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TED UNIVERSITY

CMPE 491-O SENIOR PROJECT

PROJECT SPECIFICATIONS REPORT

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1. Introduction

1.1 Description

The proposed project, titled "Voice Assistant for Visually Impaired (VAVI)," is an innovative solution designed to assist visually impaired individuals in navigating indoor environments independently and safely. The system leverages real-time image processing, machine learning, and voice-based interaction to provide users with audio-based guidance and obstacle detection.

Key Features:

1. Real-Time Object Detection and Obstacle Avoidance:
    - The system uses cameras and advanced image processing algorithms to detect objects (e.g., walls, doors, furniture) and obstacles (e.g., people, moving objects) in real-time.
    - It provides audio warnings to the user, such as "Obstacle ahead, move left" or "Stairs ahead, proceed with caution."
2. Voice-Based Navigation:
    - Users can interact with the system using voice commands, such as "Take me to the cafeteria" or "Where is the restroom?"
    - The system responds with step-by-step audio instructions, such as "Turn right in 5 meters" or "Go straight for 10 meters."
3. 3D Environment Mapping:
    - The system creates a 3D map of the indoor environment using SLAM (Simultaneous Localization and Mapping) technology.
    - This map is used to determine the user's location and plan the optimal path to their destination.
4. User-Friendly Interface:
    - The system relies entirely on voice commands and audio feedback, making it accessible to individuals with visual impairments.
    - It is designed to be intuitive and easy to use, even for those with limited technical expertise.

Project Goals:

- Enhance the independence and mobility of visually impaired individuals in indoor environments.
- Provide a cost-effective and scalable solution that can be adapted to various settings, such as schools, offices, and shopping malls.
- Promote inclusivity by addressing the challenges faced by visually impaired individuals in navigating complex spaces.

1.2 Constraints

The project is subject to several constraints that must be carefully considered during the design and implementation phases. These constraints are categorized as follows:

1. Economic Constraints:

- Budget Limitations: The project must be developed within a limited budget, which restricts the choice of hardware and software tools. For example, high-end cameras or specialized sensors may be too expensive.
- Cost-Effective Solutions: Open-source software libraries (e.g., OpenCV, TensorFlow) will be prioritized to minimize costs.
- Affordability for End-Users: The final product must be affordable for visually impaired individuals, many of whom may have limited financial resources.

2. Environmental Constraints:

- Energy Efficiency: The system must be energy-efficient to ensure long battery life, especially if it is deployed on portable devices like smartphones or wearables.
- Eco-Friendly Materials: Where possible, the hardware components should be made from recyclable or sustainable materials to minimize environmental impact.

3. Social Constraints:

- Accessibility: The system must be accessible to individuals with varying levels of technical expertise. This includes providing clear instructions and support for first-time users.

4. Political Constraints:

- Data Security: User data, such as voice commands and locati

5. Ethical Constraints:

- User Privacy: The system must respect user privacy by not storing or sharing personal data without explicit consent.
- Algorithmic Bias: The object detection and voice recognition algorithms must be trained on diverse datasets to avoid biases that could disadvantage certain groups of users.

6. Health and Safety Constraints:

- Physical Safety: The system must not pose any physical risks to users, such as providing incorrect navigation instructions that could lead to accidents.
- Psychological Safety: The audio feedback should be clear and not overly loud to avoid causing stress or hearing damage.

7. Manufacturability Constraints:

- Ease of Assembly: The system should be easy to assemble and deploy using off-the-shelf components to reduce manufacturing complexity.
- Scalability: The design should allow for mass production if the project is commercialized in the future.

8. Sustainability Constraints:

- Long-Term Use: The system should be designed for long-term use, with regular updates and maintenance to ensure its continued functionality.
- Minimizing Waste: The use of durable and recyclable materials will help minimize electronic waste.

1.3 Professional and Ethical Issues

The project adheres to the following professional and ethical standards:

1. ACM Code of Ethics and Professional Conduct:

- Prioritizing User Well-Being: The system will be designed to enhance the quality of life for visually impaired individuals, ensuring their safety and independence.
- Transparency: Users will be informed about how the system processes data and makes decisions, ensuring transparency and trust.

2. IEEE Code of Ethics:

- Avoiding Harm: The project team will take all necessary precautions to ensure that the system does not cause harm to users or the environment.
- Honesty and Integrity: The team will report results honestly and avoid conflicts of interest.

3. The Software Engineering Code of Ethics:

- Reliability and Maintainability: The software will be designed to be reliable, maintainable, and adaptable to future needs.
- User-Centric Design: The system will be developed with the needs of visually impaired individuals as the primary focus.

4. Data Privacy and Security:

- Local Data Processing: To ensure privacy, user data (e.g., voice commands, location information) will be processed locally on the device and not transmitted to external servers.
- Informed Consent: Users will be informed about how their data is used and will have the option to opt out of data collection.

5. Inclusivity:

- Affordability: Efforts will be made to ensure that the system is affordable and accessible to low-income individuals.
- Adaptability: The system will be designed to accommodate users with varying levels of visual impairment and technical expertise.

2. Requirements

2.1 Functional Requirements:

1. Real-Time Object Detection:
   - The system must detect and classify objects (e.g., walls, doors, furniture) in real-time using image processing algorithms like YOLO or SSD.
2. Obstacle Avoidance:
   - The system must identify obstacles (e.g., people, moving objects) and provide audio warnings to the user.
3. Voice-Based Navigation:
   - The system must accept voice commands (e.g., "Take me to the cafeteria") and provide step-by-step audio instructions.
4. 3D Mapping:
   - The system must create and maintain a 3D map of the environment using SLAM technology.
5. User Interface:
   - The system must provide a simple, voice-based interface for users to interact with.
6. Localization:
   - The system must accurately determine the user's location within the mapped environment.

2.2 Non-Functional Requirements:

1. Performance:
   - The system must process images and provide feedback in real-time (latency < 1 second).

2. Accuracy:
    - Object detection and navigation instructions must be at least 90% accurate.
3. Portability:
    - The system must be lightweight and portable, suitable for use on smartphones or wearable devices.
4. Battery Life:
    - The system must operate for at least 8 hours on a single charge.
5. Scalability:
    - The system must be adaptable to different indoor environments (e.g., schools, offices, malls).

2.3 Technical Requirements

1. Hardware:
    - Camera (RGB or RGB-D for depth sensing).
    - Microphone and speaker for audio input/output.
    - Portable computing device (e.g., Raspberry Pi, smartphone).
2. Software:
    - Programming Language: Python.
    - Libraries: OpenCV, TensorFlow, PyTorch, SpeechRecognition, gTTS.
    - Algorithms: YOLO (for object detection), SLAM (for mapping), Dijkstra/A* (for pathfinding).
3. Data:
    - Training data for object detection (e.g., COCO dataset).
    - Custom datasets for specific environments (e.g., school layouts).

3. References

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