Smart Infant Monitoring System

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SMART INFANT MONITORING SYSTEM

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ABSTRACT

In the contemporary world, where digitization has made the life of human beings easy and comfortable, it has also introduced certain challenges when it comes to dealing with family life. Parents, especially the working-class, faces one of the most significant challenges in the form of baby care. They are unable to observe their infants all the time. Infant monitors solve this problem by reassuring such parents that their babies are safe. Although, there are many infant monitors available in the market but many of them do not fulfill the desired requirements. The idea of this paper is to design a smart infant monitoring system that would provide high quality features such as live audio/ video streaming, recording audio, cry detection, emotion detection, temperature, and humidity sensing and determining whether the baby is asleep/ awake. The proposed system simplifies the process of infant monitoring by using Raspberry Pi. Finally, the system is tested, and its effectiveness is checked by comparing it with the available systems.

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1. INTRODUCTION

Using the smart baby monitoring system, parents can work without any tensions about their infants. This smart system helps them to keep an eye on their children remotely. Although there are a variety of products that support infant monitoring, most of them are less efficient. Therefore, the main aim of this project is to build a smart infant monitoring system that provides high quality features at a low cost.

This system uses the Internet of Things, which is a collection of devices and objects through the internet. It makes different devices capable of sending and receiving data simply using the internet. As real-time monitoring is one of the most considerable roles for the IoT, so this project aims to make a smart baby monitoring system based on Raspberry Pi, which is one of the most powerful Internet of Things devices. It will particularly focus on infant monitoring by using a microphone, speaker, camera, and temperature and humidity sensors. So, designing a system that provides high quality monitoring process will be a real challenge. This research paper proceeds as follow:

Chapter 2 consists of the literature review of the works carried out earlier and discusses their functions, characteristics, and limitations.

Chapter 3 illustrates the important features and characteristics of the proposed system.

In Chapter 4, the system components and hardware are illustrated.

Chapter 5 draws the conclusion.

2. REVIEW OF LITERATURE

Nowadays, different systems are available for smart phones/ computers/ tablets which help parents in monitoring their infants. Few of these systems and their functionalities and disadvantages are discussed as below.

2.1 KNIGHT'S WIRELESS INFANT MONITORING SYSTEM

The American Pediatrics Academy amended its policy on neonatal death. Recently, it has focused on creating an environment that promotes restful sleep so as to reduce the number of deaths among infants and children. Some characteristics were included in the construction of the Knight's Wireless infant monitoring system which included features of individual infant monitors in an integrated and unified monitoring system. It was designed to be fixed above the infant's bed having all the sensors. To avoid suffocation and chocking, there will be sensors such as temperature, motion, and audio. The smartphone will be able to access video, audio, and the infant's temperature. The system is made up of three parts: a monitor, an alarm, and a smartphone device. Monitoring is the main component which included various microprocessors, sensors, batteries, and chips for communication. The alarm, a separated unit, can be placed near an electrical socket at the end of a flat surface such as a table/ dresser. When the communication chip receives an alert from the monitoring part, the alarm part will sound an alarm and flash a warning light. To reduce infant mortality, it provides an environment that is safe for the sleep of an infant aging one year or below.

Some limitations of this system are:

1) It is only appropriate for infants that age one year or are younger.

2) It cannot measure the temperature of the room.

3) It does not provide services via the local network and can only be connected through Wi-Fi.

4) Parents cannot hear the infant's voice or converse with him or her.

5) Cry detection feature is not available in it.

6) It lacks the awake/ asleep feature.

2.2 INTEGRITY INFANT'S MONITOR

This system is a GSM based monitoring system and is designed for better caring of infants. This device monitors critical characteristics such as body temperature, pulse rate, humidity, infant movement. Also, by using GSM network, this system then sends this information to their parents. Information about parameters can be communicated to parents via an alarm for an appropriate action by them. Sensors for observing crucial factors, a GSM interface, an LCD based display and a sound alert are all managed by a single microcontroller.

Some limitations of this system are:

1) It does not provide room humidity and temperature.

2) Mobile application is not available.

3) Live audio/ video streaming feature is not available.

4) Feature for cry detection is not available.

5) Sleep/ awake feature is not available.

