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Infant Emotion Monitoring And Soothing System Using Multisensory Feedback

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ABSTRACT :

The Baby Monitoring System is an advanced, dual-functional project that integrates both hardware and software components to ensure the safety and comfort of infants. The hardware system, based on Arduino UNO, focuses on real-time baby care by detecting crying sounds, monitoring cradle conditions, and automating responses. When the Sound Sensor detects the baby's cry, the system triggers a soothing music playback via an MP3 module and automatically rocks the cradle using a Servo Motor (MG996R). The OLED display shows the crying intensity, categorized as low, medium, or high, while an SMS notification is sent to the parents using Bluetooth module. Additionally, a Moisture Sensor monitors for wetness in the cradle, triggering an SMS alert to the parents for immediate action. The software component complements the hardware by incorporating a facial recognition system using a web camera and Python's Open CV library. The system can detect emotions baby faces, ensuring unique identification and enhanced monitoring capabilities. The software runs on a laptop and provides the recognized face details on-screen This comprehensive monitoring system enhances infant care by automating responses to crying, providing real-time notifications, and enabling facial recognition-based identification. It is a user-friendly and cost-effective solution designed to assist parents in ensuring their baby's well-being and safety.

PROBLEM STATEMENT :

Infants, especially newborns, are unable to express their emotions effectively, leading to potential distress and discomfort. Current baby monitoring systems lack real-time emotion detection capabilities, relying on caregivers' manual monitoring and subjective emotional assessments. This can result in delayed responses to infant distress, potentially impacting their emotional and psychological development."

Our project aims to develop an affordable, real-time monitoring system that uses a multi-stream CNN fusion network to integrate both audio and facial expression data, deployed on the Arduino microcontroller, to improve the accuracy of infant emotional state detection and alert caregivers promptly.

INTRODUCTION :

Crying is an infant's primary and most effective form of communication. While a mother might be attuned to her baby's cries, to most others, these cries often seem indistinguishable and uniform. In today's fast-paced world, where both parents often juggle demanding careers, providing adequate time and care for a baby becomes increasingly challenging. This challenge was further amplified during the COVID-19 pandemic, as remote work blurred the boundaries between professional responsibilities and parenting. The situation becomes even more demanding when the baby is unwell, requiring constant attention and leading parents to take time off work, impacting their careers and increasing stress levels. To alleviate these challenges, there is a growing need for technology that can assist parents in monitoring and understanding their baby's needs. Since most adults find it difficult to accurately distinguish the types of cries based on sound and facial expressions alone, an automated system for cry classification becomes invaluable. This research focuses on categorizing an infant's cries into five distinct emotional states: pain, hunger, anger, sadness, and fear. The proposed system leverages a multi-stream convolutional neural network (CNN) to simultaneously and independently analyse audio and visual data for improved accuracy. By deploying this system on an ARDUINO microcontroller, the project offers a low-cost, energy-efficient solution capable of real-time operation. This technology can be particularly beneficial in smart homes, daycare centres, and hospitals, providing continuous monitoring and empowering caregivers to respond promptly to an infant's needs.

LITERATURE SURVEY :

A. Gupta, S. Kumar, and P. Sharma, International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE), 2018. This paper presents an automated baby monitoring system that detects the baby's cry using a sound sensor and activates a soothing response like music playback. The system uses a microcontroller (Arduino) to trigger a servo motor for automatic cradle rocking. SMS notifications are sent to parents using a GSM module. The study highlights the importance of real-time monitoring and automatic responses to ensure infant comfort [1].

J. Lee, H. Kim, and R. Park, IEEE Internet of Things Journal, 2019. The authors discuss a comprehensive IoT-based smart baby monitoring system capable of detecting baby sounds, monitoring room temperature, and analyzing the baby's comfort level. The system sends real-time alerts to parents through IoT-based notifications on smartphones. The study emphasizes the integration of multiple sensors, including sound, temperature, and humidity sensors, to improve baby care [2].

