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Ai powered child monitoring and Assistant System using Raspberry pi

Janmitha G P[1], Srividya C N[2], Jeevitha M[3], Dheemanth Gowda B C[4], Dr. ManojKumar S B[5]
[1,3,4]B.E. Students, Department of Electronics and Communication Engineering, BGS Institute of Technology, Adichunchanagiri University, B. G. Nagara, India.
[2]Assistant Professor, Department of Electronics and Communication Engineering, BGS Institute of Technology, Adichunchanagiri University, B. G. Nagara, India.
[5]Associate Professor, Department of Electronics and Communication Engineering, BGS Institute of Technology, Adichunchanagiri University, B. G. Nagara, India.

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Abstract: *Child monitoring and health checking are still essential issues for parents since it is hard to supervise kids in modern life constantly. This work suggests the implementation of Smart Parenting Care Robot as a novel artificial intelligence child monitoring platform based on Raspberry Pi. The presented technology consists of various components like computer vision, biomedical sensors, and Internet of Things communication for effective monitoring of the baby's well-being and activity.*
Firstly, the device is equipped with a camera that analyzes facial landmarks and checks for crying using OpenCV and Dlib libraries. Also, physiological variables like heart rate and oxygenation levels are estimated using MAX30100.Also, sensors for measuring temperature and humidity monitor the conditions and comfort zone of the child. All sorts of information collected are analyzed by smart algorithms that detect any irregularities and send corresponding alerts to the carers.
The notifications will be sent through the Telegram Bot API service. The above-mentioned innovation is efficient both financially and in terms of functionality.

Key Words: *Raspberry Pi, Infant Monitoring, Artificial Intelligence, Computer Vision, IoT, SpO_2, Heart Rate, Smart Healthcare, Telegram Bot.*

I.INTRODUCTION

These kinds of platforms are able to detect the behavior of the person in question, determine the presence of any abnormal activity, and alert the caregiver immediately about it. While the capabilities to track the activities of the baby make up one of the main features of the system in question, it uses edge intelligence for real-time processing. Unlike cloud-based baby monitors that use computation performed on servers, Raspberry Pi will be able to conduct image analysis and calculate other factors without being connected to any server.

For example, future updates can be implemented to detect sleep position of the baby, monitor the breathing rate using computer vision algorithms, or implement predictive analytics based on machine learning models trained on years of baby's health history. Combining multi-sensor fusion, AI algorithms, and IoT communication channels make the system very adaptive to real-life conditions, being able to work despite external noise and fluctuations in environmental conditions, as well as different infant behavior patterns. Such an approach not only increases the reliability of data collected during the monitoring process, but also helps to develop further more sophisticated solutions in the area of intelligent automation of childcare tasks. Furthermore, the implementation of edge computing techniques at the device level allows for more efficient processing of data generated in real time without relying too heavily on cloud services. It not only decreases the time needed to transmit data, thus allowing faster alerts in case of an emergency, but also increases safety of the system since sensitive data is no longer transferred and stored on external servers.

II.PROBLEM STATEMENT

In the early stages of infancy, babies are unable to communicate their needs, discomfort, or health conditions directly to their caregivers. Traditional baby monitoring systems are limited to basic audio and video feeds, which rely heavily on constant parental observation and interpretation. This creates significant challenges in timely detection of distress signals, health anomalies, or environmental discomforts such as wet diapers. Delayed recognition of these issues can lead to increased parental stress, overlooked health problems, and potential risks to infant well-being. There is a clear need for an intelligent, real-time monitoring system that can automatically detect and interpret an infant's distress signals such as crying, monitor vital health parameters including heart rate and oxygen saturation, and identify comfort-related needs like diaper wetness. Such a system should not only alert parents instantly but also provide continuous data logging for better understanding of the infant's health patterns.

III.OBJECTIVES

The main objective of this project is to develop an AI-powered child monitoring and assistance system using Raspberry Pi and multiple sensors to ensure infant safety and health monitoring in real time.

The specific objectives of the proposed system are as follows:

1. To build an AI-based child monitoring system using Raspberry Pi for real-time tracking of health and activity.
2. To monitor key vital signs using sensors and detect abnormalities through intelligent data processing.
3. To enhance child safety by sending instant alerts and notifications to parents via Telegram.

IV.RELATED WORK

The latest innovations in intelligent infant monitoring systems have been related to the incorporation of machine learning, computer vision, and IoT into these systems to improve efficiency of care. The identification of various forms of crying has been studied as an important feature to understand infant needs. For example, Raspberry Pi-based embedded systems have been utilized to analyze infant cries using MFCC features and deep learning algorithms to differentiate between states such as hunger, discomfort, and pain.