2.3 AUTOMATED INFANT MONITORING SYSTEM

Here, a Raspberry Pi device is connected to a camera(static), and the camera's movement is rendered dynamic by using infrared sensors and motors. The camera is located in the room's center to provide coverage in all directions. The recorded video can be seen online, and parents can get any updates/ information by logging in to the website. Moreover, when the camera is rotated, an Arduino connected with GSM module transmits alarm alerts.

It has the following limitations:

1) Mobile application is not available.

2) Feature for cry detection is not available.

2.4 ADVANCED INFANT MONITORING SYSTEM

Advanced Infant monitor is based on Raspberry Pi. Temperature, humidity, and the infant's movements are all tracked, and the infant's sleep and its sequences are recorded, allowing parents to remotely watch and observe their infant. The camera allows the parents to see what is going on. Sensors to monitor essential elements such as humidity and temperature, sound sensor with microphone and motion sensors make up this system design. The alarm sends the details of parameters to the infant's parents, allowing them to take action, if necessary.

This system has the following limitations:

1) Mobile application is not available.

2) Live streaming of audio is not available.

2.5 BABY MONITORING SYSTEM USING ARDUINO

This system uses Arduino microcontroller. Any information regarding infant observed can be recorded, stored, and transmitted to a computer. An incubator with sensors to assess heart rate and humidity is part of the monitoring system utilized in this project. It was attached to the newborn, in order to track the heartbeat. The Arduino device interface sends the measured results, such as pulse rate and level of humidity, to the computer.

Some limitations of this system are:

1) Mobile application is not available.

2) It lacks cry detection feature.

3) It lacks live audio/ video streaming.

4) Sleep/ awake feature is not available.

2.6 REAL-TIME BABY HEALTH MONITOR

This system is Android based and was designed for tough hearing parents by using mobile phones. It has humidity, body temperature, sound detecting and heartbeat measuring sensors. This technology is specifically developed to monitor physiological data collected from infants and

subsequently generate alarms in the event of an emergency. The Leonardo board is used to implement this system, which is a type of the Arduino boards. This device gathers and analyzes data from linked sensors before generating a relevant alarm depending on the information. Alarms were reported to the parents via Android based smartwatches and cellphones.

Some disadvantages of this system are:

1) Bluetooth is used by the hardware to interface a mobile application. This is bad because of the short range, battery usage, and poor security.

2) It lacks cry detection feature.

3) Sleep/ awake feature is lacking.

3. THE PROPOSED SMART INFANT MONITORING SYSTEM BASED ON IoTS

The goal of this project is to create an infant monitoring system with the following key features:

1) Live audio/ video streaming of the child.
2) Room's humidity and temperature sensing.
3) Infant's sleep/ awake notifications.
4) Detection of infant's crying with >60 Hz sound frequency.
5) Mobile application for notifications and live streaming.
6) Recording infant's audio.

Figure 1 summarizes our designed system. The proposed system is depicted in the image, which comprises of one of the most well-known microcontrollers, the Raspberry Pi, which is connected to various items and gadgets. We go over each aspect in further depth in the subsections that follow.