K. Ramesh and L. Devi, International Journal of Embedded Systems and Applications (IJESA), 2024. This work focuses on using moisture sensors to detect wet diapers in infants, triggering a notification system for parents. The system employs a microcontroller and wireless communication modules for alerting caregivers. The authors highlight how moisture detection can improve the hygiene and health of infants [3].

T. Suzuki, N. Tanaka, and Y. Watanabe, Journal of Machine Learning Research (JMLR), 2021. This paper introduces a facial recognition system for identifying infants in childcare environments. Using machine learning algorithms and OpenCV-based image processing, the system identifies multiple faces with high accuracy. The study also discusses the practical challenges of implementing face recognition for babies due to their dynamic facial features [4].

M. Ahmed, N. Patel, and S. Rao, International Conference on Smart Systems and IoT (ICSSI), 2017. The authors describe an automated cradle movement system triggered by a baby's crying sound. The system uses sound sensors to detect crying and activates a servo motor for gentle cradle movement. The study demonstrates how automation can soothe the baby without manual intervention [5].

OBJECTIVES :

Develop an Automated Baby Monitoring System

Design a hardware-based solution using Arduino UNO to monitor and respond to critical baby conditions like crying and cradle wetness.

Detect and Analyze Baby's Crying Sound

Implement a sound sensor to detect the baby's cry and display the information on an OLED screen.

Provide Real-Time Soothing Mechanisms

Automatically play soothing music using an MP3 module and activate cradle rocking through a servo motor (MG996R) to comfort the baby.

Send Real-Time Notifications to Parents

Use a Bluetooth module to send SMS alerts to parents in response to the baby crying or wetness in the cradle.

COMPONENTS

Hardware:

1.Sound Sensor (Cry Detection)

A sound sensor in a baby monitoring cradle works by detecting sound waves, such as a baby's cry, through a microphone.
If the sensor detects crying, the following actions are triggered:
OLED Display: Displays the intensity of the crying as low, medium, or high.
MP3 Module and Speaker: Starts playing soothing music to calm the crying baby.
Servo Motor (MG996R): Activates automatic cradle movement to comfort the crying baby.
Bluetooth Module: Sends an SMS notification to parents mobile, alerts them that the baby is crying.

2.Moisture Sensor (Wetness Detection)

A moisture sensor is an electronic device used to detect the presence and level of moisture or water in a medium. In the context of a baby cradle monitoring system, it is primarily used to identify wet diapers or spilled liquids on the bedding, ensuring the baby's comfort and hygiene.
If wetness is detected, the following actions occur:
Bluetooth Module: Sends an SMS notification to the parents to inform them that the baby is crying and it needs attention.
The other responses are not triggered to avoid unnecessary actions.

3.Bluetooth Module (SMS Alerts)

The Bluetooth module transmits SMS notifications to the parent's phone using connected mobile application or communication module. Messages include the condition of the baby, such as:

"Baby is crying. Please check immediately."
"Cradle is wet. Please attend to the baby."

4.Servo Motor (Cradle Movement)

The servo motor (MG996R) controls the rocking movement of the cradle. When a crying sound is detected, the motor is activated to initiate gentle cradle movement to soothe the baby.

5.OLED Display (Status Display)

The OLED display provides visual information about the system's operation: Crying intensity (Low, Medium, or High), System status, such as "Music Playing" or "Cradle Moving.", Alerts related to moisture detection.

Software:

1. **Web Camera Input**

A webcam continuously captures video frames of the baby's face.

2. **Face Detection**

Open CV's Haar Cascade Classifier or Dlib library detects the baby's face with the video stream.

3. **Face Recognition**

Pre-trained facial recognition models are used to identify up to 5 unique baby faces.
The system can distinguish and identify each baby based on previously stored facial data.

4. **Output Display**

The facial recognition result, including the baby's identification and country, displayed on the laptop screen.
This feature is particularly useful in childcare centers or hospitals where multiple babies may need monitoring.