Moreover, deep learning-based monitoring system architectures use combinations of microphones, cameras, and edge computing devices to detect crying and send data to mobile devices to alert parents instantly . Early investigations in this area have concentrated on audio and motion analysis through Raspberry Pi-based monitoring techniques to detect motions and crying of infants through live videos and sound detectors. While many developments have been made thus far, most of the current technologies only rely on audio or vision-based monitoring but do not integrate physiological sensing capabilities. Consequently, there is still a considerable demand for an AI- powered multi-modal solution, which combines behavioral analysis with real-time health monitoring capabilities to create a more advanced infant care technology. Several studies have noted the need for domain-specific models in infant facial landmark detection due to the fact that traditional approaches to face recognition usually underperform in identifying infant facial features because of structural and expressive differences. While many developments have been made thus far, most of the current technologies only rely on audio or vision-based monitoring but do not integrate physiological sensing capabilities. Consequently, there is still a considerable demand for an AI-powered multi-modal solution, which combines behavioral analysis with real-time health monitoring capabilities to create a more advanced infant care technology.

V.PROPOSED METHODOLOGY

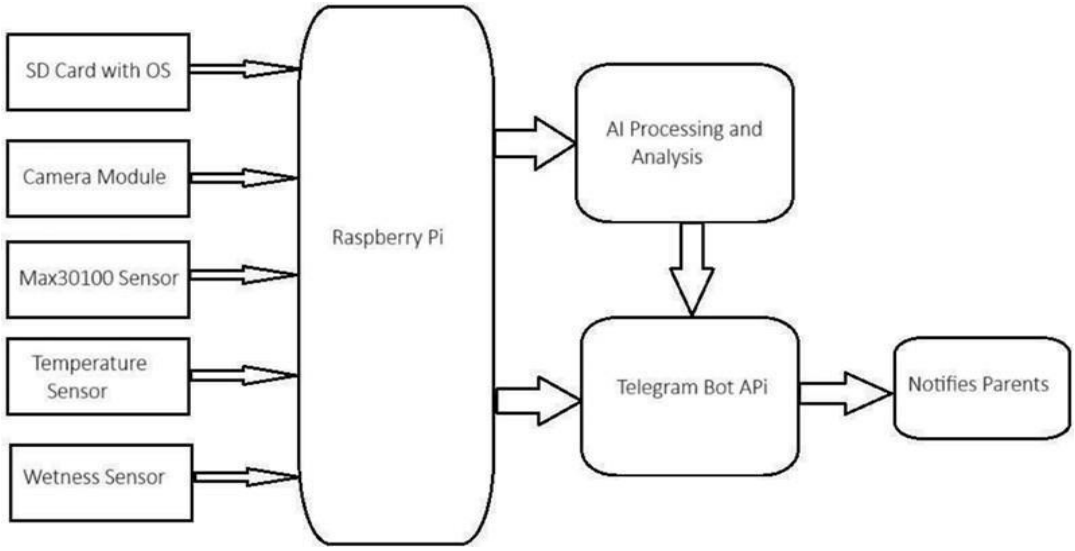

Fig 1: Block Diagram of Baby Monitoring System

This system will be an Artificial Intelligence enabled Smart Parenting Care Robot aimed at offering comprehensive monitoring of health, behavioral and comfort conditions of the baby via multi-sensors and Computer Vision approaches. Centralized around Raspberry Pi, the device that works as a control and communication component of the system for acquiring data and analyzing it, the robot includes a camera component that captures video images and offers visual monitoring. Thanks to advanced computer vision algorithms based on OpenCV and Dlib libraries, the smart robot recognizes the face of a baby and determines its features such as eye and mouth aspect ratios (EAR and MAR, respectively). In this way, the robot is able to detect crying or distress states of babies in real time. In addition, the strength of the above. Mentioned vision-based system is that it will avoid the risk of false alarms as a result of other noises in the surroundings. Furthermore, the system contains several biomedical and environment sensors, which allow it to assess the level of health and comfort of infants. They include MAX30100 that is used for measuring SpO2 and heart rate of infants.

Also, there is a wetness sensor used to monitor the wetness of the diapers by measuring electrical conductivity, thus ensuring that the caregivers receive notifications on time for changing the diapers. All sensor readings are gathered via GPIO and I2C ports and analyzed in real time using the Raspberry Pi .Intelligent algorithms are incorporated in the system to compare sensor values and AI output values with pre-defined values and patterns. In case of any deviations, for example, increased crying, abnormal heart rate, decreased oxygen level, increased temperature, and wet diapers, then the system will instantly inform the parent. The notification will reach the guardian through the Telegram Bot API irrespective of where they might be at that moment, since edge computing will ensure that all processes run on the device itself without having to communicate with remote servers. Also, the proposed model adopts the use of modular design architecture, hence making future modifications relatively easy. It can easily be improved to include other functionalities, including cloud computing, deep learning models, and additional sensor units.

