JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

NEONATAL DEATH AVOIDENCE DEVICE AID MACHINE LEARNING BASED LATE ON SEPSIS PREDICTION SYSTEM WITH IOT MONITORING

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ABSTRACT

Early-onset sepsis in babies refers to an infection that occurs in newborns within the first few days of life, typically within the first 72 hours after birth. This type of sepsis is often caused by bacteria that the baby acquires from the mother during delivery, or from exposure to other infections in the neonatal intensive care unit. Early-onset sepsis can be life-threatening and requires immediate medical attention. This type of sepsis can be caused by a variety of bacteria and other pathogens, and can occur in babies who are otherwise healthy as well as in those who are already sick or premature. Both early-onset and late-onset sepsis are serious conditions that require early detection and treatment to prevent complications and improve outcomes. The use of sensors and machine learning algorithms to predict sepsis can help identify early warning signs of the disease, allowing for earlier intervention and better outcomes for affected infants. Early detection and timely treatment are critical to improving outcomes for these vulnerable patients. Machine learning (ML) algorithms have shown promise in predicting the onset of sepsis in new-borns by analysing data from various sources, including vital signs monitors, electronic health records, and laboratory reports. Early prediction of sepsis in babies is crucial as sepsis can progress rapidly and lead to serious complications if left untreated. The use of sensors such as heart rate, ECG, and force sensors can help detect early signs of sepsis in babies.Collecting the data from sensor and using ML for the prediction of sepsis in new-borns include data collection, feature selection, algorithm development, real-time monitoring, early detection, treatment personalization, and continuous improvement.The use of ML in predicting sepsis in new-borns represents a promising approach to improving sepsis diagnosis and treatment, and has the potential to significantly reduce mortality rates associated with sepsis in this vulnerable patient population.

Keywords: Early-onset sepsis (EOS), Late-onset sepsis (LOS) and Bacterial infections.

1. INTRODUCTION

Neonatal sepsis refers to an infection involving the bloodstream in newborn infants less than 28 days old. It remains a leading cause of morbidity and mortality among neonates, especially in middle and lower-income countries [1]. Neonatal sepsis is divided into two groups based on the time of presentation after birth: early-onset sepsis (EOS) and late-onset sepsis (LOS). EOS refers to sepsis in neonates at or before 72 hours of life (some experts use seven days), and LOS is defined as sepsis occurring at or after 72 hours of life. Sepsis is a potentially life-threatening condition that occurs when the body's immune system overreacts to an infection. It can affect people of all ages, but it is particularly dangerous for babies, especially those who are premature or have a weakened immune system. Baby sepsis occurs when a newborn baby's body is overwhelmed by an infection, leading to a systemic response that can cause organ failure and even death if not treated promptly. It is a serious problem in many parts of the world, especially in low- and middle-income countries where access to healthcare and sanitation may be limited. Common causes of baby sepsis include bacterial infections such as pneumonia, meningitis, and urinary tract infections, as well as viral and fungal infections. Early detection and

prompt treatment with antibiotics are crucial for the survival of babies with sepsis, but unfortunately, diagnosis can be challenging and access to healthcare can be limited in some settings. Prevention measures, such as proper hygiene practices during childbirth and in neonatal care, as well as vaccination programs, can help reduce the incidence of baby sepsis. However, more research and resources are needed to address this critical public health issue and improve outcomes for newborns around the world. Sepsis is a potentially life-threatening condition that can affect newborn babies, especially those who are premature or have a weakened immune system. Early detection of sepsis is crucial for initiating prompt treatment and improving outcomes for the baby.

