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IOT Embedded Sensor based Cloud Agent System for Sudden Infant Death Syndrome Monitoring and Analysis using Machine Learning

Talasila Bhanuteja[1], Puligundla Puneeth[2], Poonati Anudeep[3], Chennupati Ashish[4], Avulapati Anusha[5]
[1,2,3,4,5] Undergraduate Students
School of Computer Science and Engineering
VIT University
Vellore, Tamilnadu, India.

***Abstract*—During the beginning phases, newborn children need legitimate rest and rest for development and improvement. Subsequently, it is the obligation of the guardians/watchman to give the fundamental consideration and thoughtfulness regarding the baby. Be that as it may, with the cutting edge way of life, guardians are occupied and have a great deal of work with brief period to accommodate their little ones. In this day and age we see that the vast majority of the families comprise of for the most part the guardians and youngsters. At the point when a child is brought into the world in a family there must be somebody to take care of the child. A few guardians need to do a twofold errand of keeping a mind the child just as accomplish the family work. Keeping a caretaker could be a choice yet not all can manage the cost of babysitters and furthermore it is consistently hard for guardians to depend on certain aliens to take care of their child. So to help such guardians we have chosen to think of a keen support which will help a mother or a dad have a track of their kid and accomplish some family work all the while. The temperature and wetness sensor distinguishes the temperature and wetness of the child and in the event that it builds a specific level, hint message will be ship off the guardians. The beat sensor estimates the baby's heartbeat, the inhale sensor screens the newborn child's inhale and advise the suffocation, The Tilt sensor screens the newborn child's plane and the movement sensor distinguishes the unusual individual development close to the baby, additionally message is will be shipped off the guardians utilizing advanced mobile phones with the assistance of cloud server. Further the collected data will be analyzed using machine learning algorithms such as logistic regression and Random forest technique.**

Keywords*— *Temperature sensor, pulse sensor, activity sensor, sound sensor, MQTT protocol, Nodemcu, IOT, logistic regression, Random forest.

I INTRODUCTION

In the previous decade, baby death rate in India has increased significantly. The fundamental cause watched was Sudden Infant Death Syndrome. This was more regrettable for the situation of visually impaired and hard of hearing guardians as now and again numerous genuine or crucial indications of the newborn children left unnoticed. The essential concern was and to alarm crippled guardians and make it moderate for everyday citizens. Remote innovation means to caution them even in their nonattendance or that of a therapeutic delegate. The proposed framework is a skilled wellbeing checking framework for newborn children with remote correspondence. Sensors, for example, temperature sensor, beat sensor, and so on are being utilized to identify different medical problems of a newborn child at a beginning period by utilizing an IOT based wearable wellbeing observing framework which examinations certain parameters like temperature, beat rate, and so forth. IOT Based newborn child observing framework fills in as a compelling strategy for observing newborn children younger than 0 a year. It moves the deliberate estimations of various parameters got from the sensors over a remote system to the web cloud. Observing framework is intended to raise an alert if there should be an occurrence of a crisis and for guardians with inabilities, a vibration engine joined to their wrists creates a vibration in case of a crisis. The information from the cloud is utilized for additional investigation. The unexpected fall and increment in physiological parameters may cause Sudden Infants Death Syndrome (SIDS) and may prompt obviously perilous occasions. The small scale controller based equipment incorporates coordinated sensors which join tangible capacities in the wearable equipment making it fit for estimating the physiological parameters (temperature and heart pulsates) achieving the need of constant wellbeing checking. It will inform for the potential dangerous occasions. The equipment will have the option to yield the simple estimations of detected information which thus will be synchronized with cloud server by means of center product design. Wearable equipment will speak with center product design through remote correspondence. The essential information handling on the distributed storage will recognize the basic conditions just as will make reports. The last segment of the framework, for example versatile application is included with ongoing notice, alarms in the basic circumstance. It will show the constant wellbeing status. The wellbeing sensors bolsters for breaking down the contribution from the patient and the aftereffects of all the parameters are put away in the cloud database. In the cloud database both the patient subtleties and the specialist subtleties are put away. In the event that any irregularity felt by the patient signs will send to the restorative authorities and too the patients on the off chance that they need to have any proposals from the specialist they can have it