The process of developing this unique AI-powered baby surveillance system will be conducted in a manner that ensures a reliable evaluation of the baby's condition. Initially, the setup of the hardware elements, which include Raspberry Pi with a camera module, MAX30100 pulse oximeter, temperature, and wetness sensors, will be done by employing the use of the General Purpose Input Output (GPIO) and Inter-Integrated Circuit (I2C). The whole process will be carried out in a Python coding environment.To begin with, a dataset would be collected and preprocessed to enable training of a machine learning model, which will be able to discern a crying or uncomfortable infant from one in a normal state of well-being. In this case, real-time videos are continuously captured via a camera, from where images of the infant's face and facial landmarks are detected and used to compute metrics such as EAR and MAR values.

On the other hand, the physiological measurements, namely heart rate and SpO2, are collected by the MAX30100 sensor while the temperature and moisture sensors collect information on temperature and wetness in the baby's diaper, respectively. The input data stream undergoes analysis through AI-powered inference where thresholds for each parameter must be set to determine the baby's condition. At all times, the system checks if any parameter exceeds the set safe values, such as high temperature, high or low heart rate, low SpO_2 values, or wetness detection. In cases where there are no abnormalities, the process continues unaltered; otherwise, the system identifies the type of problem and initiates an alerting mechanism. An alert is immediately forwarded to the caregivers via Telegram Bot API, detailing the detected problem.

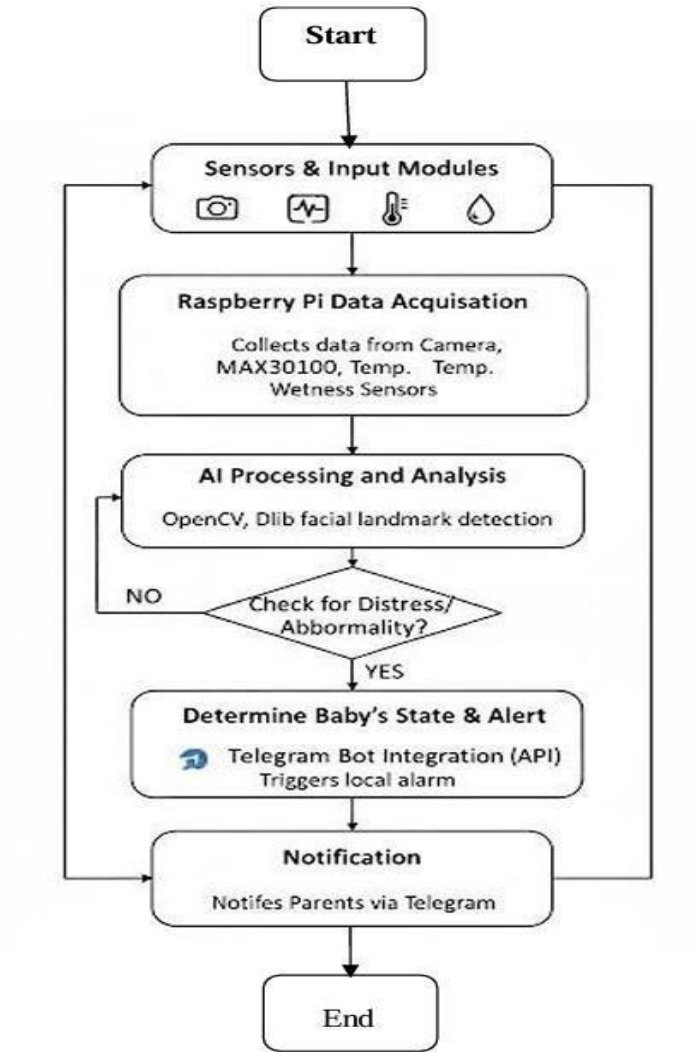

Fig 2: Flow Chart of Baby Monitoring System

The architecture of the proposed artificial intelligence child- monitoring system involves multi-layered modular components that perform data acquisition, data processing, data analysis, and information dissemination to the system administrator. The first layer involved in the design of the system includes the hardware component and includes Raspberry Pi camera, MAX30100 Pulse Oximeter Sensor, temperature sensor, and wetness sensor.All of these sensors connect to the Raspberry Pi computer through GPIO and I2C interfaces. These sensors receive information from various sources in diverse formats, including videos, heart rate, SpO_2, temperature, and moisture measurements. The next stage in this system architecture is the processing layer. All processing operations in this stage are performed by the Raspberry Pi computer.