WORKING :

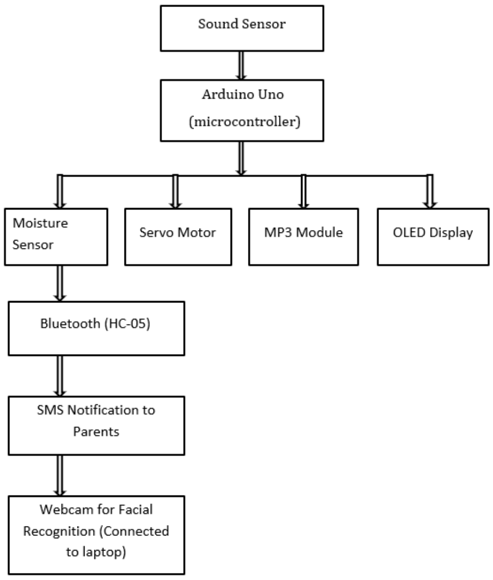


Fig 1:Block Diagram of the cradle system

The block diagram in fig 1 works according to the flow described below:

1.Data Collection:

* Sound Sensor: Monitors continuously for sounds from the baby.
* Moisture Sensor: Checks the cradle for wetness.
* Webcam: Captures images of the baby's face.

2. Processing of the data collected:

* Arduino Uno (Microcontroller):
* Receives data from both the sensors that is moisture and sound sensor.
* Processes the data to take up any actions needed to be taken (e.g., playing a lullaby, alerting parents).
* Controls the motor to rock if the baby is crying.
* Sends data to the OLED Display to show present status and readings of the sensors.
* Laptop (with Facial Recognition Software):
* Receives images from the Webcam.
* Analyzes the image to detect facial expressions and emotions.

3. Communication and Control:

* Bluetooth (HC-05):
* Enables wireless communication between the cradle system and external devices (e.g., smartphones, tablets).
* Allows remote monitoring of the baby's status.
* SMS Notification:
* Sends text messages to designated caregivers to alert them of important events (e.g., crying, diaper change).
* OLED Display:

* Provides a visual interface for the system.
* Displays information like baby's state, sensor readings, and alerts.
* MP3 Module:
* Plays pre-recorded audio files (e.g., lullabies) based on the system's logic or user input.

4. Decision Making:

* The Arduino processes the data from all sources (sound, moisture, facial expressions) to determine the appropriate course of action. This might include:
* Playing a soothing sound.
* Rocking the cradle.
* Sending an alert to the caregiver.
* Activating the diaper-changing mechanism.

Overall Flow:

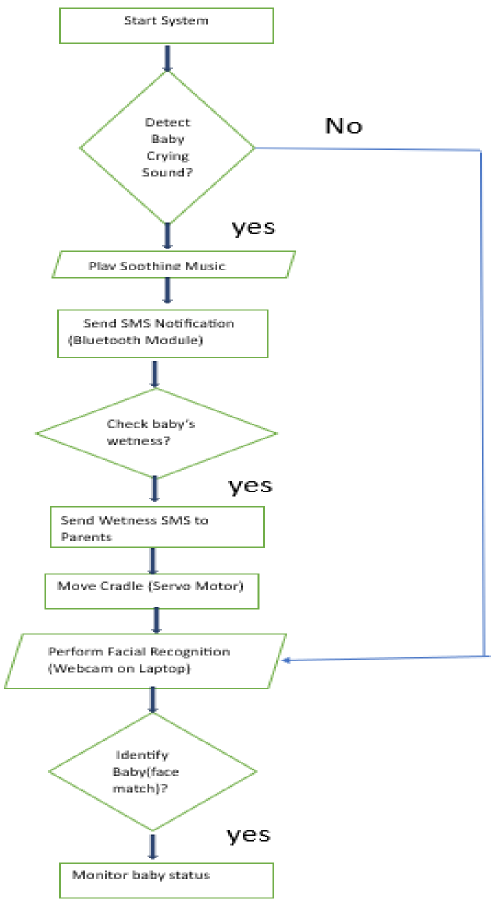
* Sensors gather data.
* Arduino processes data and controls components.
* Communication modules enable remote monitoring and control.
* Facial recognition software analyzes emotions.
* System takes appropriate actions based on the combined data.