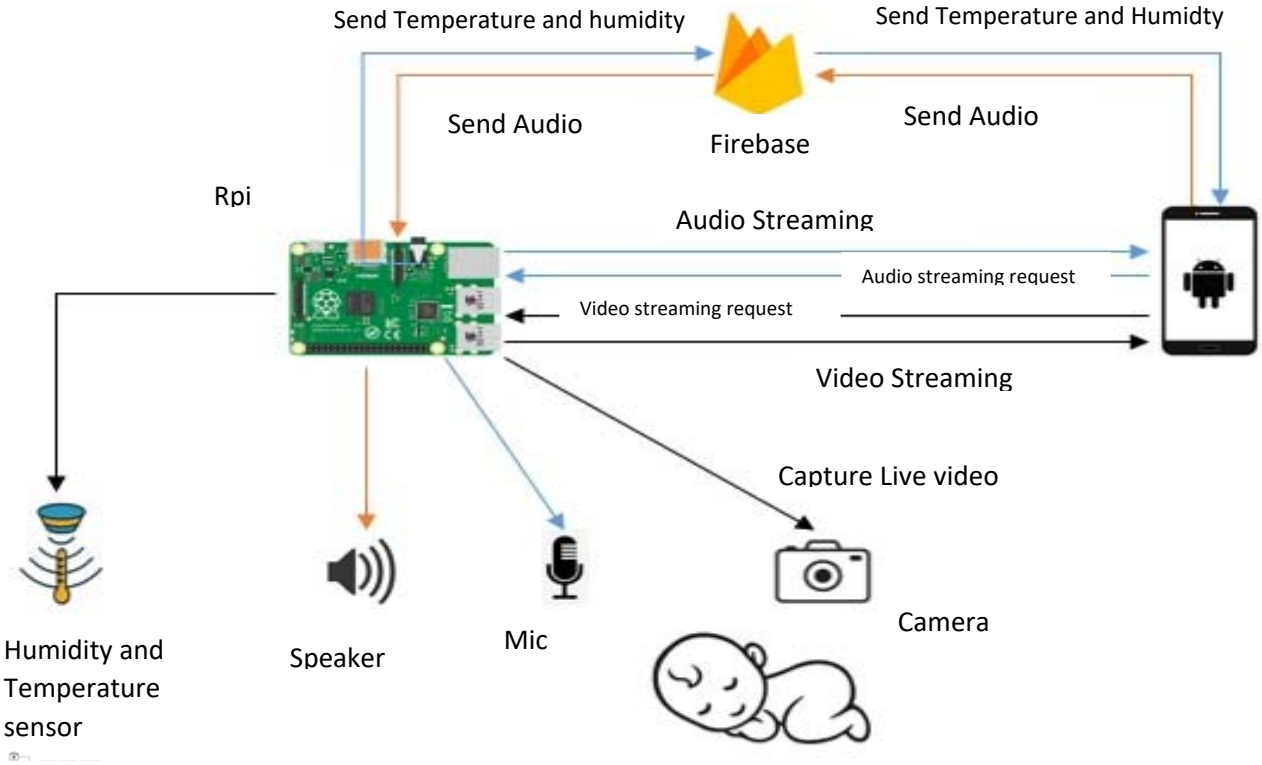

Figure 1

3.1 LIVE AUDIO AND VIDEO STREAMING

We'll use a camera and mini USB mic to connect to the Raspberry Pi because it doesn't have a built-in camera or microphone. We choose a no Infrared (NoIR) camera that doesn't use an infrared filter, allowing us to shoot images in the dark with infrared illumination in complement to daytime photos.

With the help of PyAudio, the audio processing is done. We can easily use Python to record and play audio on a number of devices with PyAudio. The VideoLan Client (VLC) application

was used to transmit audio through HTTP protocol for audio streaming. The media player software of VideoLan client is an open source and free of cost framework.

Its infrastructure can handle a variety of streaming protocols as well as a variety of multimedia assets. With the help of the LibVLC SDK, we use a player that supports a real-time streaming protocol (RTSP) server protocol to display the audio stream on the mobile application. On the other hand, several tools are utilized to broadcast the video. As seen in fig 2, for Raspberry Pi based webcams, the PiCam software provides a video/ audio recording tool.

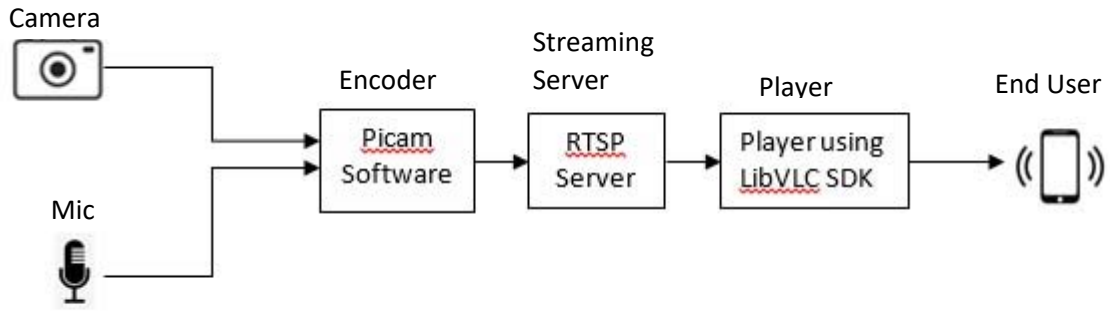

Figure 2

3.2 AUDIO RECORDING FEATURE

This function has two choices: the first is to record the infant's voice so that the parents can upload it to Firebase and then download it to the Raspberry Pi, as shown in Fig. 3.

