TED UNIVERSITY

CMPE 491 / SENG 491 Senior Project

General AI Safety Systems Project Proposal

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1.Introduction

This document discusses the constraints and requirements for the General AI Safety Systems. This system enhances children's safety by employing artificial intelligence and image processing to monitor attendance, enforce seatbelt use, detect in-vehicle behavior, and optimize routes. This report outlines hardware, software, environmental, operational, safety, ethical, and privacy considerations, while also addressing professional responsibilities.

1.1 Description

The primary objective of the General AI Safety Systems is to ensure children's safety during school transportation. By employing real-time face recognition, seatbelt monitoring, and behavior analysis, the system can promptly detect and respond to potential safety concerns. Through data sharing with parents and school authorities, the project aims to increase transparency and alleviate concerns over student safety.

1.2 Constraints

1.2.1 Hardware Constraints

- **Camera Quality**: High-resolution, low-light cameras are needed to accurately monitor face recognition and behavior detection.
- **Seatbelt Sensors**: Reliable sensors are required for real-time seatbelt monitoring to ensure correct use.
- **Processing Power**: Sufficient on-board processing capabilities are needed to handle real-time image analysis and route optimization.

1.2.2 Software Constraints

- **Algorithm Accuracy**: High accuracy in face and behavior recognition is essential to minimize errors.
- **Real-Time Processing**: The system must process video feeds, sensor data, and route optimization in real-time.
- **Data Encryption**: Secure encryption protocols are necessary to protect the data shared with parents and school staff.

1.2.3 Environmental Constraints

- **Lighting and Weather Conditions**: The system must function reliably under various weather and lighting conditions to ensure continuous monitoring.

1.2.4 Operational Constraints

- **User Interface**: A user-friendly interface is necessary for bus drivers, parents, and school administrators to interact with the system efficiently.

- **Maintenance**: Regular maintenance is essential to ensure the accuracy of sensors and real-time image processing capabilities.

1.2.5 Safety and Regulatory Constraints

- **Compliance**: The system must comply with privacy laws and child safety regulations.
- **Testing and Validation**: The system must be rigorously tested to confirm its safety and effectiveness.

1.2.6 Budgetary Constraints

- **Development and Maintenance Costs**: Budgeting for both initial development and long-term maintenance is essential to ensure system sustainability.

1.2.7 Time Constraints

- **Project Timeline**: A clear schedule with milestones for development, testing, and deployment should be established.
- **Response Time**: The system must be able to promptly respond to safety concerns to maximize protective benefits.

1.2.8 Ethical and Privacy Constraints

- **Data Privacy**: The system must protect students' data in compliance with relevant data protection laws, ensuring secure handling of personally identifiable information.
- **Transparency**: Clear information regarding data usage should be provided to all stakeholders to maintain trust.

1.3 Professional and Ethical Issues

This project must prioritize the welfare and safety of children, maintaining transparency in its design and operation. Data privacy, especially regarding children, is of utmost concern, and the system should comply with child protection and privacy regulations. Professionally, the project team must adhere to quality standards, ensuring accuracy and reliability without bias. Compliance with relevant educational and transportation standards is critical to fulfilling the project's ethical and legal responsibilities.

2. Requirements

Data Collection and Annotation

Dataset Diversity: Collect a dataset of images and videos featuring various scenarios related to children's transportation safety, including boarding, seatbelt usage, and in-vehicle behavior. The dataset should cover different lighting conditions (e.g., morning, midday, night) and environments (indoor, outdoor, varying weather conditions).

Annotation: Data should be labeled to distinguish between compliance (e.g., seatbelt worn) and non-compliance (e.g., standing while the vehicle is in motion). Labels should also categorize different actions (e.g., seated, unseated, unsafe behavior) to train the AI model effectively. Annotation may need revision depending on model results.

Traffic Data Integration: Collect real-time traffic data from reliable sources (e.g., GPS, traffic APIs) to assess congestion and road conditions.

