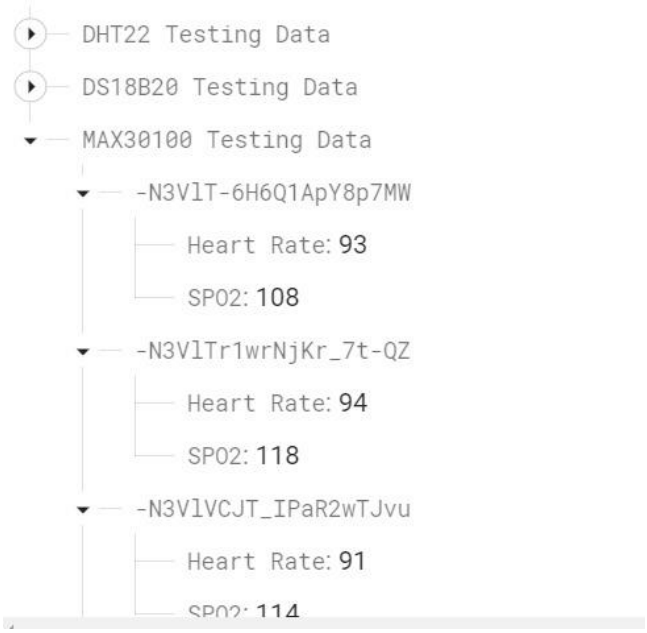

Figure 34: MAX30100 readings stored in Firebase

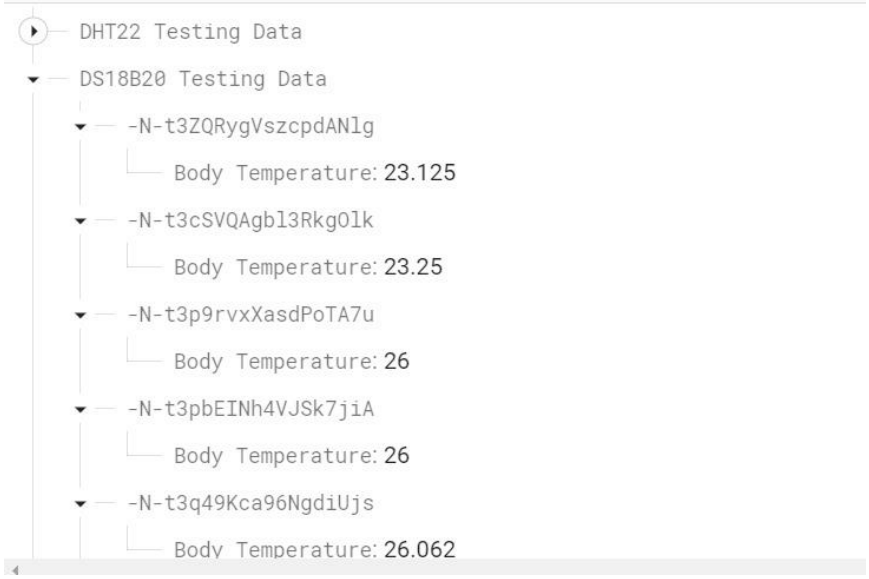

Figure 35: DS18B20 readings stored in Firebase

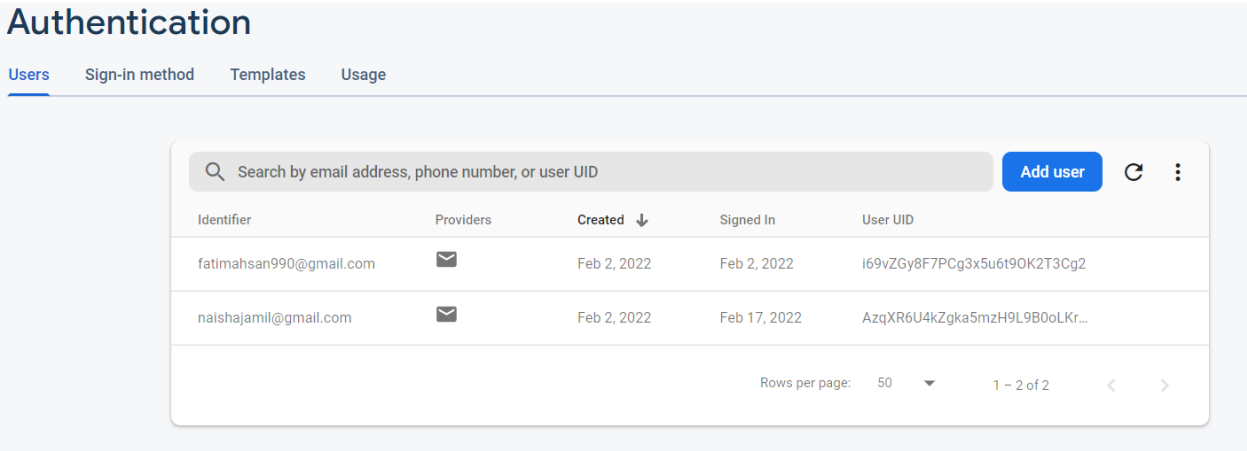

Figure 36: User registration stored in Firebase

Chapter 5: Market Analysis

Marketing any project requires a comprehensive market analysis, based on which a business plan is established. The primary goal is to determine that there is, in fact, a market where it is a marketable device and there will be enough demand to generate adequate profits to support a business that can grow in the long term and invest in research and development. Moreover, it helps to identify not only the need but also the demand for the equipment.