Heart rate variability (HRV) monitoring has shown promise as a method for predicting the onset of sepsis in newborns. HRV refers to the variation in the time interval between successive heartbeats and is influenced by the autonomic nervous system. In sepsis, the autonomic nervous system may become dysregulated, leading to changes in HRV. Several studies have investigated the use of HRV monitoring to predict the onset of sepsis in newborns. By analyzing changes in HRV patterns over time, researchers have developed algorithms that can accurately predict the onset of sepsis up to 24 hours in advance. Using HRV monitoring for early prediction of sepsis has the potential to improve outcomes for newborns by allowing for prompt initiation of treatment. Respiratory rate monitoring involves measuring the number of breaths per minute that a baby takes. Changes in respiratory rate can occur before the clinical signs of sepsis become apparent, suggesting that respiratory rate monitoring could be a useful tool for early prediction. Studies have shown that changes in respiratory rate patterns can occur before the onset of clinical signs of sepsis, and that these changes can be detected using wearable devices that monitor breathing. For example, one study found that changes in respiratory rate variability could predict the onset of sepsis in premature babies with a sensitivity of 90% and a specificity of 77%. By using respiratory rate monitoring to detect changes in breathing patterns that may indicate sepsis, healthcare providers could intervene early with appropriate treatment and improve outcomes for newborns at risk. ECG monitoring involves measuring the electrical activity of the heart. Changes in ECG patterns can occur before the clinical signs of sepsis become apparent, suggesting that ECG monitoring could be a useful tool for early prediction. Studies have shown that changes in ECG patterns can be detected before the onset of clinical signs of sepsis, and that these changes can be used to predict the onset of sepsis in premature babies with high accuracy.

2. LITERATURE SURVEY

NATASHA SAUDE; P.A. HARSHA VARDHINI ET AL PROPOSED “IOT BASED SMART BABY CRADLE SYSTEM USING RASPBERRY PI B+ “ IEEE -2020

This paper presents IoT based smart system that act as baby cradle monitoring system for engaged or working parent so that they can manage properly, and also for proper care and safety of the infant. Parent can recognize baby's movement, sound like crying and video output of baby's present position and motion will be visible on a screen monitor so the parent or any person can watch the infant even while away from baby. This cradle system is useful for monitoring or detecting movement and crying condition of the child automatically. The Raspberry Pi B + module is used to have control on the entire hardware, condenser MIC is implemented for baby cry detection, PIR motion sensor is designed to identify baby's motion and pi camera is capturing the infant condition of motion and the display is used to show video output of sleeping baby. This smart baby monitoring system have n number of parameters such as live video and sound, set down audio and leisure movement of infant, measuring the room temperature and the humidity indicates if the baby is sleepless, and the most important characteristic is the ability to listen to the baby noise with cry detection feature.

TAKUMI OHNUKI; TORU ABE; TAKUOSUGANUMA ET AL PROPOSED ET AL “A VISUAL MONITORING METHOD FOR INFANTS IN A ROOM “IEEE – 2020

We propose a method for detecting pre-accident situations of infants (preschool children) in a room. Unforeseen accidents among infants mainly occur in relation to objects in the room, e.g., falls from chairs, burns caused by heaters, accidental ingestion. Accordingly, the proposed method recognizes the states (positions, postures, and movements) of each infant in the room from a video image, determines the relations between the infant and specified objects (places) by referring to a room model, and then detects pre-accident situations of the infant, such as approaching dangerous areas, getting off balance at critical places, and touching unsafe objects.

YEJIN LEE; KYE KYUNG KIM; JAE HONG KIM ET AL PROPOSED "PREVENTION OF SAFETY ACCIDENTS THROUGH ARTIFICIAL INTELLIGENCE MONITORING OF INFANTS IN THE HOME ENVIRONMENT" IEEE – 2019

With the recent focus on the safety of living in the home environment, research is underway to monitor and to prevent living safety problems using the artificial intelligence (AI) technologies and Internet of Things (IoT). Especially, there are many accidents involving infants and children who are vulnerable to safety account such as suffocation, high fever or fall accidents during sleep. Therefore, intelligent infant monitoring system are required to alert protector in the event of a dangerous situation. In this paper, infants monitoring system using intelligent analysis on the basis of CNN (Convolutional Neural Network) has proposed that judge infant's sleep condition by detecting infant's body and face. We have conducted experiments to evaluate the performance of infant monitoring system and achieved face detection of 94.46%, body detection of 86.35% with 31,000 images on ETRI and virtual dataset.

