Thesis Project Portfolio

FSAE Data Acquisition Corner Board

(Technical Report)

Zoox: A Moral Analysis of Autonomous Vehicles

(STS Research Paper)

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Sociotechnical Synthesis

This project presents the design, development, and testing of a custom data acquisition corner board for the Virginia Motorsports Education's (VME) Formula SAE (FSAE) car, the VM25. The customer competes in the Formula Society of Automotive Engineers (FSAE) competition each year and is iterating on the data acquisition hardware and software system for the new car. The current system has each sensor in each wheel wired directly into the central data computer, which will be replaced by a single CAN bus data line connecting the four wheels. Each sensor will send its analog signal to its wheel's sensor board, which will be multiplexed into a digital signal and then sent out to the central computer via the CAN protocol. The hardware centers on a custom-built microcontroller integrated onto a custom six-layer PCB, featuring power regulation, electromagnetic compatibility measures, and automotive-grade connectors. Extensive testing protocols validated power delivery, analog-to-digital conversion, and CAN communication, with final system verification conducted on a debug board due to assembly challenges with the embedded MCU. The project achieved significant reductions in wiring complexity and improved modularity. Lessons learned include the importance of meticulous component selection, adherence to documentation, and the value of iterative prototyping, especially with complex surface-mount assemblies. Future work will focus on enhancing reliability, adding real-time clock functionality, expanding sensor support, and further miniaturizing the board for integration into the 2025 competition vehicle.

Autonomous vehicles (AVs) represent a transformative shift in urban transportation, promising enhanced safety, reduced emissions, and improved mobility. The STS project examines the technological, ethical, and societal dimensions of AV deployment through a case study of Zoox, Inc. Their purpose-built, bidirectional electric vehicle leverages a sophisticated sensor suite, including cameras, lidar, and radar, for 360-degree perception and real-time scene understanding, enabling fully autonomous operation without manual controls. Its AI-driven software integrates mapping, localization, and object classification to navigate complex urban environments, predict behaviors on the road, and plan safe routes. The company also invests in simulation and teleoperation tools to address rare edge cases and network latency challenges. Redundancy in hardware and safety systems underscores Zoox's proactive approach to passenger protection, and the company aligns its safety protocols with evolving federal guidelines. However, AVs also raise unresolved ethical dilemmas, such as decision-making in unavoidable accident scenarios, and introduce new legal complexities regarding liability and data privacy. Public acceptance is shaped by perceptions of safety, transparency in data usage, and the impact on professional drivers, while regulatory frameworks remain inconsistent in safety reporting, insurance, and operator requirements across states. This analysis highlights the need for robust technical solutions, clearer liability standards, and inclusive policy development to realize the societal benefits of AVs. Continued research and stakeholder engagement are essential for fostering public trust and ensuring the responsible integration of autonomous vehicles into the transportation ecosystem.

The two projects are closely related through their shared focus on advancing the technological foundations and societal integration for more effective and efficient vehicles in transportation. Both explore how sophisticated sensor systems, data acquisition, and real-time processing are essential for enabling safe, effective, and ethical operation for a vehicle. The technical project centers on data acquisition for a Formula SAE vehicle, aiming to modernize sensor integration and streamline communication. This technical innovation directly supports the kind of meaningful data collection that underpins the perception, localization, and decision-making systems described in the STS project’s study of Zoox, Inc. Their autonomous vehicles (AVs) rely on a complex network of sensors and embedded computing to create a recognition of their environment, mirroring the emphasis on sensor fusion and real-time data handling found in the technical project. Moreover, both projects address the broader implications of these technologies. The technical project’s modular, scalable hardware approach enables rapid adaptation and future upgrades, which is critical as AV companies like Zoox continually refine their systems to meet evolving safety standards and ethical expectations. The STS project expands this discussion to include regulatory, ethical, and public perception challenges, highlighting the need for transparent, reliable data and vital system design. Together, these projects illustrate the interplay between hardware innovation and the societal, regulatory, and ethical frameworks necessary for the successful deployment of autonomous vehicles.