**Methodology**

**1. Research and Assessment**

• **Objective**: To establish a solid foundation for the smart cradle project by thoroughly researching existing technologies, user needs, and safety standards.

• **Activities**:

• **Literature Review**: Analyze current smart cradle systems and baby monitoring technologies to identify strengths, weaknesses, and gaps that the project can address.

• **Technical Feasibility**: Evaluate the availability and suitability of sensors, microcontrollers, and communication modules for the project.

• **Regulatory Compliance**: Research relevant safety standards and regulations that must be adhered to, ensuring the system is safe for use around infants.

• **Outcome**: A comprehensive understanding of the user needs, existing solutions, and the technical and regulatory landscape that informs the project scope and design.

**2. Define Project Scope**

• **Objective**: To clearly outline the project’s goals, deliverables, constraints, and expectations.

• **Activities**:

• **Core Functionalities**: Define the essential features of the smart cradle, such as detecting baby movements, monitoring sound levels, providing live video feeds, and ensuring safety through electricity leakage detection.

• **Constraints**: Establish boundaries including budget, time, hardware capabilities, and compliance with safety standards.

• **Deliverables**: List the key outputs of the project, including the fully functioning smart cradle system, documentation, and user manuals.

• **Outcome**: A well-defined project scope document that aligns with stakeholder expectations and guides subsequent development stages.

**3. Conceptual Design**

• **Objective**: To develop a high-level design of the smart cradle system, detailing how each component will interact to achieve the project’s goals.

• **Activities**:

• **System Architecture**: Create a block diagram illustrating the system’s architecture, highlighting the interactions between sensors, the Raspberry Pi, communication modules, and the user interface.

• **Subsystem Design**: Define the functionality of each subsystem (e.g., Sensor Subsystem, Processing Subsystem, Communication Subsystem) and their interdependencies.

• **Data Flow**: Outline the data flow from sensor input to processing and finally to user alerts and notifications.

• **Outcome**: A conceptual design that provides a clear blueprint for the detailed design and development phases.

**Block Diagram**:

Not yet

**4. Hardware Selection**

• **Objective**: To choose the most appropriate hardware components that will ensure the system meets its functional and performance requirements.

• **Activities**:

• **Sensor Selection**: Choose sensors for detecting baby presence (pressure sensor), sound (sound sensor), and monitoring video (NoIR camera).

• **Microcontroller**: Select the Raspberry Pi as the central processing unit for managing sensor data, processing, and communication tasks.

• **Communication Module**: Opt for a Wi-Fi module to enable remote monitoring and notifications.

• **Power Supply**: Plan for a reliable power supply that can support continuous operation without interruptions.

• **Outcome**: A finalized list of hardware components with sources, delivery times, and justifications for each selection.

**5. Software Development**

• **Objective**: To develop the software required for sensor data processing, system control, and user interaction.

• **Activities**:

• **Front-End Development**: Develop a user-friendly web interface using HTML, CSS, and JavaScript, enabling parents to monitor their baby remotely.

• **Back-End Development**: Implement the server-side logic using Flask, handling data processing, notifications, and communication with the Raspberry Pi.

• **Sensor Integration**: Write software to interface with the sensors, process their data, and trigger actions based on the conditions detected.

• **Communication Protocols**: Implement Wi-Fi communication to support real-time data transfer and alerts.

• **Outcome**: A fully functional software system that integrates seamlessly with the hardware to deliver all specified functionalities.

**6. Testing and Iteration**

• **Objective**: To ensure that the system is reliable, safe, and meets all functional requirements through rigorous testing and iterative refinement.

• **Activities**:

• **Unit Testing**: Test each sensor and component individually to ensure accurate readings and proper operation.

• **Integration Testing**: Verify that all subsystems (sensors, processing, communication, UI) work together without issues.

• **System Testing**: Simulate real-world scenarios, such as the baby crying or moving out of the cradle, to validate the system’s responses.

• **Iteration**: Refine the design based on test results, fixing any bugs and optimizing performance.

• **Outcome**: A reliable and robust system that has been thoroughly tested and refined to ensure safety and functionality.

**7. Documentation**

• **Objective**: To create comprehensive documentation that ensures the system can be understood, maintained, and effectively used.

• **Activities**:

• **System Documentation**: Document the overall system architecture, design decisions, and implementation details.

• **User Manuals**: Write clear and concise guides for parents on how to set up and use the smart cradle.

• **Maintenance Guides**: Provide instructions for maintaining the system, including software updates and hardware replacements.

• **Testing Reports**: Record all test cases, results, and issues encountered during the testing phase.

• **Outcome**: Complete documentation that supports the system’s use, maintenance, and future development.

**6. Functionality**

**(1) Baby Movement Detection Mode:**

The process for this mode will be:

a. The pressure sensor continuously monitors the changes of baby’s weight to detect weather the baby is in the cradle or not.

b. If the baby moves out the cradle, the pressure sensor will detect the unnormal changes of weight.

c. The Raspberry Pi processes the sensor data.

d. If a potential unnormal leaving is detected, an alert is immediately triggered:

- The system sends a notification to the parents via email or SMS.

- An audible alarm or light indicator activates on the cradle.

The primary function of this mode is to ensure the baby’s safety by continuously monitoring the baby’s position within the cradle. The system uses pressure sensors to detect if there is a unnormal changes of weight.

**(2) Baby Cry Detection Mode:**

The process for this mode will be:

a. The sound sensor monitors the ambient noise level in the cradle.

b. If the baby starts crying, the sensor detects the increase in sound levels.

c. The Raspberry Pi analyzes the sound data to confirm if it is a baby cry.

d. If the cry is confirmed:

- The system plays a soothing song or activates the cradle’s swinging mechanism to comfort the baby.

- The system sends a notification to the parents via email or SMS.

This mode ensures the baby’s comfort and well-being by detecting crying sounds and taking appropriate actions to soothe the baby. It also notifies the parents, keeping them informed of the baby’s condition.

**(3) Real-Time Video Monitoring Mode:**

The process for this mode will be:

a. The NoIR camera captures live video of the baby in the cradle.

b. The video feed is processed by the Raspberry Pi.

c. The video is streamed to the web interface, allowing parents to monitor the baby remotely.

d. The system logs video footage for later review if needed.

The primary function of this mode is to allow parents to visually monitor their baby in real-time from anywhere via a web interface. The camera provides a continuous video feed that can also be recorded for review, ensuring that parents are always aware of the baby’s condition.

**(4) Electricity Leakage Detection Mode:**

The process for this mode will be:

a. The system continuously monitors the electrical integrity of the cradle’s power supply.

b. Sensors detect any abnormal electrical currents that could indicate a leakage.

c. The Raspberry Pi processes the electrical data.

d. If a leakage is detected:

- The system immediately cuts off the power supply to prevent harm.

- An alert is sent to the parents via email or SMS to inform them of the issue.

This mode is designed to protect the baby from electrical hazards by monitoring the cradle’s power supply. If any electrical leakage is detected, the system quickly shuts off the power and alerts the parents, ensuring the baby’s safety.