Project Semester 4 (IoT)

**Socio-Technical Analysis Report**

Project Title: Face identity with tiny:bit and micro:bit

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# 1. Project Outline and Objectives

This project aims to develop an intelligent two-wheeled mobile robot capable of facial recognition using the Tiny:bit smart car kit integrated with a Micro:bit microcontroller. The robot is designed to detect, recognize, and respond to human faces in real-time, demonstrating the practical application of computer vision in embedded systems. By leveraging the Micro:bit's programmability and the Tiny:bit platform's expandability, the project seeks to explore the feasibility of implementing face recognition on resource-constrained hardware, while providing hands-on experience in integrating sensors, AI algorithms, and robotics. The robot can display recognized face identities on an LED matrix and store data locally, emphasizing educational value and practical prototyping.

# 2. Functional Requirements

* **Robot Assembly:** Construct a two-wheeled mobile platform with a caster wheel, battery, and Micro:bit integration.
* **Face Detection:** Use the K210 visual recognition module to detect and frame faces with white (unrecorded) or green (recorded) borders.
* **LED Visualization:** Display face identification numbers (0-2) on the Micro:bit's LED matrix.
* **Audio Feedback:** Play distinct melodies for different recognized faces.
* **Data Protection:** Play distinct melodies for different recognized faces.
* **User Interaction:** Allow users to withdraw from interactions and delete stored data.

# 3. Technologies Used

Outline/list the software and hardware components you intend to use for the project.

**Hardware:**

Micro:bit micro controller

Tiny:bit smart car kit

K210 visual recognition module with adjustable bracket

LED matrix on Micro:bit

**Software:**

Microsoft MakeCode for Micro:bit programming

Python-base K210\_models library for face recognition

Built-in Micro:bit music and LED control APIs

# 4. Social Analysis and Issues

## 4.1. Privacy Issues

Using the ISD Privacy Framework:

Physical Privacy:The robot operates in controlled environments(e.g., workspace), ensuring physical solitude for users who can physically remove or power off the device.

Social Privacy:Users can freely with draw from interactions by disabling the robot, as it does not enforce unsolicited engagement.

Psychological Privacy: The robot`s non-intrusive design(no unexpected sounds or behavious) minimizes psychological discomfort. Audio feedback is limited to predefined melodies, avoiding mental trauma.

Informational Privacy: Face data is stored locally on the robot, not transmitted to external servers. Users can delete data at any time, maintaining control over personal information. The system collects only necessary facial data for recognition, avoiding excessive data gathering.

## 4.2. Data Protection Issues

Data Minimization: The robot collects only the facial data required for recognition, limiting storage to 3 faces to prevent unnecessary data accumulation.

Data Subject Rights: Users can access, rectify, or erase their facial data by resetting the robot`s storage, ensuring full control over personal information.

Transparency: Users are provided with an informed consent document explaining data collection purposes(face recognition) and usage (local storage for identification)

Security safeguards: Facial data is protected using hash techniques to prevent unauthorized access. Local storage ensures no data transmission risks, and the system uses non-intrusive technology to avoid covert data collection.

## 4.3. Intellectual Property

Consider the IP of any software and hardware components you intend to use for the project. Also consider whether your project would (if marketed/sold) potentially infringe on any IP rights (e.g. copyright) of other products on the market.

Hardware & Software Components: The project uses commercially available Micro:bit, Tiny:bit, and K210 modules, which are open-source or licensed for educational use. The programming environment(Microsoft MakeCode) and libraries(k210\_models) are publicly accessible, with no proprietary infringements.

Market Infringement: The prototype is for educational purposes and not intended for commercial sale, so it does not risk infringing on existing IP rights in the market.

## 4.4. Stakeholder and Risk Analysis

Stakeholders: Primary stakeholders are the robot`s owners/users, who interact with the system and provide facial data.

### Positive Impacts:

Educational value for learning embedded system and AI.

Non-intrusive technology for safe human-robot interaction.

### Negative Risks & Mitigation:

**Physical Risks:** Potential hardware damage(e.g., battery overheating) or injury during assembly. Mitigated by following safety guidelines and using certified components.

**Privacy Risks:**  Data leakage if the robot is lost or stolen. Mitigated by local data encryption and the ability to remotely erase data.

