BabyGuardian – Always watching, always caring

For

Internet of Things (IoT) Project

Higher National Diploma in Software Engineering 24.1F

Project Proposal

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1. Abstract

This project, BabyGuardian, is an innovative smart IoT solution that is built to support parents and caregivers by enhancing infant safety and comfort. Utilizing various IoT technologies, the system tracks essential features like room temperature, infant motion, sound levels etc. in real time. It delivers immediate alerts and intelligent responses to specific changes. The goal is to minimize the stress level of constant monitoring while providing user friendly tools which is integrated with mobile apps for parents and caregivers to care their babies 24/7.

2. Acknowledgement

We are especially grateful to our module advisor, **Mr. Bathiya Seneviratne**, for his continuous support, insightful comments, and valuable guidance throughout the development of the *BabyGuardian* smart baby monitoring system. The success of this project is a result of dedicated teamwork and collaborative efforts, with each member contributing unique ideas and skills to refine and complete the system. We also wish to thank our peers who shared constructive feedback and encouragement, helping us enhance both the technical and practical aspects of the project. We deeply appreciate the contributions of open-source communities and IoT development platforms, which provided access to essential tools, code libraries, and documentation that enriched our learning experience. These resources enabled us to explore and experiment with various sensors, components, and communication methods, ultimately shaping the functionality of BabyGuardian. The support of our educational organization and the availability of laboratory facilities were also instrumental in building and testing our prototypes. Lastly, we extend heartfelt thanks to our families for their constant motivation, patience, and understanding during the many late nights and long hours we spent bringing this project to life.

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3. Introduction

In today's world, struggling with professional responsibilities and baby care can be a problem for many parents and caregivers. Factors like maintaining a comfortable environment and ensuring the baby's safety are essential hard to manage constantly. To overcome this challenge. I came up with BabyGuardian – AI smart baby monitoring system which is designed to provide the intelligent for parents and caregivers. This system keeps the tracks of key features like room temperature, noise levels, movement and lighting to create a secure and safety space for babies. The BabyGuardian app allows the users (parents or caregivers) to get any alerts about specific features very user friendly and make it the most efficient tool built yet. With these parents and caregivers can reduce stress levels and empowers with peace of mind and better care for little ones,

4. Problem Definition

- ✓ Many parents or caregivers struggle to monitor their babies every day due to their busy work, household duties and everyday responsibilities.
- ✓ Lack of continuous supervision can lead to missed moments where the baby needs immediate attention.
- ✓ Limited monitoring without knows in traditional method.
- ✓ Sudden Temperature rises, abnormal movements or changes in surrounding environment.
- ✓ Strong need for monitoring the babies with real time insights.
- ✓ Continuous tracking, smart analytics and automated responses through mobile app.
- ✓ Parents or caregivers provided with peace of mind even when they are away from the child.

5. Objectives

- ✓ **Main Objective**: Provide a smart, reliable, and real-time baby monitoring solution to enhance infant safety, comfort, and well-being.
- ✓ **Stress Reduction**: Reduce the burden and stress on parents and caregivers by automating and simplifying monitoring tasks.
- ✓ **Continuous Monitoring**: Track key environmental and behavioral parameters such as:
    - Room temperature
    - Body temperature
    - Humidity
    - Light levels
    - Sound
    - Motion
    - Air quality
- ✓ **Proactive Alerts**: Use smart sensors and wireless communication to send real-time alerts for situations like:
    - Overheating
    - Poor air quality
    - Unusual noise or motion
    - Potential fire hazards
- ✓ **Automated Soothing Actions**:
    - Swing cradle when baby cries
    - Turn on lights when it gets dark
- ✓ **Remote Monitoring**: Enable parents to monitor and respond to their baby's condition from a distance using IoT and push notification features.
- ✓ **Technology Integration**: Leverage IoT to bridge the gap between parenting and smart technology.
- ✓ **Affordability & Efficiency**: Aim for an affordable, energy-efficient, and user-friendly system suitable for modern homes.