But above everything else comes the intelligence level or analysis stage, where AI algorithms and threshold logic will be used to analyze the data gathered through the visual sensors. In this regard, the algorithm will calculate different parameters, including the Eye Aspect Ratio (EAR) and Mouth Aspect Ratio (MAR), to verify crying. On the other hand, physiological readings will be compared with pre-defined safety levels in case any anomaly occurs such as fever, irregular heart rate, and decreased oxygen levels. The use of edge computing allows for performing all necessary procedures locally through the use of the Raspberry Pi hardware. Thus, the system will minimize any possible delays or lagging caused by data transfer or computations performed in the cloud environment. Lastly, there is a communication layer that uses Telegram Bot API in order to deliver alerts and notifications about infants' condition to caregivers in real-time mode. As such, it will allow establishing reliable remote access to the monitoring process and getting immediate information whenever any abnormality occurs.

VI.RESULT AND DISCUSSION

The system design provides a smart and integrated artificial intelligence-based solution for the monitoring and assistance of infants. The system design uses a Raspberry Pi as the primary processing unit for collecting, processing, and transmitting data. A camera module is also used in this system for the purpose of obtaining live videos of the baby to facilitate visual monitoring and detection processes. With the help of some sophisticated computer vision algorithms used in the OpenCV and Dlib libraries, this system performs detection of facial landmarks and calculation of Eye Aspect Ratio (EAR) and Mouth Aspect Ratio (MAR). This will help the system to detect instances when the baby is crying or distressed. This is also a better solution than any audio-based monitoring system because it offers noise resistance capabilities. Besides, the proposed system uses several sensors to monitor the physiological and environmental aspects of babies. In particular, the MAX30100 sensor is used for detecting the heart rate and SpO2 levels, while a temperature sensor can be used to detect fever or any abnormality in the baby's body temperature.

Moreover, the wetness sensor monitors the moisture content of the diaper in order to maintain proper hygienic conditions for the child. All data obtained from the sensors is then evaluated by means of intelligent algorithms implemented on Raspberry Pi and based on a comparison of the readings of the sensors with the threshold values and outputs of AI. As soon as any irregularity is detected, for example excessive crying, an abnormal state of the baby, elevated body temperature or wet diapers, an alert will be issued immediately. In case of abnormal conditions notifications will be sent to the caregiver via Telegram Bot API, providing him/her with prompt communication no matter how far from home he/she may be. By utilizing the technology of edge computing all processing can be done locally, thus significantly reducing latency, increasing reliability, and protecting user's privacy. Also, a modular approach to design allows for flexible further integration, including, among others, cloud services and implementation of Deep Learning techniques or even other sensors.

To validate the efficacy of the proposed child monitoring system through AI, it underwent evaluation under various real- time conditions, including accuracy and dependability in monitoring infants' health status and behavioral activities. Based on the findings, the designed system has shown efficient capability in continuous collection and processing of visual and physiological data streams. Through the use of a computer vision-based method, the system has been able to identify facial landmarks and parameters such as EAR and MAR.

Fig 3: Telegram Notification for parents

Observations from experiments indicate that a vision-based technique can deliver more precise results compared to an audio-based system especially in situations where there is background noise, thus reducing the number of false alarms. With regard to monitoring physiological parameters, the physiological monitoring module equipped with MAX30100 was able to provide precise measurements of heart rate and SpO_2. The measurements recorded were stable in normal conditions while they reacted promptly when abnormal values such as an increase in heart rate or decrease in oxygen saturation levels were introduced.

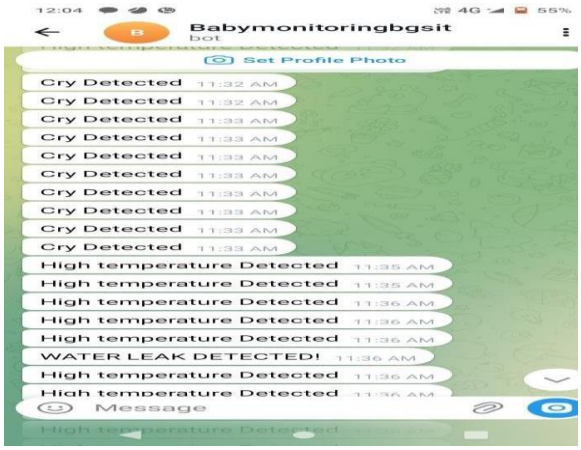

Fig 4: Cry, Temperature, Water Detection Notification.