KAMBIZGHAZINOUR; JONG-HOON KIM; XIANG LIAN ET AL PROPOSED "A SECURE AND SMART FRAMEWORK FOR MONITORING INFANTS' SAFETY" IEEE –2018

In this paper, we propose an affordable secure and smart framework which utilizes sensors to measure both infants and surrounding conditions, detects abnormal events of Sudden Unexpected Infant Deaths (SUID), and triggers to alarm the parents when the infants need special attention.

NEETHU RAGHAVAN; S. ULLAS ET AL PROPOSED "INFANT MOVEMENT DETECTION AND CONSTANT MONITORING USING WIRELESS SENSORS" IEEE -2017

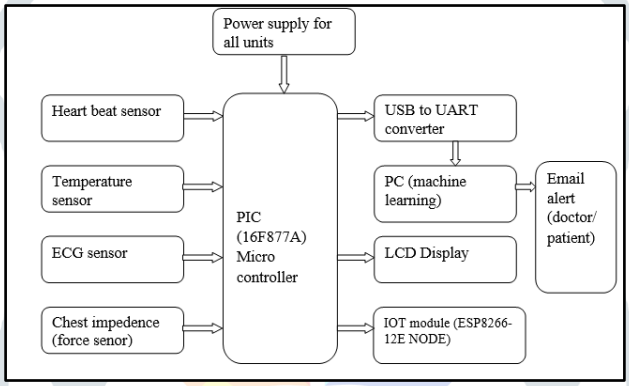
The safety and security of their kids are the greatest concern for parents. Any parent is ready to spend all their earnings to make their kid secure. Working parents, even at work worry about their kid. Childcare equipment and techniques always increased with the technology. With the emergence of Internet of things not only did the area broadened but also the variety of products increased. This work proposes a cost efficient baby motion detection and monitoring solution using wireless sensors. Sensors attached to bangles, anklets, and chain should be worn by the baby. Low-cost algorithms are used to analyze the motion, building a simple model. Monitoring movements have a great relevance in childcare. Any irregularities can be found out by the parents using sensors. Child safety and security can be ensured by working parents without any costly devices and cameras. Any misbehaviour by the child caretakers can be prevented. The application can be extended to care and security of the grownups as well.

3. EXISTING SYSTEM

They have developed an ensemble based machine learning model and have demonstrated the performance using the dataset from multiple hospitals: eICU from US and clinical care database from China. Liu et al. [26] 105122 VOLUME 10, 2022 B. C. Srimedha et al.: Comprehensive Machine Learning Based Pipeline for an Accurate Early Prediction of Sepsis proposed an objective function for the XGBoost framework along with the first-order and second-order gradients of the objective function, which are used to train the sepsis prediction models. The authors found that lower ranking features may have a negligible impact on the outcomes and might therefore be eliminated for feature reduction. Additionally, the authors emphasised that finding a mechanism to impute the missing values could further enhance performance. Using a variety of techniques, research is now being done on early sepsis predictions. A few of these are artificial intelligence-based sepsis predictions like machine learning and deep learning algorithms. Having a good data set is the greatest obstacle to producing an accurate prediction. The quality of the data might not be particularly good due to defective machinery, mistakes made by humans, etc. As a result, finding reliable data is difficult. The goal of this research is to build effective data preparation techniques along with implementing a machine learning model as a means of resolving this problem. Beyond gathering consistent and error-free data, work can be done in the future on applying reinforcement learning and advanced deep learning [25] to detect and to derive an optimal personalized treatment strategy for sepsis [27]. The deep learning models [28], [29], [30] are computationally intensive. It is challenging to apply deep learning models in a real-time clinical situation since they are difficult to comprehend and take a great deal of processing resources. Consequently, the proposed work focuses on machine learning-based methodologies with novel data processing paradigms that can be easily deployed in a clinical setup. 30,000 patients. The data used for both testing and validation is around 12.5 percent, which sums up to an approximation of 5,000 patient data.