- ✓ **Overall Impact**: Promote a safer, smarter, and more nurturing environment for infants.

6. Proposed System

The solution is an **IoT-based smart baby monitoring system** that provides:

- **Real-time monitoring and alerts**
- **Environmental sensing** (temperature, humidity, air quality)
- **Activity detection** (motion and sound)
- **Automatic cradle swing** based on baby motion or sound
- **Fire alert system** (smoke + heat triggers buzzer)
- **Comfort adjustment** (e.g., triggering AC or heater based on temperature)
- **Wet diaper alert** (based on baby's weight + moisture detection)
- **Light automation** (if LDR detects darkness and baby is present

7. Methodology

The development of the BabyGuardian smart baby monitoring system was carried out using a well-organized and practical approach that included research, system design, implementation, and testing phases to ensure a dependable and efficient solution. The process started with thorough background research and problem analysis, where I explored common challenges faced by parents and reviewed the limitations of existing baby monitoring systems. This helped me identify key missing features and areas where improvements were needed.

Using these insights, I designed the system based on an IoT framework, integrating various sensors to monitor different parameters. These included the DHT11 for tracking room temperature and humidity, MLX90614 for measuring body temperature without contact, KY-038 for detecting sound, HC-SR501 for motion sensing, MQ-135 for air quality monitoring, and an LDR for ambient light detection. These sensors were connected to microcontrollers like the Arduino Uno and ESP32, which served as the main processing units.

To support real-time monitoring and communication, I used modules such as the ESP8266 for Wi-Fi connectivity and HC-05 for Bluetooth communication. The system's firmware was programmed using C/C++ for Arduino and Python scripts for handling the Wi-Fi module, while the MQTT protocol was used for reliable and lightweight messaging between devices and the user interface.

After finalizing the circuit design, the components were assembled on a breadboard, and each sensor was tested individually to verify functionality. This was followed by full system integration and testing to ensure stable performance and accurate data collection. Power was supplied using a 12V adapter, regulated to 5V with an LM7805 voltage regulator for consistent output to the components.

Finally, the prototype was deployed in a simulated environment to assess how well it performed under real-world conditions. Special attention was given to response time, system stability, and ease of interaction. Based on observations and simulated scenarios, adjustments were made to enhance the system's accuracy, minimize false alerts, and improve overall user experience.

8. Hardware & Software Requirements

Sensor/Component	Function
DHT11	Measures Temperature & Humidity
MLX90614	Detects Body Temperature
KY-038	Detects Sound
HC-SR501	Detects Motion (PIR Sensor)
MQ-135	Detects Air Quality / Smoke
LDR	Detects light is turn on or not
MG995 Servo	Used to swing the cradle
16x2 LCD	Displays key values or status
Buzzer	Triggers audible alerts
ESP8266/HC-05	For Wi-Fi / Bluetooth Connection
Arduino Uno / ESP32	Microcontroller for system logic
LM7805 Voltage Regulator	Provides a stable 5V output to microcontrollers and sensors

Software/Tool	Purpose
Arduino IDE	Programming the Arduino uno and ESP32 microcontrollers
Python (ESP8266 scripts)	To handle WiFi communication and data processing
MQTT Protocol	Real-time communication between devices and mobile app
Mobile App	Receive alerts (could use services like Blynk or Firebase)
Simulation Tools (Optional)	For pre-deployment testing of code and hardware logic