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II LITERATURE SURVEY

From the typical support to the programmed swing support, there are numerous sorts of the support. The utilization of child support came in when the security of the child was at risk.it would be progressively comfortable for an infant to rest in a support or in restriction which is uniquely made for them with additional sheet material, for example, covers or blankets. It was additionally adjusted in such a manner that they are versatile. Child rearing babies is a troublesome assignment in the underlying stages. It gets hard for guardians to comprehend the language of their babies yet child screens help to attempt to comprehend their newborn children by giving them with vitals so the guardians can comprehend the reason for uneasiness experienced by the infant. For the most part, when the guardians are not close by, the swinging movement assists infant with unwinding and take a short snooze. This was the reason programmed swinging support was created. It is one of the phenomenal guides that was extremely useful for child rearing which is economical and still in the advertise.

In [1] a support with a checking framework is utilized. In Baby checking utilizing reconnaissance the Smart infant screen that lets you track rest designs and other valuable information in a partner application. The optical long range focal point is a stick out highlight that includes flexibility.1080p and 720p survey is accessible. The accessible frameworks permit recording live recordings and hints of a baby. Cell phone applications enable a client to screen a camera-prepared gadget, for example, another cell phone or a tablet. On the other hand, Wi-Fi or Bluetooth can connect a camera to a committed application on a cell phone or tablet. This implies a keen gadget shouldn't be left in the infant's room. In an infant, screens give two-way correspondence which permits the parent to talk back to the infant (parent argue). This innovation furnishes a cooperation of the parent with the youngster when the parent is away from the kid. This framework incorporates reconnaissance frameworks moreover. Mohit Kumar, Mrs Suryakala talked about a customary way to deal with screen the newborn child incorporates steady observing of newborn child utilizing a web camera or keeping medical caretaker for the infant or utilizing sound checking. However, this framework gave genuine feelings of serenity to guardians when they were away from their newborn child as they can get the updates of the soundness of the infant. The essential part was that the correspondence was finished by utilizing a GSM interface in which Short Messaging Service (SMS). Mrudula Borkar, Neha Kenkre, Harshada Patke[2] expressed that glow is a significant parameter for the newborn child in an hatchery. The framework mostly centered on checking the ideal temperature of newborn child hatchery. The Arduino UNO is furthermore, the RF transmitter and beneficiary module were executed and sends the information from a microcontroller to the PC for better observing reason. N.A.A Hadi, M.H.C. Hasan, N.M.Z. Hashim, N.R.Mohamad, A.S. Rahimi, K.A.M. Annuar[5] expressed that the current prescribed strategy for giving newborn child temperature guideline in asset settings was Kangaroo Mother Care\ (KMC), the act of putting babies, legitimately onto the mother's chest. Suruthi, S. Suma [3] actualized by observing the temperature and heartbeat rate utilizing the suitable sensors. The accelerometer was utilized as the movement sensor. The GSM Modem interfaced with the microcontroller sends a ready SMS to the parent's portable number. Shijo Joseph Mathew, S. Mathankumar, S. Vaishnodevi [4] executed that the singlechip small scale controller read the encompassing temperature, quietude, breath alongside the sensor. All the worth was shown on LCD. Single chip miniaturized scale controller was utilized to break down all the three sensor information and any variety happened, an alarm was sent to guardians consequently. KMC has exhibited benefits as far as improved weight gain for preterm newborn children. In [6] utilized an Arduino Leonardo board in the framework structure alongside an internal heat level sensor, a sound location sensor, a finger heartbeat identifier, furthermore, a mugginess sensor. Notice of alert circumstances has been effectively given through a vibrating savvy, SMS, and LEDs (Light Emitting Diode) utilizing Arduino board and Android based applications. Faruk AKTAS, Emre KAVUS, Yunus KAVUS [7] examined about the temperature and heartbeat rate and furthermore depicts the structure of a very minimal effort remote child observing framework which estimates pulse and internal heat level of a baby and sends the information to a remote end where the information will be shown and guardians or overseers will have the option to look at him/her. It [8] expressed that the framework was to screen the parameters Like Light, breath, the Audio/voice of the infant that he/she was alright or crying. The Door was a parameter to give Intruder ringer with the goal that it gave a caution/Led sign assuming any individual entered in the spot/Room of infant by breaking the sensor. In [9] programmed swinging support, when the guardians are not close by, the swinging movement assists infant with unwinding and take a short rest. This was the reason programmed swinging support was created. It is one of the incredible guides that was extremely useful for child rearing which is modest and still in the showcase. This is the most utilized existing framework utilized these days. The support recognizes a crying infant utilizing the mic alongside the sign molding and the infant bassinet begins swinging with the assistance of an engine.