The same trend was observed with respect to detecting variations in temperatures and moisture level in diapers using the thermal sensor and wetness sensor respectively.Multi-sensor data fusion with AI-based algorithms considerably increased the decision-making ability of our application since the dependence of the system on one single parameter was decreased along with the ability to verify the state of infants based on multiple parameters.

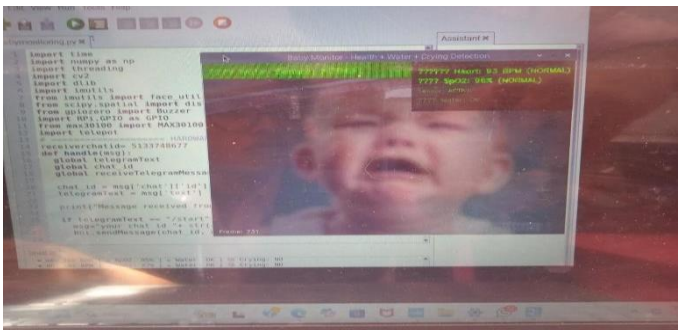

Fig 5: Live Video and Sensor Data

The deployment of the alert system using the Telegram Bot API demonstrated low latency and instant transmission of alerts to care providers, which marked a big step forward.

Additionally, the integration of edge computing within the Raspberry Pi made our system less dependent on cloud computing services, providing faster computing speed and better data security. On the contrary, certain problems emerged while testing the product.

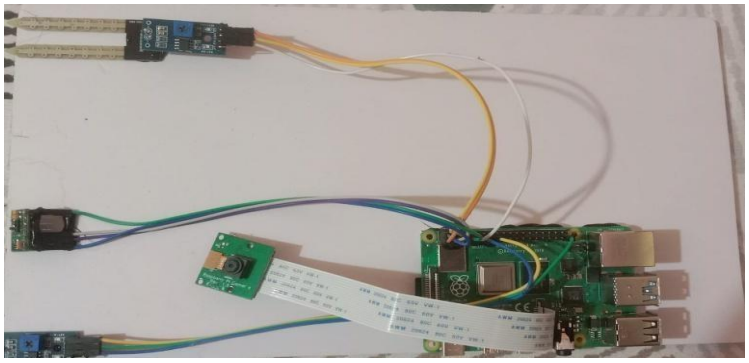

Fig 6: Project Kit

Firstly, the facial recognition algorithm could not identify the face accurately under poor light conditions. Moreover, there were certain difficulties with the accuracy of sensor data when the sensor was installed improperly and infants were moving. Overall, although there were a few weaknesses with the system, we can conclude that its performance is acceptable; it works reliably and efficiently while remaining a smart, affordable, and reliable application for infant monitoring.

VII.CONCLUSION

The current research suggests designing an Artificial Intelligence (AI)-based Smart Parenting Care Robot which has capabilities to monitor babies using computer vision, biomedical sensor technologies, and IoT technology-based communication in the domain of embedded systems. The proposed design uses the Raspberry Pi as the CPU. The Robot can detect facial features of the baby as well as other physiological information such as heart rate, oxygen saturation level (SpO_2), body temperature, and wet diaper status.Integration of AI algorithms by implementing the OpenCV and Dlib libraries helps detect crying and discomfort more efficiently than audio monitoring devices currently available. Multi-sensor data fusion also provides reliable alerts as it avoids unnecessary alerts, helping improve decision- making accuracy. With the real-time notification function via Telegram Bot API, any unusual activity will be communicated in real time to help the caregivers intervene immediately. Implementation of edge computing contributes significantly to the performance of this device, as it results in increased efficiency, privacy, and low latency. The system can be considered cost-efficient, scalable, and user-friendly despite some minor limitations, including sensitivity to lighting and sensor positions.

Moreover, the suggested system offers a variety of opportunities for developing next-generation smart childcare ecosystems through constant collection and intelligent analysis of data. The gathered information may be used for discovering the health, sleep, and behavioral patterns of infants that will help caregivers and physicians to make decisions. Further development of the system may include the use of cloud computing and deep learning algorithms that will allow predicting certain problems with the health of infants. Mobile applications, speech recognition, or wearable devices may also be introduced to provide better interaction between users and the system. The flexibility and scalability of the existing system make it suitable for use in other pediatric care and remote health monitoring purposes. Thus, it not only solves some current problems associated with infants' care but also helps develop intelligent healthcare solutions of the future.

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