Historical Route Data: Gather historical data on travel times for different routes to help predict traffic patterns and optimize future routes.

School Locations: Maintain an updated database of school locations and student addresses to facilitate route planning.

Route Optimization Algorithms

Algorithm Selection: Implement efficient algorithms such as Dijkstra's, A*, or genetic algorithms to determine the fastest and safest routes.

Dynamic Routing: Enable the system to adapt routes in real-time based on traffic conditions, accidents, and other unforeseen events.

Model Development

Model Selection: Implement a deep learning model suited for real-time image analysis. Based on preliminary research, consider models such as YOLO (You Only Look Once) for efficient and accurate behavior recognition. Explore different models (e.g., SSD, MobileNet) if the results indicate performance limitations with YOLO.

Training Process: Use the collected dataset to train the model, optimizing for accuracy and minimal false-positive/negative rates. Hyperparameter tuning, data augmentation, and transfer learning may be applied to improve accuracy across different scenarios.

Model Evaluation: Performance metrics (e.g., accuracy, F1 score) and test the model on a validation dataset with similar characteristics to real-world conditions.

Hardware Integration

Camera and Sensor Compatibility: Compatibility between hardware (high-resolution cameras, seatbelt sensors) and the AI model for optimal real-time processing. The system should be optimized for minimal lag and seamless integration with onboard vehicle systems.

Processing Power: The onboard processing unit must handle high-throughput data (video feed and sensor input) and execute real-time analytics without impacting system performance.

Alarm and Notification System

Alert Mechanisms: Implement customizable alerts to suit different stakeholders (bus drivers, parents, school administrators). Alerts could include notifications on mobile apps, auditory signals within the bus, or direct communication with school staff.

Priority Handling: In critical situations (e.g., seatbelt non-compliance or unsafe behavior), the system should trigger immediate alerts to prompt rapid intervention.

Calibration and Customization

System Calibration: The AI model should undergo calibration to adapt to different vehicles, environments, and lighting conditions. Calibration may be periodically updated based on environmental changes or system upgrades.

User Customization: Allow administrators to configure alert sensitivity, define acceptable behaviors, and customize data sharing preferences to fit school policies and regulatory standards.

Scalability

Multi-Vehicle Support: The system must scale across various buses, each potentially requiring different settings for the model (e.g., bus size, camera angle).

Cross-Site Operation: Design to accommodate deployment across multiple locations, such as different schools or transportation regions.

Security and Privacy

Data Protection: Apply data encryption and follow data protection regulations (e.g., GDPR) to safeguard camera feeds and personal information. The system must store data securely, ensuring compliance with legal requirements related to child safety and privacy.

Access Control: Only authorized users (e.g., bus drivers, parents, administrators) should access system data, with role-based restrictions for added security.

Safety Considerations

Safe Routes Selection: Prioritize routes that avoid high-crime areas or locations with a history of accidents, ensuring children's safety during transit.

School Zones Awareness: Implement alerts for school zones, ensuring that drivers are reminded to follow reduced speed limits and increased caution.

Maintenance and Updates

Regular Model Updates: Schedule regular updates to address changing safety standards and emerging threats. Maintenance should cover both software (AI model, alert protocols) and hardware (sensors, cameras) for reliability.

Self-Diagnostic: The system should include self-diagnostic features to detect hardware failures or data transmission issues, ensuring prompt servicing.

User Interface

Interface Accessibility: Provide a user interface compatible with mobile and desktop platforms, allowing users to configure settings, view alerts, and monitor data.

Training and Support: Ensure user support and training sessions for bus drivers, parents, and administrators for smooth operation and quick troubleshooting.

Customization Options: Allow bus drivers or school administrators to set preferences, such as avoiding certain areas, prioritizing shorter travel times, or considering specific safety concerns.

Multi-Stop Optimization: Design the route finder to efficiently handle multi-stop routes, considering the order of stops to minimize travel time

Documentation

Installation and Setup: Provide user documentation for setup, including hardware installation, software configuration, and network requirements.