III SYSTEM OVERVIEW

Node MCU is the core of the framework. Hub MCU controls the entire framework. At the point when the child is conscious from the rest, at first the support swings with a smooth song with assistance of Speaker and engine individually. This may support the child to quit sobbing well into the night by and by. In any case, on the off chance that the child doesn't quit crying, the circumstance is informed to the parent. The framework goes backs to check the wetness and temperature esteem. On the off chance that there is an adjustment in the ordinary room Temperature, Humidity or Wet Sensor relating activities will be done. On the off chance that the Temperature has surpassed the ordinary room temperature quite possibly the infant may be feeling hot which is the main motivation behind why the infant may be crying. The DHT11 sensor quantifies the

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temperature and the message is transmitted to the hub MCU that informs cloud which thusly tells the parent. Essentially if the wetness is distinguished, the cloud tells the parent in the comparative way. As soon as the temperature detected by temperature sensor and wetness detected by wetness sensor raises above particular level, then intimation is sent to caretakers or parents in the form of message. The pulse sensor measures the infant's pulse, the breathe sensor monitors the infant's breathe and notify the suffocation, The Tilt sensor monitors the infant's plane and the motion sensor detects the abnormal person movement near the infant, cloud server is used to send the messages to the smart phones of parents. Before sending the messages to the smart phones of parents through cloud server, many conditions are checked. The microcontroller gets the three information sources - from the remote sensor, breathe enhancer module and the temperature sensor.

IV SYSTEM ARCHITECTURE

Child health monitoring system's architecture has both software and hardware components and its architecture is shown in Fig.(2) in the form of block diagram and each module mentioned in the block diagram are explained in detail below.

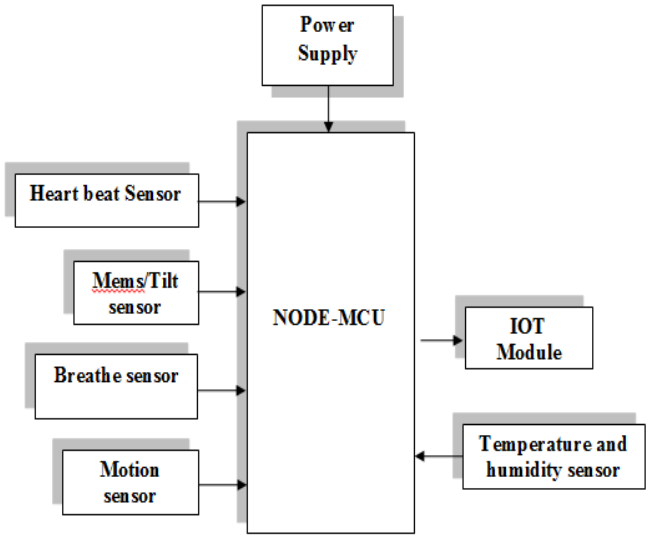

Fig-2.System Architecture

Child health monitoring system's architecture contains 4 important parts.

1. Sensor nodes- These are used to collect the important signals from child.
2. Computing system- Through this, signals are processed into interpretable data.
3. Display and alert unit- Display unit is used to display the reading processed from sensors. Alert unit is used to alert the parents by using buzzers if any unusual readings are absorbed.

4. Cloud computing is also the main part as it is used to for remote monitoring and wirelessly transmit the notifications to the mobile of the parent.