Market Size

Not only in Pakistan, but around the world, people need something easy to use to make their lives easier. The market size for our products is huge because many people can be targeted. This will avoid manual labor in the hospital to collect data from individual infants, i.e., data collection after certain time periods. Moreover, our solution is less expensive than other products on the market and it will be in great demand in daycare centers as well for child monitoring.

5.1 Business Model

The business model is the base of a start-up business. It is the guiding document for the initial years of operations and strategic decisions of a company. It is a plan for the proper functioning of a business, identifying revenue sources, target customers, products, and financial details. Since, it is a lengthy document it cannot be included in this report.

5.2 SWOT Analysis

SWOT analysis helps businesses analyze strengths, weaknesses, opportunities and threats. Having oversight of these allows a business to succeed in the market and become a better competitor. Our SWOT analysis shows that although we have existing threats and weaknesses, the opportunity at hand is too good to ignore. A largely untapped market, a troubled population as well as completed research provide us with the perfect foundation for success.

Strengths +	Weaknesses –
• Have Industry partners	• Lack of marketing experience

(RiseTech) • Completed research and presently in prototyping stage	• Customer trust • Other competitors
Opportunities + • Local neglected target market other solutions can be relatively expensive • Market needs this service	Threats – • Existing businesses may start entering the market • Customer response may not be optimal

Table 2: SWOT analysis

Chapter 6: Conclusion and Future Prospects

6.1 Conclusion

The project developed a baby monitoring system based on IOT. An android mobile application was also developed to show the data to the user and notifies the user whenever there is any ambiguity. The device manufacturing and designing was carried out all the way from inception to prototyping to β-testing. The targets of the task set toward the beginning have subsequently been met and are expressed underneath:

- An IOT based child observing framework for emergency clinics and childcares with an assembling cost of roughly 20,000 PKR
- An android versatile application which will act as a child MONITORING framework
- A LCD screen which is introduced on the lodging to show the fundamental vitals

6.2 Future Prospects

The project has great prospects in the future. As a complete product there are multiple new ways to make it even better and provide more development work. Many of the planned improvements could not be implemented due to time constraints. We hope that these recommendations will be taken with a positive outlook and will be worked on with great zeal.

One possible addition is the installation of camera on the crib that will be used to monitor the baby's position. It will record the surrounding of the baby and sends the video output to the user.

Another possible addition can be the use AI to determine the height of the baby using the camera module to detect malnutrition in the baby.

Furthermore, there is currently no data available of such babies who dies because of SIDS, hypothermia and malnutrition and their growth is not monitored in Pakistan and if we gain mass adoption then we will have the first database of such people and can gain profit from that data by either selling it or providing consultancy services.
Another Addition in the application is that it will tell the location of the nearby hospitals in case there is any ambiguity is faced in the daycare centres.