Usage and Troubleshooting: Include a manual for system use and troubleshooting, covering steps for common issues, data retrieval, and alert handling.

Technical Specifications: Documentation should list hardware requirements, network specifications, and performance benchmarks to assist in future upgrades or modifications.

Testing and Validation

Field Testing: Conduct field testing under real conditions (different lighting, varying weather) to verify reliability. Tests should confirm system accuracy in identifying correct behaviors and safety violations.

Regulatory Compliance Testing: Tests to confirm adherence to child safety regulations and privacy laws. Any detected non-compliance should prompt immediate adjustments before deployment.

Compliance and Regulations

Legal Compliance: System should complies with local, national, and international regulations concerning child transportation, safety, and data privacy.

Certifications: Necessary certifications from regulatory bodies to affirm the system's adherence to safety and privacy standards.

Cost Estimation

Budget Allocation: Develop a budget plan covering the costs of hardware, software development, data acquisition, and future maintenance. Consider long-term financial planning to cover possible model updates and system upgrades.

Performance Metrics

Efficiency Metrics: Monitor key performance indicators (KPIs) such as average travel time, fuel consumption, and adherence to schedules to evaluate the effectiveness of the routing system.

User Satisfaction Ratings: Implement a rating system for bus drivers and parents to assess the effectiveness of routes chosen and their satisfaction with the system.

Customer Support

Support System: A customer support protocol to handle queries, technical issues, and maintenance requests, timely resolution and system uptime.

3. References

1. **Technical Standards and Professional Ethics**

    ACM Code of Ethics and Professional Conduct: Provides guidelines for ethical decision-making and professional responsibilities in computer science and engineering.

    https://www.acm.org/code-of-ethics

    Stanford Encyclopedia of Philosophy - Ethics of Computer and Information Science: This resource offers insights into ethical considerations specific to computer science, including AI and data privacy.

    https://plato.stanford.edu/archives/sum2020/entries/ethics-computer/#ProEthComEth

2. **Object Detection and AI Algorithms**

    Redmon, J., & Farhadi, A. (2018). ***YOLOv3: An Incremental Improvement*****. arXiv preprint arXiv:1804.02767. This research presents the YOLOv3 model, a highly efficient, real-time object detection algorithm, ideal for fire and safety applications where rapid detection is essential.**

    Liu, W., Anguelov, D., Erhan, D., Szegedy, C., Reed, S., Fu, C. Y., & Berg, A. C. (2016). ***SSD: Single Shot MultiBox Detector*****. In** ***European Conference on Computer Vision (ECCV)*****. This paper introduces SSD, another real-time object detection model that can be used as an alternative for high-accuracy detection.**

3. **Regulatory and Privacy Standards**

    General Data Protection Regulation (GDPR): A comprehensive regulation outlining privacy and data security standards in the EU, essential for handling sensitive data in AI applications.

    https://eur-lex.europa.eu/eli/reg/2016/679/oj

    National Highway Traffic Safety Administration (NHTSA) - Child Safety Regulations: NHTSA guidelines provide critical insights into child safety standards for transportation, relevant for system compliance.
    https://www.nhtsa.gov/

4. **Testing and Validation Techniques**

    Myers, G. J., Sandler, C., & Badgett, T. (2011). ***The Art of Software Testing*****. 3rd ed., John Wiley & Sons.**

    Spence, C., & Thomas, J. (2020). ***Transportation Safety Management and Risk Assessment: Guidelines for Practitioners*****.** ***Journal of Transportation Safety & Security*****.**

    Aarts, E., & Wichert, R. (2016). ***Ambient Intelligence: A Survey on the State-of-the-Art*****.** ***Journal of Ambient Intelligence and Smart Environments*****, 8(3), 227-245.**

    Project Management Institute (2017). ***A Guide to the Project Management Body of Knowledge (PMBOK Guide)*****.**