V HARDWARE

A. *NodeMCU:*

NodeMCU is mainly used in many IOT (Internet of Things) based applications as it contains in-built Wi-Fi, it is a microcontroller and is the most important hardware part in the application. It contains 1 analog pin, 11 digital pins, 1 data port and other pins for communication.

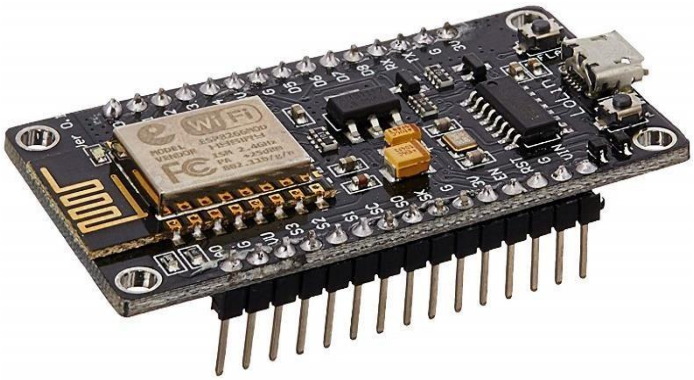

Fig-3. NodeMCU

Protocol like SPI, I2C, etc. NodeMCU is cost effective microcontroller which have made into hotspot and Wi-Fi based on the requirement. It can be almost every time peripherals like analog sensor, digital sensor, RFID reader, GSM, GPS, ZigBee, Bluetooth module, RF transmitter/receiver, LCD, Touch screen, OLED ad other device.

B. *sound sensor*:

Sound sensor is used to identify any variable sounds and sound power is also calculated. This method is used for many purposes like security, switch and many checking apps. The precision of it can also be changed based on the requirement. A mouthpiece is used to supply the contribution to an enhancer, top identifier and support. When a sound is recognized by the sensor, a signal voltage is formed and then it is sent to a microcontroller then performs vital handling.

C. DHT 11:

Sensor DHT11 electronic temperature and clamminess sensor is a composite Sensor contains a balanced propelled banner yield of the temperature and moistness. Use of a gave propelled modules gathering development and the temperature and wetness recognizing advancement, to make sure that it has high astounding long stretch security and unfaltering quality. Theis sensor combines a wet parts resistive sentiment and NTC temperature estimation contraptions, and related with a first class 8-piece microcontroller.

D. Pulse sensor:

Pulse Sensor is mainly used to get the readings of live heartbeat or heart-rate. The Pulse Sensor Amped is a fitting and-play sensor for Node MCU. It is used by many people like craftsmen, sportsmen, creators, and designers who need their heart-rate to be monitored continuously. The heartrate readings are quick and easily sensed as it has a basic optical pulse sensor or with enhancement and clamor undoing hardware. The voltage and current drawn is 5V and 4mA and hence it is used for many applications.

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E. PIR Sensor:

PIRs are mainly used to read the levels of infrared radiation as it contains pyro electric sensor. The infrared radiation is recognized by the sensor by a warm inquiry. A PIR sensor recognizes the infrared light radiated by a warm inquiry. It has the sensors namely pyro electric sensor that sense the temperature change caused by infrared radiation into electric banner. An electric charge is delivered when the infrared radiation hits the valuable stone. The closeness of people inside an area district of about 14 meters can be recognized using a PIR sensor.

F. *Android Application:*

It is important non-hardware component of the process, a custom made android app are used. These apps will let the user to control the signal, those apps will be given to driver of emergency vehicles in order to control the traffic light and other function of this app is used to take the picture of the traffic signal violator which is sensed by IR sensor used for monitoring.

G. Message Queuing Telemetry Transport (MQTT) protocol:

MQTT is a telemetry protocol standard, used for light weight hardware communication, mainly used in the M2M (machine-to- machine) communication. It is a publish-subscribe model i.e.; it publishes and subscribes to a given topic. Broker sends the information to the server. The data related to a topic subscribed by the client is also sent to the client by broker. It is mainly used when there is limited resources available in IoT devices. A resource constrained device is a small device with limited CPU memory and power resource. So to enable MQTT in the small device is possible that makes its compatible.