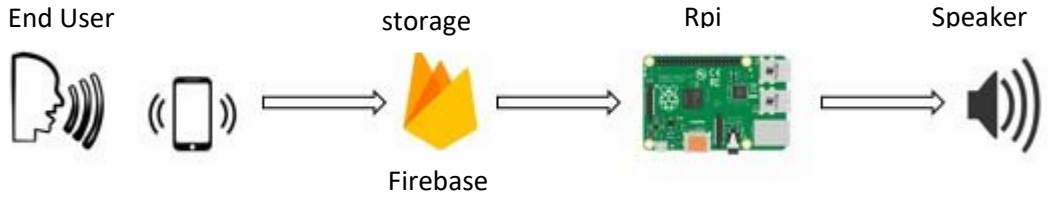

Figure 3

The other option, as indicated in Fig. 4, is to play audio content picked by the parents and previously stored in the application. We do this by connecting a particular speaker to the Raspberry Pi through an audio connection.

Speaker

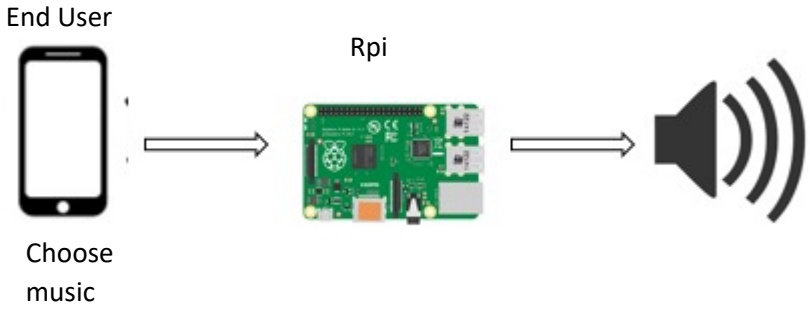

Figure 4

3.3 HUMIDITY AND TEMPERATURE FEATURES

The Raspberry Pi is equipped with ultra-low-cost temperature and humidity sensors for sensing the ambient temperature and humidity variation. As demonstrated in Fig 5, Firebase Real-time Database synchronizes and stores the sensor readings with a NoSQL cloud database. The format of the stored information is JavaScript Object Notation (JSON), and it can be delivered in real time to the client. Even if the app is in offline mode, the data is still accessible. To assist the infant sleep safely, the temperature in the infant's room should be between 16 and 23 degrees Celsius. After every fifive minutes, a python code runs on the device(Raspberry Pi), which senses the temperature change. A notification message is issued to the client via Firebase Cloud Messaging if the temperature is greater than 23C or lower than 16C, informing the parents of the unusual temperature level.