9. Existing Research & Literature Review

In recent years, significant advancements in Internet of Things (IoT) and sensor-based technologies have enabled the development of intelligent baby monitoring systems that go beyond traditional audio and video monitoring. Existing research highlights the limitations of conventional baby monitors, which often lack real-time data processing, adaptive automation, and multi-sensor integration. Studies such as those conducted by Zhang et al. (2020) emphasize the importance of incorporating environmental sensing and automated alert mechanisms to enhance infant safety and parental convenience. Literature also points to the growing demand for systems capable of detecting not just audio cues like crying, but also physical conditions such as body temperature, humidity, air quality, and motion, as observed in projects like "Smart Infant Monitoring Using IoT" (Patel & Mehta, 2019), which used sensors and a microcontroller to send alerts through a mobile app. Moreover, research by Kumar and Singh (2021) explored the integration of machine learning with sensor data to minimize false alarms and improve decision-making accuracy, showing the potential for predictive analytics in baby care. Several systems also explored the use of GSM and Wi-Fi modules for remote monitoring, yet many lacked a combination of both environmental tracking and actuator-based responses like automatic cradle swinging or light control. These studies collectively demonstrate the effectiveness of smart sensor networks in enhancing infant care but also reveal gaps in automation, user customization, and integrated real-time alerts—gaps that the BabyGuardian system aims to fill by offering a more holistic and responsive approach to baby monitoring.

10. Discussion

The design and development of the BabyGuardian smart monitoring system reflect the potential of combining IoT technologies with sensor-based networks to create a reliable and real-time baby care solution. Throughout the process, the system effectively showcased its ability to track essential environmental and behavioral conditions, including room temperature, humidity, motion, sound, air quality, and more. With the inclusion of automated features like cradle swinging and light control, BabyGuardian provides an added layer of comfort and safety for infants, especially when direct parental supervision is limited due to other responsibilities.

During testing, the system performed well in terms of accuracy and consistency, successfully collecting sensor data and delivering instant alerts via wireless communication. Key hardware elements, such as the LM7805 voltage regulator for managing a stable power supply and the use of MQTT for lightweight and efficient communication, helped improve the overall functionality and dependability of the system.

That said, certain challenges were encountered, including handling occasional false alerts, maintaining steady connectivity, and optimizing energy usage. These were addressed through fine-tuning and calibration of both hardware and software components. The project also emphasized the need for easy-to-use interfaces and clear alert systems, ensuring that parents or caregivers can respond to emergencies quickly and confidently.

While BabyGuardian has successfully addressed many shortcomings of conventional monitoring tools, there is still room to grow. Future improvements could include the addition of a mobile app dashboard for better remote control, AI-powered prediction features to detect abnormal patterns, and multi-user support for families with shared caregiving roles. Overall, the BabyGuardian project demonstrates how thoughtfully applied technology can support busy parents and promote safer, smarter care for infants.