FLOWCHART

.For the working of hardware

1. Start
2. Sound Sensor Input → Detect crying sound.
   If crying is detected → Activate Music Playback, Servo Motor, and SMS Alert.
3. Moisture Sensor Input → Detect wetness.
   If wetness is detected → Send SMS Alert.
4. Webcam Input → Capture baby's face.
5. Face Recognition → Identify face and country.
6. Output Display → Display results on laptop and OLED screen.
7. Stop

Fig 2 Flowchart for infant monitoring system



For the working of software

1. Start

- Explanation: The program begins by initializing essential components like importing libraries and loading pre-trained models.
- Code:

```
import cv2
import numpy as np
import time
from tensorflow.keras.models import load_model
import json
```

2. Load Emotion Detection Model

- Explanation:
  - Load the pre-trained model (baby_emotion_model.h5) for emotion detection.
  - Handle errors if the model file is missing or corrupted.
- Code:

```
try:
    emotion_model = load_model('baby_emotion_model.h5')
print("Model loaded successfully.")
except OSError as e:
print("Error loading model:", e)
exit()
```

3. Load Emotion Labels

- Explanation:
  - Load class_indices.json, which contains emotion labels like "Happy", "Sad", "Neutral", etc.
  - Handle errors if the file is not found.
- Code

```
try:
    with open('class_indices.json', 'r') as f:
    class_indices = json.load(f)
    emotion_labels = list(class_indices.keys())
print("Class indices loaded successfully.")
except FileNotFoundError:
print("Error: Class indices file not found.")
exit()
```

4. Initialize Face Detection

- Explanation:
  - Load the Haar Cascade model for detecting faces in the webcam feed.
  - Use a pre-trained haarcascade_frontalface_default.xml.
- Code:

```
face_cascade = cv2.CascadeClassifier(cv2.data.haarcascades + 'haarcascade_frontalface_default.xml')
```

5. Start Webcam Feed

- Explanation:
  - Use OpenCV's VideoCapture to start capturing video from the webcam.
  - Check if the webcam feed is functioning properly.
- Code:

```
cap = cv2.VideoCapture(1)
```

6. Main Processing Loop

The program continuously processes frames until the user exits by pressing 'q'.

6.1 Capture Frames

- Explanation:
  - Capture frames from the webcam.
  - Convert each frame to grayscale for efficient face detection.
- Code:

```
ret, frame = cap.read()
gray = cv2.cvtColor(frame, cv2.COLOR_BGR2GRAY)
```

6.2 Detect Faces

- Explanation:
  - Use Haar Cascade to detect faces in the grayscale frame.
  - Each face is returned as a rectangular region.
- Code:

```
faces = face_cascade.detectMultiScale(gray, scaleFactor=1.1, minNeighbors=5, minSize=(30, 30))
```

6.3 Process Each Face

For every detected face:

1. Crop and Preprocess the Face:
   - Extract the face region, resize it to (48, 48) pixels, normalize the pixel values, and prepare it for model prediction.

```
face_crop = gray[y:y + h, x:x + w]
face_crop = cv2.resize(face_crop, (48, 48)).astype('float32') / 255.0
face_crop = np.expand_dims(face_crop, axis=-1)
face_crop = np.expand_dims(face_crop, axis=0)
```

2. Predict Emotion:
   - Use the pre-trained model to predict the emotion.
   - Find the emotion with the highest confidence score.

```
emotion_prediction = emotion_model.predict(face_crop)
confidence = np.max(emotion_prediction)
max_index = np.argmax(emotion_prediction)
emotion_label = emotion_labels[max_index]
```

3. Check Confidence Threshold:
   - Display the detected emotion if confidence > threshold; otherwise, display "Uncertain".

```
if confidence > confidence_threshold:
cv2.putText(frame, f"{emotion_label}", (x, y - 10), cv2.FONT_HERSHEY_SIMPLEX, 0.9,         (255, 0, 0), 2)
else:
cv2.putText(frame, "Emotion: Uncertain", (x, y - 10), cv2.FONT_HERSHEY_SIMPLEX, 0.9, (0, 0, 255), 2)
```