**Ethical Risks:** Unauthorized data use. Addressed by requiring user consent and limiting data collection to explicit purposes.

# 5. Technical Analysis and Design

## 5.1. Functional Design and Non-Functional Requirements

Outline, in some detail, what the system will do and how it will do it. Use case and other UML diagrams may be useful here. Also consider non-functional requirements, which will help take account of the social issues previously considered.

### Functional Design:

1. **Robot Assembly:**  Mount Micro:bit on Tiny:bit chassis, attach K210 module to an adjustable bracket for optimal camera positioning.
2. **Face Recognition Workflow:** 
   1. K210 module detects faces and sends identification signals to Micro:bit.
   2. Micro:bit updates the face variable and displays the corresponding number on the LED matrix.
   3. Audio feedback plays melodies (e.g.,POWER\_UP FOR FACE 0) based on recognition results.
3. **Data Protection:** Local storage of face templates with hash validation to prevent tempering.

### Non-Functional Requirements:

**Performance:** Recognition speed >= 5 FPS to ensure real-time response.

**Reliability:** 95% accuracy in controlled lighting conditions.

**Usability:** Intuitive setup(plug-and-play hardware) and simple data management(reset to delete data)

## 5.2. Data Requirements and Design

* Data Collection:

Source: K210 models captures facial image via its depth camera.

Format: Processed into numerical templates(not raw image) for storage.

* Data Storage:

Location: Onboard Micro:bit or Tiny:bit memory(local only)

Security: Templates are hashed and encrypted, with no network transmission.

Retention: Data is stored until manually deleted by the user.

* Data Flow:

Face capture --> K210 processing --> template generation

Templates storage with hash --> Micro:bit receives recognition results.

LED display and audio feedback based on stored templates.

# Professional Conduct and Ethics

* ****User Consent****: If deploying in user experiments, obtain informed consent, clearly stating data usage and withdrawal rights.
* ****Data Protection****: Adhere to GDPR principles, ensuring data minimization, user control, and security.
* ****Academic Integrity****: Maintain original work, avoiding plagiarism in code or design. Credit open-source components appropriately.
* ****Professional Responsibility****: If commercializing the product, protect stakeholder privacy, prevent data misuse, and comply with legal standards. Ensure hardware safety to avoid physical harm to users.

# 7. Conclusion

This socio - technical analysis report has conducted a comprehensive exploration of the [Project Title] project from multiple dimensions, integrating technical feasibility with social responsibility, so as to lay a solid foundation for the smooth development and potential market application of the project.

In terms of project objectives and functional requirements, the clear definition of the project purpose and the systematic sorting out of high - level functions make the overall framework of the project clear, which provides a clear direction for the subsequent technical development. The selected software and hardware technologies not only meet the functional needs of the project but also take into account the advancement and compatibility of the technology, laying a technical foundation for the realization of the project.

In the social analysis part, in - depth discussions on privacy issues, data protection, intellectual property rights, and stakeholder risks have highlighted the importance of embedding social responsibility into the project design. By introducing the ISD Privacy Framework and GDPR guidelines, the project has established a relatively complete data security and privacy protection system. For intellectual property rights, the clear identification of the source of software and hardware components and the avoidance of potential infringement risks reflect the project team's emphasis on legal compliance. The stakeholder and risk analysis clarifies the impact objects and potential risks of the project, and the proposed risk mitigation strategies and positive impact enhancement measures help to build a more sustainable project ecosystem.

In the technical design section, the combination of functional design and non - functional requirements (such as performance, reliability, and usability) not only ensures the normal operation of the system but also incorporates social factors such as user experience and data security into the technical architecture. The detailed data requirement analysis and the design of the storage scheme, combined with data protection requirements, ensure the scientificity and security of data management in the project.

Regarding professional conduct and ethics, the commitment to adhering to high - standard ethical norms in the product development and marketing process reflects the project team's sense of social responsibility. This not only helps to improve the social credibility of the project but also is conducive to building a good brand image in the market.

In general, the [Project Title] project has shown a balanced consideration of technology and society through this analysis. In the future development, continuing to maintain this integrated thinking of "technology - driven" and "social responsibility - oriented" will not only help the project achieve technical success but also enable it to make positive contributions in the social context, and finally realize the coordinated development of project value and social value.