11. Future Implementations

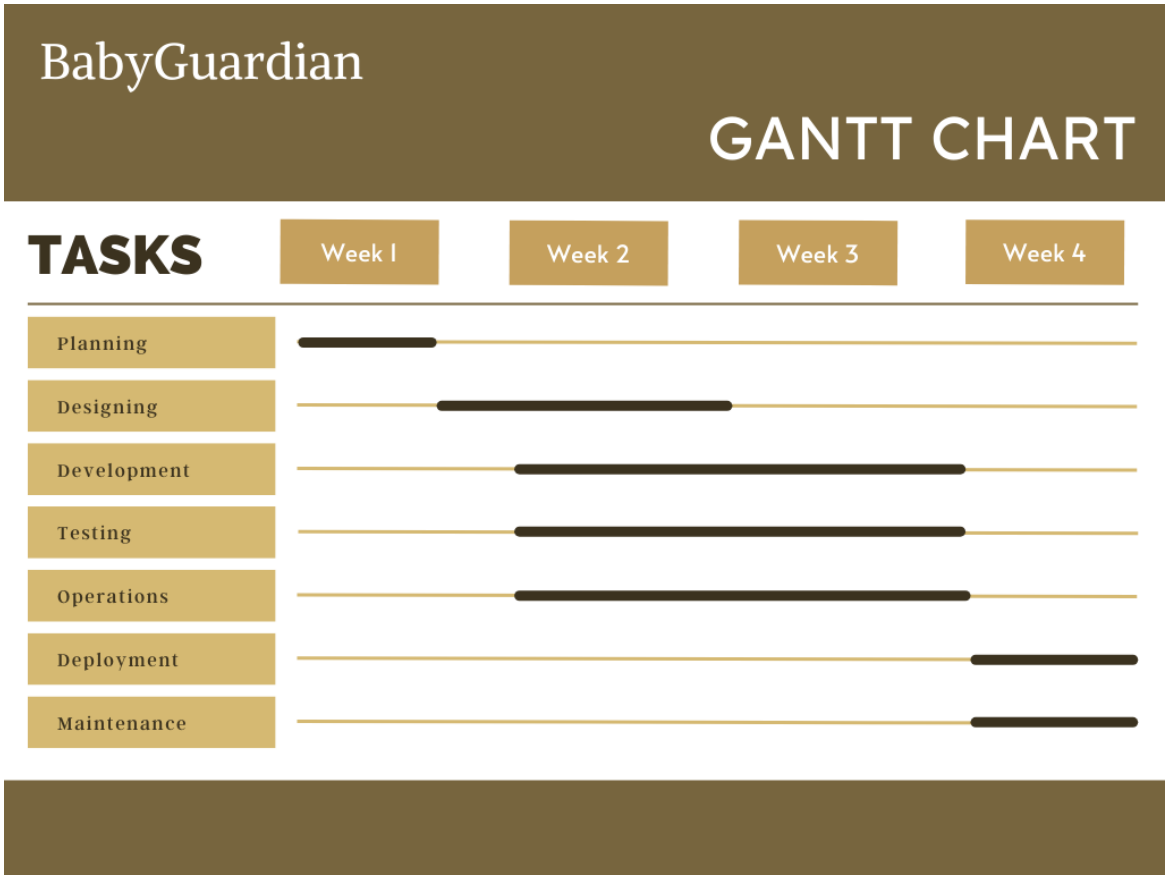
In the future, the BabyGuardian smart baby monitoring system can be enhanced with several advanced features to make it even more effective, flexible, and user-friendly. One of the main improvements would be the development of a dedicated mobile app that lets parents view live sensor readings, receive instant alerts, and control the system remotely from their smartphones—giving them more freedom and peace of mind, especially when they're not at home.

To take things a step further, integrating AI and machine learning could help the system recognize patterns and predict the baby's behavior or possible risks, which would also reduce the chances of false alarms. Another useful upgrade would be adding live video monitoring using IP cameras, with support for cloud storage to view both real-time footage and past recordings.

Making the system battery-powered with energy-efficient components, and even exploring solar charging options, could improve its portability and make it useful in places with limited power access—such as rural areas or while traveling. Security is also important, so adding features like encrypted data transmission and secure login would help protect user privacy.

Support for multiple user accounts would make it easier for both parents and other caregivers to share responsibilities. A modular design would allow users to add or remove specific sensors based on their unique needs, making the system more flexible and customizable. Altogether, these improvements would transform BabyGuardian from just a monitoring device into a smart, adaptable assistant that supports modern parenting in a truly meaningful way.

12. Timeline (Gantt Chart)



13. Budget (Estimated)

Component	Cost (LKR)
Arduino Uno R3	2,500
DHT11 Temperature & Humidity Sensor	330
MLX90614 Infrared Temperature Sensor	1,950
KY-038 Sound Sensor	140
HC-SR501 PIR Motion Sensor	250
ESP-32 WROOM Microcontroller	1,800
MG995 Servo Motor	1,290
MQ – 135 Gas Sensor	490
Light Dependent Resistor (LDR)	20
Regiform	780
MG995 Servo Motor	1,290
16x2 LCD Display with 12C Module	1,190
Buzzer	40
LED Indicators	10
Bread Board 400 (Small)	250
Jumper Wires	500
Resistors, Capacitors,etc…	200
Total	**13,030/=**

14. References

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