MQTT sessions divide into 4 stages:

- Connection
- Authentication
- Communication
- Termination

A TCP/IP connection between a client and broker is created, and that is when MQTT connection starts. Standard port (or) custom port is used. Careful observation or recognition is needed as the old session might continue in case reused client identity is provided. SSL/TLS are used by the standard ports, which is 1883 for non-encrypted communication and 8883 using for encrypted communication. Authentication of MQTT is presented to client as clear-text username and password and also by using SSL/TS server certificate. MQTT communication sends a message packet that contains Optional Variable header, fixed header, a 256MB of message payload and Quality of Service (QoS) level. There are three different Quality of Service in which more reliable is higher level of QoS but latency and bandwidth requirements is more. MQTT termination is disconnecting the MQTT connection properly; it gives ability to easily reconnect and resuming where it let off.

H. Data processing visualization using Losant:

Losant is a cloud platform that is designed for IOT in order to build more advanced connected solutions. It is a ready to use platform and is also very powerful. Open communication standards like REST and MQTT are used by it in order to transfer property from one to several other devices. Losant has the aggregation, powerful knowledge assortment, and mental image options to assist perceive and enhance sensing element knowledge. It has drag-and-drop option that helps you to make actions, sends notifications, and machine-to-machine communication takes place when programming is not performed. In order to know the several options Losant provides keenly, you can inspect the Losant Walkthrough that guides you through building an area of dashboard.

Losant's platform integrated cloud computing is an inbuilt smart functionality with in the platform that deploys the workflows to connected devices and then executes them on the device. It is different from other inbuilt functions and workflows present in Losant platform. Data is integrated using the losant API and then this sensor data that is collected is sent to firebase using that API and then the data is fetched for live algorithms processing and android application that analyzes the constraints that are faced by infant. Also possibility of any threats for the infant can also be predicted.

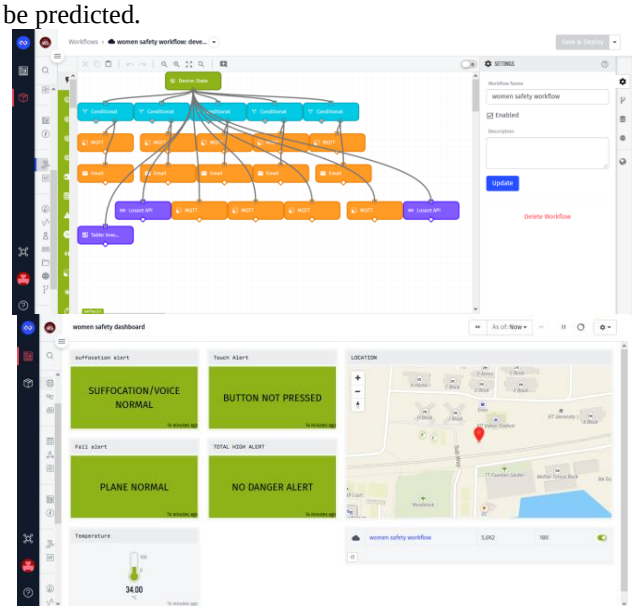

Fig-4. Losant workflow and Dashboard

I Applying Machine Learning Algorithm:

Machine learning is based on Artificial Intelligence. Machine learning algorithms train the data and learn and analyse data in order to predict the results or provide conclusions. No explicit program is needed. These algorithms mainly works on accessing data, analyzing the data, removing any false data if present and finally predicting results.

II Logistic regression:

Logistic regression is one of the machine learning technique which is used for statistical analysis of the sensor data in the form of binary classification methods, like the parameters which was obtained from the sensor is normal or abnormal, using the decision boundary technique we can predict the true and false data i.e abnormal or normal data, which can be differentiated in colors with predicted probability, the process involves the conversion of the input data to the binary output variable, removal of noise from the trained data by eliminating the misclassified data, applying the

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Gaussian distribution to obtain the linear relationship between the input and output variables removing correlated inputs ,removing the converge failed data's (i.e)removing lots of zeros.