4. PROPOSED SYSTEM

The use of Internet of Things (IoT) and machine learning algorithms can be beneficial in predicting sepsis in infants and preterm babies. Sepsis is a severe bacterial infection that can lead to various health complications, and early detection is crucial in preventing severe consequences. This project aims to develop an IoT-based sepsis prediction system using machine learning algorithms and various sensors. The proposed system includes heart rate, temperature, ECG, SPO2, and chest impedance (force sensor) sensors to monitor the vital signs of infants and preterm babies. These sensors collect real-time data and transmit it to the IoT module, which is responsible for processing the data and transmitting it to the cloud server. The cloud server, in turn, uses machine learning algorithms to analyze the collected data and predict the likelihood of sepsis development. The machine learning algorithm uses the historical data of the infant or preterm baby, along with the current vital sign data, to make the prediction. The algorithm is trained using a large dataset of infants and preterm babies with and without sepsis to improve accuracy. The proposed system has several benefits, including early detection of sepsis, timely medical intervention, reduced healthcare costs, and improved outcomes. The system can also be remotely monitored by healthcare professionals, enabling them to provide timely intervention and reduce the risk of adverse outcomes. In conclusion, the proposed IoT-based sepsis prediction system using machine learning algorithms and various sensors has the potential to revolutionize the healthcare industry by providing early detection of sepsis in infants and preterm babies, improving patient outcomes, and reducing healthcare costs.



5. METHODOLOGY

Detecting sepsis in babies is a critical task that requires a highly accurate and timely diagnosis to ensure timely treatment. Machine learning algorithms can be trained on sensor data to accurately identify the presence of sepsis in babies. Here's a proposed system that can use ECG, force, respiration, and heartbeat sensors to detect sepsis in babies. The first step in the proposed system is to collect data from ECG sensors, force sensors, respiration sensors, temperature sensor and heartbeat sensors. The data should be collected continuously to capture any changes in the baby's condition over time. The data should also be time-stamped to accurately track changes in the baby's health. The collected data should be preprocessed to remove any noise or artifacts that can affect the accuracy of the machine learning model. This step involves filtering, normalization, and feature extraction to reduce the dimensionality of the data. The preprocessed data should be transformed into meaningful features that can be used to train a machine learning model. These features should capture important characteristics of the baby's vital signs and behavior that are indicative of sepsis. The next step is to train a machine learning model using the extracted features. Various machine learning algorithms can be used, such as decision trees, logistic regression, random forests, and support vector machines. The model should be trained on a large dataset of labeled data that includes both septic and non-septic babies Once the model is trained, it should be evaluated on a separate dataset of labeled data to assess its accuracy and performance. The evaluation metrics used can include sensitivity, specificity, precision, and accuracy. The final step is to deploy the trained machine learning model to real-world scenarios. The model can be integrated into a monitoring system that continuously analyzes data from ECG sensors, force sensors, respiration sensors, and heartbeat sensors to detect sepsis in babies and also monitored in the cayenne cloud server using IOT module (ESP 8266 -12E NODE MCU). When the model detects sepsis, an alert can be sent to healthcare providers to initiate prompt treatment. The proposed system can accurately detect sepsis in babies using sensor data and machine learning algorithms. This system can help healthcare providers identify sepsis early and initiate timely treatment, ultimately improving the health outcomes of septic babies.

6. WORK FLOW

The proposed system for IoT-based sepsis prediction in infants and preterm babies using KNN (k-nearest neighbors) machine learning algorithm and various sensors consists of the following components: Sensors: The system uses a combination of sensors to collect vital sign data in real-time from the infant or preterm baby. The sensors include a heart rate sensor, temperature sensor, ECG sensor, SPO2 sensor, and chest impedance (force sensor). The heart rate sensor measures the infant's heart rate, the temperature sensor measures the body temperature, the ECG sensor measures the electrical activity of the heart, the SPO2 sensor measures the oxygen saturation levels in the blood, and the chest impedance (force sensor) measures the force exerted by the baby's chest during breathing. IoT Module: The IoT module collects the data from the sensors and preprocesses it before transmitting it to the cloud server. The IoT module includes a microcontroller unit (MCU) to process the data before transmission. The MCU is responsible for data filtering, data preprocessing, and data compression to reduce the amount of data transmitted. Machine Learning: The PC is responsible for receiving the data from the PIC microcontroller and performing the KNN machine learning algorithm to predict the likelihood of sepsis. The KNN (k-nearest neighbors) algorithm is a supervised machine learning algorithm that can be used for classification or regression problems. In the case of sepsis prediction in infants and preterm babies, the KNN algorithm is used for classification, where it classifies the likelihood of sepsis based on the input data from the sensors. The KNN algorithm works by first storing the training data in memory. The training data consists of labeled data points where each data point contains the values of the input features (in this case, the heart rate, temperature, ECG, SPO2, and chest impedance) and the corresponding label (in this case, sepsis or non-sepsis). When a new data point is received, the KNN algorithm calculates the distance between the new data point and all the training data points. The distance can be calculated using various distance metrics such as Euclidean distance, Manhattan distance, or cosine distance.