Appendix A

Hardware Evolution

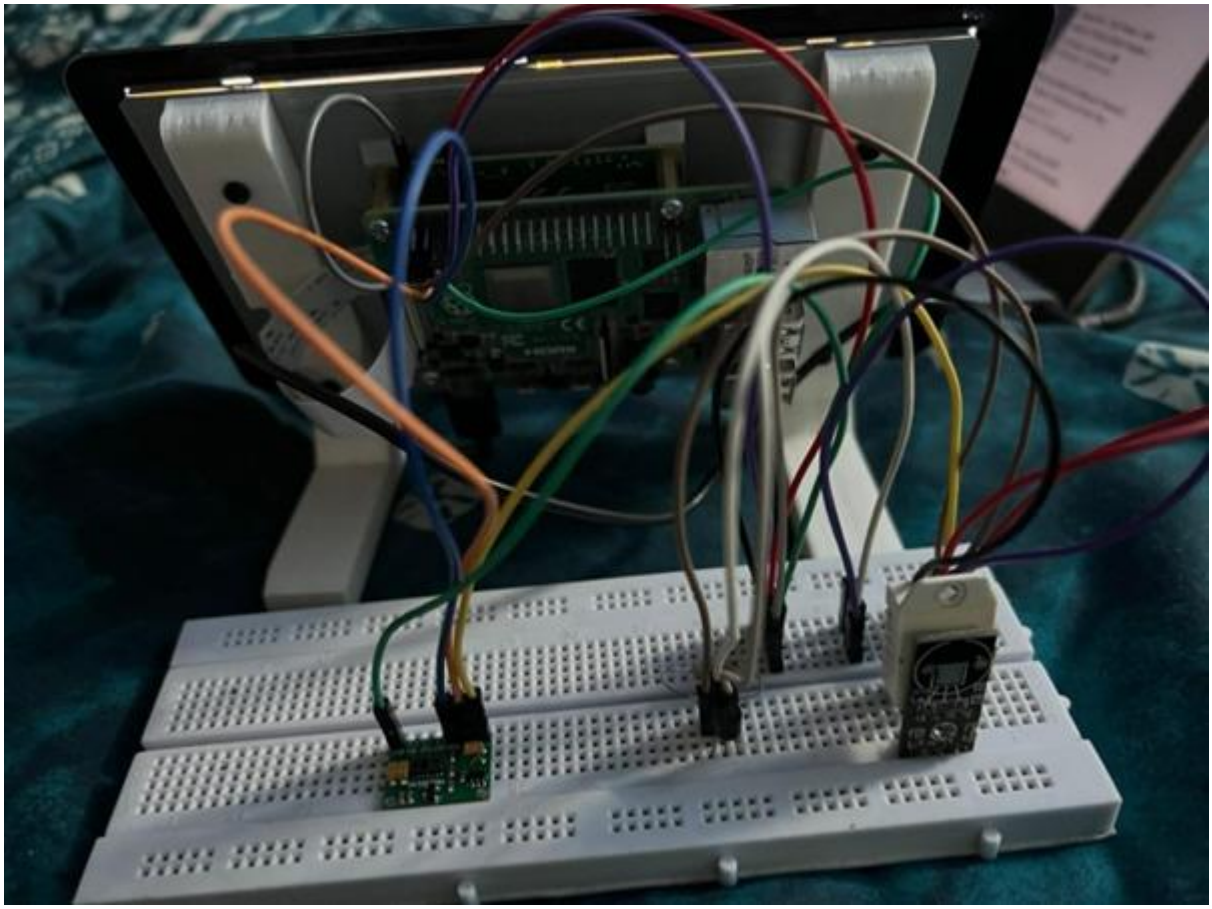

Figure 37: Initial hardware prototype

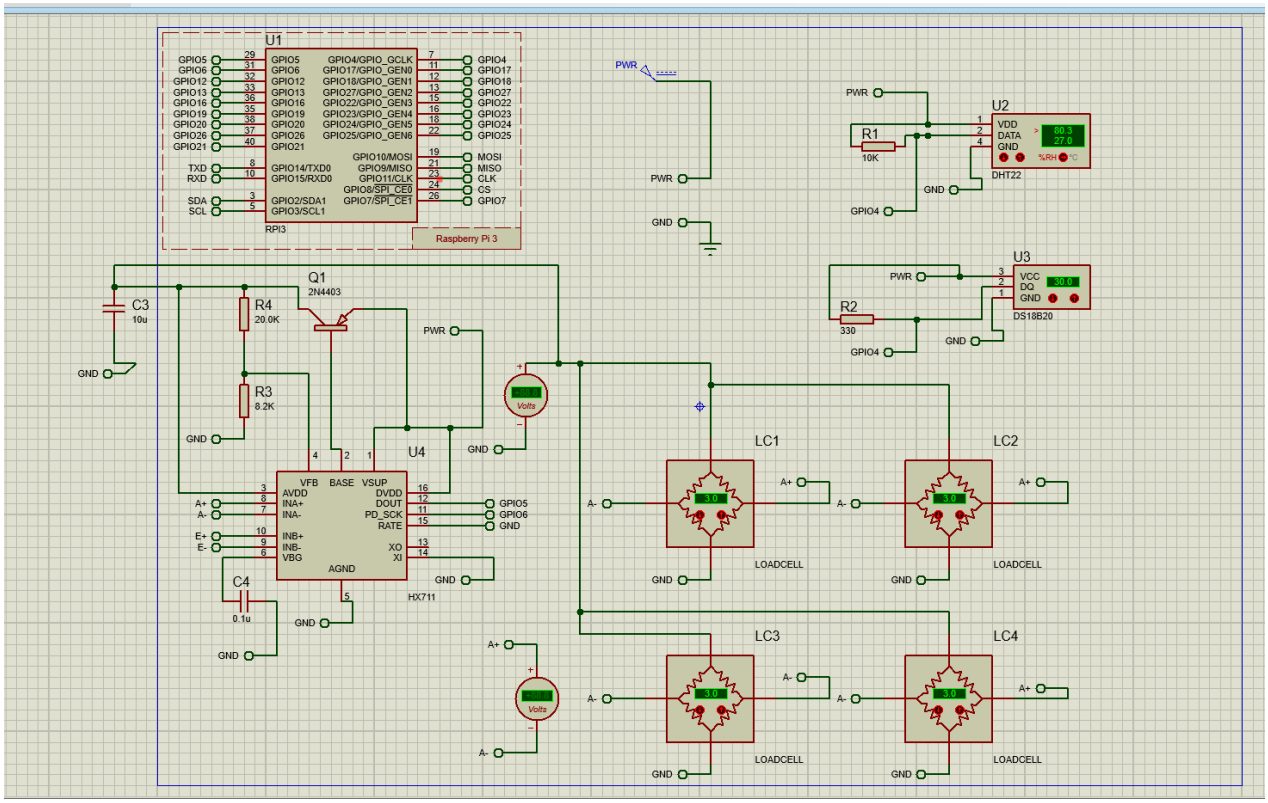

Figure 38: Circuit diagram

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