III Random Forest Algorithm:

This algorithm is adaptable, simple to implement machine learning algorithmic rule which results even while not hype-parameter standardization, provides an outstanding result commonly. It is one among the supremely used algorithms, because of its adaptable nature and also it can be used for both regression and classification use-cases. This is a supervised ML algorithm. As the name itself indicates "Random Forest", it creates a forest in a random fashion. In forest, as branch of clusters it builds, as many as branches of Decision Trees, which are mostly trained using bagging or grouping method. The prevalent plan of textile methodology is that the accuracy of general result increases with combining two or more number of algorithms. The enormous advantage of this algorithm is, it can be utilized for both regression and classification tasks, which are currently involved in majority of ML systems. It has equally matching excited parameters as a grouping classifier, as a set of many decision trees. Mostly, in this algorithm, there's no need to merge decision trees with large classifier. The various classifier class can be used for this. By using Random Forest regressor, regression tasks can be carried out. As this algorithm generates extra randomness, it searches for simplest feature in random set of available options instead of sorting the most prominent feature whereas ripping a node. This emerges as a robust-model due to its large diversity. Therefore, in this algorithm we solely create a random set of options that is taken in the consideration throughout the algorithmic rule for rending a node. Additional random trees can be built by addition victimization random threshold values, for each and every feature instead of sorting simplest potential thresholds (like a standard call tree does). This algorithm has wide range of applications in many different fields. In this use-case, we obtain infant's body parameter data with the location, by using this algorithm exact combination of data can be identified through which predicting future data is feasible and false data can be eliminated.

Precondition: A training set $S: = (x_1, y_1). . . (x_n, y_n)$, features F, and number of trees in forest B.

1. function RandomForest(S, F)
2. $H \leftarrow \emptyset$
3. **for** $i \in 1, \ldots, B$ **do**
4. $S^{(i)} \leftarrow$ A bootstrap sample from S
5. $h_i \leftarrow$ Randomized Tree Learn($S^{(i)}$, F)
6. $H \leftarrow H \cup \{h_i\}$
7. **end for**
8. **return** H
9. **end function**
10. **function** Randomized Tree Learn(S, F)
11. At each node
12. $f \leftarrow$ very small subset of F
13. Split on best feature in f
14. **return** the learned tree
15. **end function**

VI CONCLUSION

The infant checking framework is fit for distinguishing startling occasions and enrolling a few physiological parameters, making it a ground-breaking restorative apparatus to track wellbeing of infant and a solid continuous screen of newborn children. There is an arrangement for introducing and aligning the framework as per a child's body also, movement designs, for example the typical heartbeat rate, beat rates during eating and resting, time when the youngster for the most part takes his/her feast (after which he/she should wash hands appropriately) can be enrolled before use or in an occasional way during a short. In view of this adjustment step, the tunable parameters of the calculation for occasion discovery and ready notice are set. Occasional alignment over the lifetime of the gadget can modify for sensor float because of maturing and ecological varieties

VII FUTURE WORK

Sound sensor (CZN-15E) can be supplanted with very good quality sound sensors with voice acknowledgment innovation for the location of crying or some other upset clamors caused. By utilizing this innovation, it makes the plan increasingly exact and precise as the clamor recognition is additionally arranged and analyzed and afterward anticipated. Since the alarm is possibly activated if the child cries or if there is any tremendous unsettling influences in the encompassing, it takes out the probability of bogus cautions and accordingly guarantees appropriate observing. Temperature sensor at a propelled stage can be utilized to record the pace of variety in temperature to distinguish conditions like febrile seizure which happens in kids, where seizures will in general happen when the body temperature turns out to be high. Accordingly with a quicker and exact observing framework, it helps the guardians in helping their kids at such conditions come what may. The presentation of pulse fluctuation estimation (HRV) incorporates different focal points other than inherent pulse estimation. Generally cardiovascular furthermore, self-ruling sensory system can be observed. Vibration design creation for different sensor yields. This improves the ready framework, as every sensor yield has an alternate vibrating design which helps the hard of hearing and visually impaired guardians in recognizing and perceiving the parameter.

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