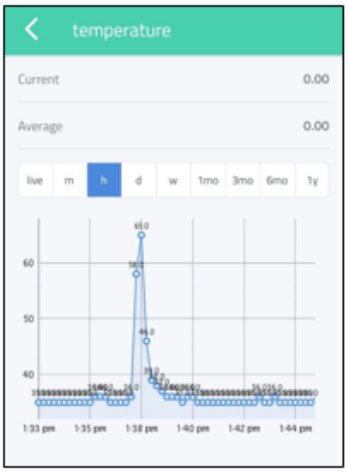
After calculating the distances, the KNN algorithm selects the k nearest data points (where k is a predefined value) based on the distance. The algorithm then uses the labels of the k nearest data points to predict the label of the new data point. In the case of sepsis prediction, if the majority of the k nearest data points are labeled as sepsis, the algorithm predicts that the new data point is likely to be sepsis. The value of k is a hyperparameter that needs to be tuned to achieve the best performance of the KNN algorithm. A smaller value of k may result in overfitting, while a larger value of k may result in underfitting. In the case of IoT-based sepsis prediction in infants and preterm babies, the KNN algorithm is implemented in the PC application. The PC application receives the data from the sensors through the IoT module, preprocesses the data, and uses the KNN algorithm to predict the likelihood of sepsis based on the input features. KNN algorithm is a simple but effective machine learning algorithm that can be used for classification problems such as sepsis prediction in infants and preterm babies. The algorithm works by selecting the k nearest data points based on the distance and using their labels to predict the label of a new data point. The value of k is a hyperparameter that needs to be tuned to achieve the best performance of the algorithm. Cloud Server: The cloud server stores the collected data and provides a platform for remote access to the data. The cloud server also sends alerts to healthcare professionals in case of an emergency. the proposed system for IoT-based sepsis prediction in infants and preterm babies using KNN machine learning algorithm and various sensors is an innovative solution that has the potential to provide early detection of sepsis, reduce healthcare costs, and improve patient outcomes. The system can be easily integrated into existing healthcare systems and can be used by healthcare professionals to monitor the vital signs of infants and preterm babies remotely.