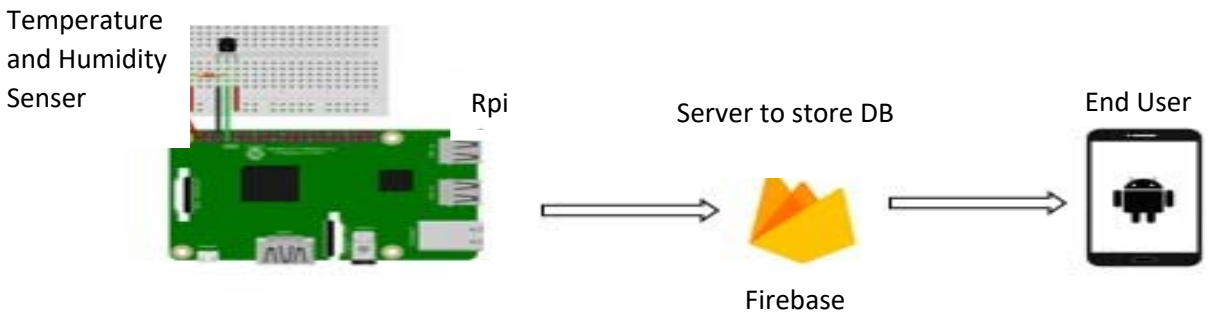

Figure 5

3.4 SLEEP/ AWAKE DETECTION FEATURE

Today, the human eye-gaze, blinking and eye movement can be recorded with relatively high reliability by unobtrusive techniques. Though, there are relatively few techniques proposed for the active scene where the head and the camera move independently, and the eye moves freely in all directions independently of the face. Though, care must be taken, that eye-gaze tracking data is used in a sensible way, since the nature of human eye movements is a combination of several voluntary and involuntary cognitive processes. The blinking of an eye is the rapid closure and opening of a person's eye. Each person's blinking pattern is slightly different. The speed with which the eye closes and reopens, squeezing degree the eye, and the duration of the blink all varies. The blink of an eye lasts between 100 and 400 milliseconds. To locate the eyes and eyelid contours, we propose using state-of-the-art detectors for facial landmark. The eye aspect ratio (EAR), which is utilised as an approximation of the eye opening condition, is calculated from the landmarks observed in the picture. Because the per-frame eye aspect ratio (EAR) may not always accurately distinguish eye blinks, a classification model that considers a broader temporal window of a frame is developed.All the process is done with the help of OpenCv.

3.5 CRY DETECTION FEATURE

For parents who are separated from their infants, it is critical to have prompt notification in the event of infant's crying. For cry detection, we employ the Tensor Flow Model. Rather than raw audio, the model is built to deal using samples of frequency. This is because if we want to detect a certain audio, we need to know its "spectral" signature, which consists of a base frequency (or a restricted range within which the base frequency normally falls) and a collection of harmonics connected to it by certain ratios. Furthermore, neither amplitude (irrespective of the input volume, the frequency ratios are fixed) nor phase impact the ratios between such frequencies (irrespective of the recording start time, there will be same spectral signature of a continuous sound signal). When compared to the case where we just feed raw samples of audio to a model, this strategy is far more inclined to train a robust sound recognition model due to its time constant characteristic and amplitude. Furthermore, we can make this prototype simpler (by simply arranging frequencies into bins without compromising performance, it allows us to reduce dimensions effectively), and considerably lighter (it will include 50 to 100 frequency bands as input values, irrespective of sample period).

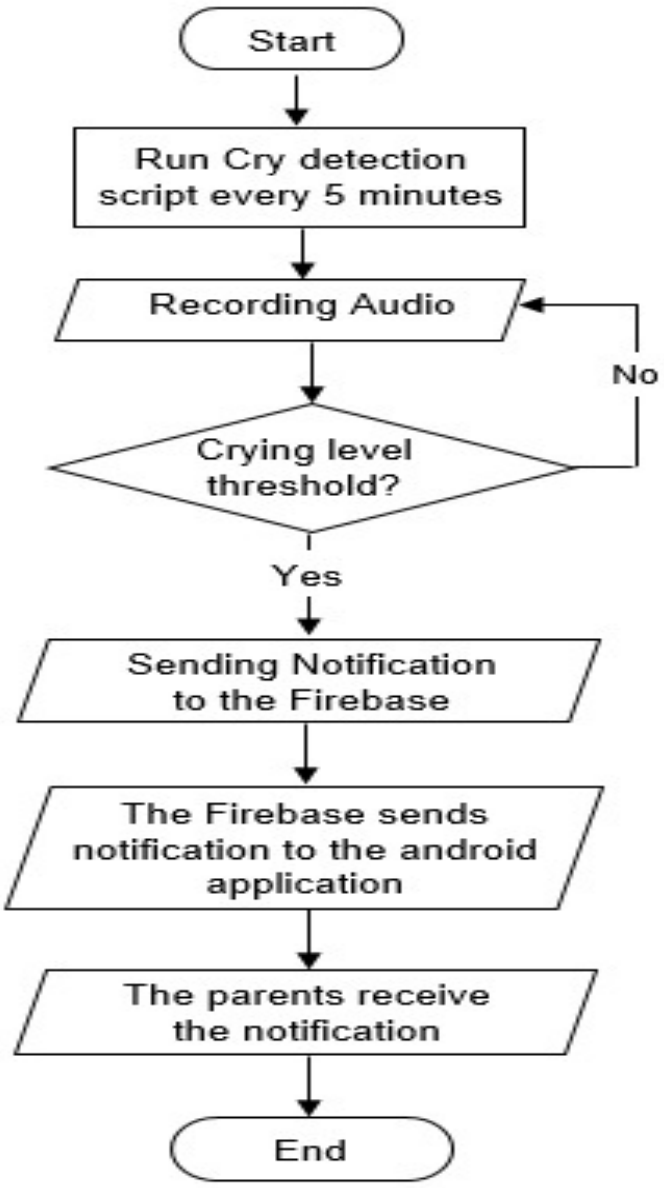
Start
Run Cry detection script every 5 minutes
Recording Audio
No
Crying level threshold?
Yes
Sending Notification to the Firebase
The Firebase sends notification to the android application
The parents receive the notification
End