6.4 Periodic Image Capture

- Explanation:
  - Capture and display the face region with its detected emotion every 50 seconds.
- Code:

```
current_time = time.time()
if current_time - last_capture_time >= capture_interval:
last_capture_time = current_time
captured_image = frame[y:y + h, x:x + w]
show_captured_image(captured_image, emotion_label)
```

6.5 Display the Frame

- Explanation:

- Display the video feed with detected faces and emotion labels.

```
cv2.imshow('Emotion Detection', frame)
```

7. Exit Program

- Explanation:
  - Release resources and close the program when the user presses 'q'.
- Code

```
if cv2.waitKey(1) & 0xFF == ord('q'):
break
cap.release()
cv2.destroyAllWindows()
```

WORKING PROJECT IMAGES :

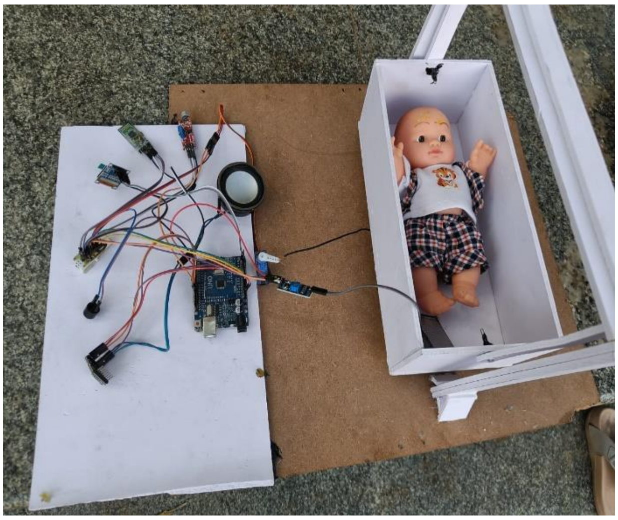


Fig 3

Fig 4

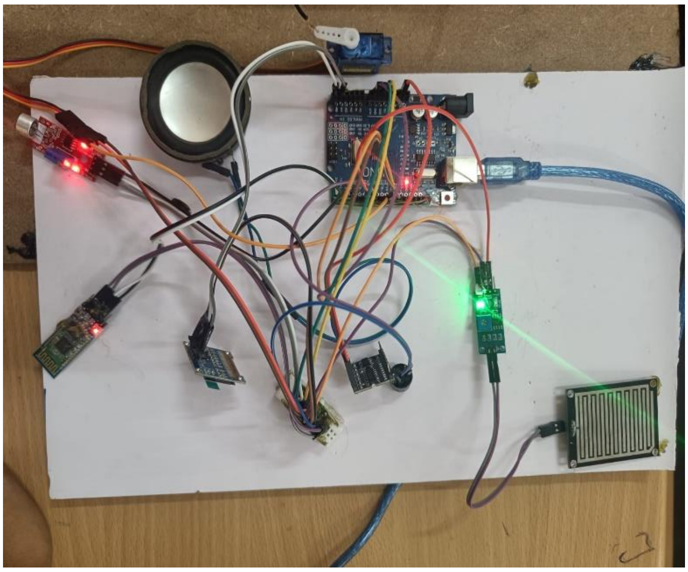


Fig 5

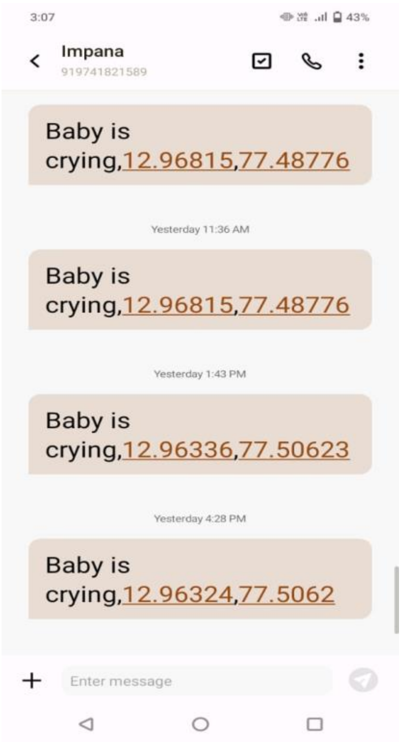


Fig 6

In the above figures 3,4 and 5, we have connected all the components listed above according to the pin diagram in to meet the expected outcome. This hardware implementation of the baby cradle along with the other components and sensors which works along to produce the expected results.