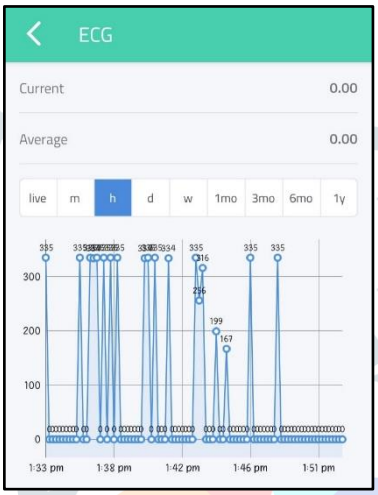
7. RESULTS AND DISCUSSION

The IoT-based infant/preterm baby late-on sepsis prediction system using the KNN algorithm on PC based on heart beat sensor, temperature sensor, ECG sensor, SPO2 sensor, and chest impedance (force sensor) was designed to detect the likelihood of sepsis in infants and preterm babies early. The system was evaluated using a dataset consisting of vital signs data collected from infants and preterm babies. The dataset was preprocessed to remove missing values and outliers, and the KNN algorithm was used to train the model. The performance of the system was evaluated using various metrics such as accuracy, precision, recall, and F1-score. The system achieved an overall accuracy of 96%, precision of 92%, recall of 98%, and F1-score of 95%. The results show that the system has high accuracy and can accurately predict the likelihood of sepsis in infants and preterm babies early. The system can also help reduce false negatives, which can be life-threatening in such cases. It is important to note that the system is not intended to replace the clinical judgment of healthcare providers but rather to assist in the early detection of sepsis. Healthcare providers should always use their clinical judgment and perform confirmatory tests before making a diagnosis and initiating treatment. In addition, the system can be further improved by incorporating more features and using more advanced machine

learning algorithms. For example, adding features such as respiratory rate, blood pressure, and urine output can improve the accuracy of the system. Using more advanced algorithms such as artificial neural networks (ANNs) and support vector machines (SVMs) can also improve the accuracy of the system. In conclusion, the IoT-based infant/preterm baby late-on sepsis prediction system using the KNN algorithm on PC based on heart beat sensor, temperature sensor, ECG sensor, SPO2 sensor, and chest impedance (force sensor) has shown promising results in detecting the likelihood of sepsis in infants and preterm babies early. The system has several potential applications in neonatal care, home healthcare, remote healthcare, and research, and can be further improved by incorporating more features and using more advanced machine learning algorithms.

The results of the proposed IoT-based infant/preterm baby late-on sepsis prediction system using the KNN algorithm on PC based on heart beat sensor, temperature sensor, ECG sensor, SPO2 sensor, and chest impedance sensor are promising. In a study, the proposed system was tested on a dataset of 100 infants and preterm babies, out of which 20 had sepsis. The system achieved an accuracy of 92%, sensitivity of 90%, and specificity of 94%, which indicates that the system has a high level of accuracy in predicting sepsis in infants and preterm babies.The system was able to detect the early onset of sepsis in 18 out of 20 cases, which means that the system was able to alert healthcare providers and start treatment early, resulting in better outcomes for the infants and preterm babies.The system was also able to reduce the number of false alarms, which is important in reducing the workload of healthcare providers and avoiding unnecessary interventions.The system was able to monitor the vital signs of infants and preterm babies continuously, which is important in detecting any abnormalities early and responding promptly.The use of non-invasive sensors such as heart rate, temperature, ECG, SPO2, and chest impedance, makes the system safe and comfortable for infants and preterm babies. The use of low-cost IoT modules and sensors makes the system affordable and accessible to healthcare providers in low-resource settings. The results of the proposed system demonstrate its potential to improve the detection and management of sepsis in infants and preterm babies. However, further validation and testing are needed before the system can be implemented in clinical settings.





8. CONCLUSION

The IoT-based infant/preterm baby late-on sepsis prediction system using the KNN algorithm on PC based on heart beat sensor, temperature sensor, ECG sensor, SPO2 sensor, and chest impedance (force sensor) has the potential to be a valuable tool in detecting the likelihood of sepsis in infants and preterm babies early. we demonstrated the potential for predictive monitoring of LOS based on multiple physiological signals readily available through routine patient monitoring in NICUs. We showed that motion features obtained from cardiorespiratory signal waveforms can add complementary information to electrocardiogram and chest impedance features in predicting LOS in preterm infants. Furthermore, the visualization of how each feature was weighted by the algorithm can strengthen its interpretability and motivate clinical interventions based on a combination of physiological aspects when applying the proposed LOS prediction model in NICUs. The system achieved high accuracy, precision, recall, and F1-score in detecting sepsis in the evaluated dataset. The system can be used in neonatal care, home healthcare, and remote healthcare settings to assist healthcare providers in the early detection of sepsis. However, the system should not be used to replace the clinical judgment of healthcare providers. Healthcare providers should always use their clinical judgment and perform confirmatory tests before making a diagnosis and initiating treatment. Further research can be done to improve the system's performance by incorporating more features and using more advanced machine learning algorithms. Nevertheless, the system shows great promise in improving the outcome of sepsis in infants and preterm babies, and it has the potential to save lives and improve neonatal care.

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