Figure 6

3.6 EMOTION DETECTION

Using deep convolutional neural networks, this study seeks to categorise the emotion on an individual's face into one of seven categories. The model was developed using the FER-2013 database, which was presented at the International Conference on Machine Learning in 2013. (ICML). There are 48x48 sized, 35887 grayscale, face photos in this database, having seven different types of emotions - happy, sad, angry, afraid, neutral, disgusted and astonished. The depository is compatible with tensorflow-2.0 and by using the tensorflow.keras library makes use of the Keras API.

3.7 ANDROID APPLICATION

Flutter was used to create an android application which is simple and easy to use.

Google's Flutter is an open-source user interface used for software development. Cross-platform apps can be created from a single codebase for iOS, Linux, Android, Windows, web, Google Fuchsia, and the Mac.

4. HARDWARE REQUIRED

1) Raspberry Pi 4 Model B
2) Raspberry Camera Module v2
3) DHT11-Temperature and Humidity Sensor
4) USB Microphone
5) 16 GB Micro SD Card
6) Speaker
7) Premium jumper wires
8) Resistors
9) Breadboard

4.1 HARDWARE INTEGRATION

Figure 7

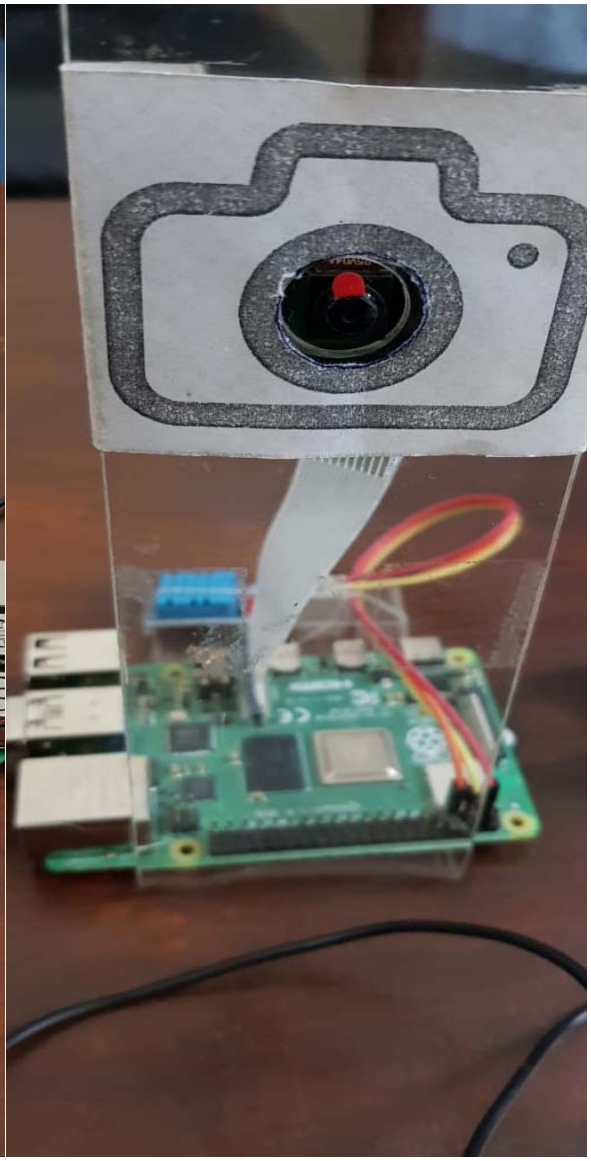

Figure 8

5. CONCLUSION

The major goal of this project is to develop a smart baby monitoring system that allows the caretakers to monitor and interact with their children. We discovered some infant monitoring systems in the literature, but they did not support all of the characteristics that a smart infant monitoring system should have. Compared to the previous systems, ours can support six different features on a single system while maintaining all of the needed attributes. Nonetheless, the heartbeat-measuring feature is not supported by our suggested system. Furthermore, our smart system can detect seven various sorts of emotions, including joyful, sad, disgust, angry, neutral, afraid, and surprised. It can also notify parents if there are any unusual circumstances, such as a high temperature or a screaming baby.

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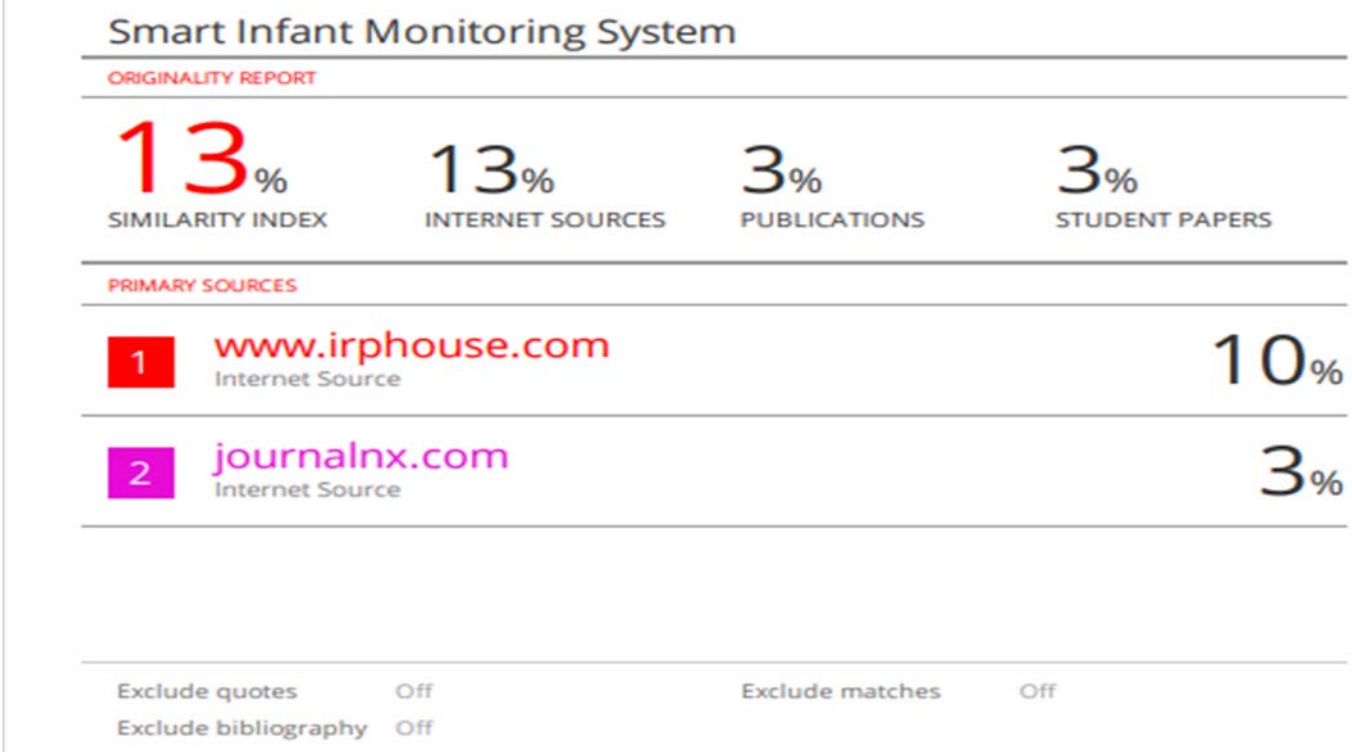

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