And the fig 5.6 shows the alert messages given to the parent when the baby gets wet and starts crying and a SMS notification is sent using the Bluetooth module HC-05.

When the baby urinates in the cradle, the GSM gives the alert to the parent through the SMS and when the baby is crying the camera and microphone capture the face and audio and using the algorithms the system detect the expression(happy, cry, anger, sadness and neutral) and gives it to the parent along with the movement of the cradle with servomotors and the soothing music plays on so that the baby can calm down.

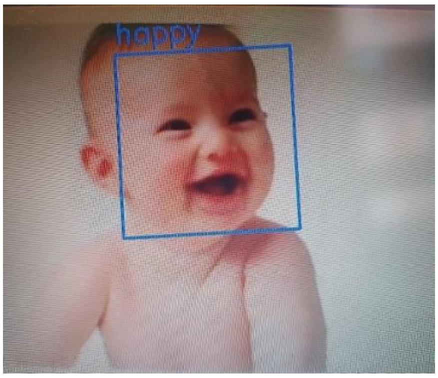


Fig 7

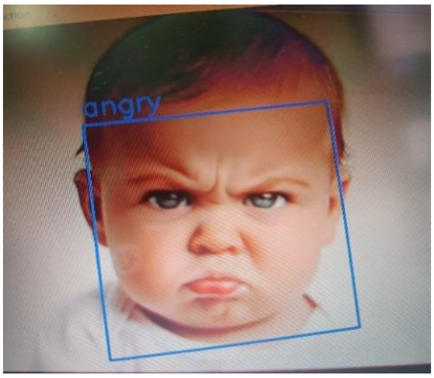


Fig 8

Fig 9

Fig 10

Fig 11

The fig 7 shows the first emotion detected of the baby using datasets given by us and the baby's emotion in the picture is happy and in the second picture that is fig 8 , the emotion detected is angry.

Next in the fig 8 the emotion detected is sad that is the baby will be crying caused by any irritation or while being uncomfortable. The fig 9 depicts the emotion of the baby when it is surprised and

fig 10 shows the emotion of a state when the baby is neutral with no expressions. These are results of the face emotion detection part.

CONCLUSION :

The Baby Monitoring System demonstrated effective integration of hardware and software components to create a reliable and responsive baby monitoring solution. The system successfully detects crying and moisture, notes parents via SMS, moves the cradle, and provides facial recognition for identifying the baby. While the system performed well under ideal conditions, certain environmental factors such as lighting and sensor calibration must be optimized for better accuracy and performance. Future improvements in sensor quality, facial recognition, and communication systems can further enhance the reliability and functionality of the system.

Our system provides convienient and reliable cradle which is more efficient than the normal or traditional cradle which guarantees safety when no one present near the baby.And modern parents can understand their emotion via camera and analyse the situation of the baby.

FUTURE SCOPES :

The baby monitoring cradle system has certain potential to evolve into a sophisticated AI, and IOT-enabled solution for modern parents. These advancements would not only enhance convenience and peace of mind for parents but also ensure a safer, healthier, and more comfortable environment for babies.Further we can integrate machine learning and find out the routine of the babies activities and direct the parents with those from time to time reminders.

ACKNOWLEDGMENT

The fulfillment that comes with the successful completion of this significant project would be incomplete without acknowledging the individuals who made it possible. Their unwavering support and encouragement played a pivotal role in ensuring the project's success. We extend our heartfelt gratitude to Dr. Ambedkar Institute of Technology for its inspiring ideals and for providing us with the facilities that enabled this achievement. We are deeply thankful to our Principal, Dr. Thippeswamy, for his constant support and for fostering an environment conducive to productive work. Our sincere appreciation goes to Dr. Jambunath Baligar, Professor and Head of the Department of Electronics and Communication Engineering, for his valuable support throughout the process. Finally, we express our profound gratitude to our mini-project guide,

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