Remote-Control of an Off-Road Automated Vehicle over the 5G Network for Agriculture Applications.

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ABSTRACT:

- This research project pioneers the integration of 5G technology to control an off-road Jeep Grand Cherokee remotely, offering the precision and robustness of being directly behind the wheel, even from miles away to achieve unprecedented control and operational efficiency. Exploiting the rapid data transfer and minimal delay offered by 5G networks, this project has developed an advanced system that allows for the real-time remote operation and surveillance of autonomous vehicles in rugged terrain. My approach integrates the vehicle's onboard control systems and sensors with external devices, including a drive-by-wire kit by New Eagle, dSPACE's MicroAutoBox 2, Swift Navigation's (GNSS) Global Navigation Satellite System/(GPS) Global Positioning System via CAN communication, and a dashboard-mounted (HMI) Human-Machine Interface display that presents live data and system status to any in-vehicle driver. Additionally, this data is made available to a remote driver through the network on their laptop, equipped with a dual-display feature to provide thorough information access to both in-vehicle and remote drivers. This configuration is designed to support effective and informed decision-making. From a software perspective, leveraging MATLAB and Simulink, ROS, and Embedded-C programming, together with other specialized tools, establishes a solid base for the flawless integration and interaction among the vehicle's systems, ensuring comprehensive tests for safety, dependability, and increased situational awareness via a joystick and multiple cameras. This innovation showcases the possibilities for conducting remote explorations, responding to emergencies, and executing autonomous operations, heralding a new era in the tele-operation of vehicles.

METHODOLOGY:

GNSS/GPS Setup and Testing:

- Established a dual-station GNSS/GPS configuration involving an RTK station in the vehicle and a base station at a fixed site to enhance positioning accuracy using differential measurements, capturing essential data metrics like baseline, position, and velocity.
- Utilized real-time data acquisition to monitor and record GNSS/GPS performance metrics, ensuring precision in navigation and positioning critical for subsequent integration with vehicle control systems.

Hardware Setup with Drive-By-Wire Kit:

- Integrated a New Eagle drive-by-wire (DBW) system into a Jeep Grand Cherokee, connecting it to essential control units such as ECU, TCU, EPS, throttle, braking controls, and various sensors, enhancing vehicle automation capabilities.
- Developed and mounted a Human-Machine Interface (HMI) on the dashboard, providing real-time feedback on system status, control activation, power usage, and fault diagnostics, essential for driver awareness and interaction with the DBW system.

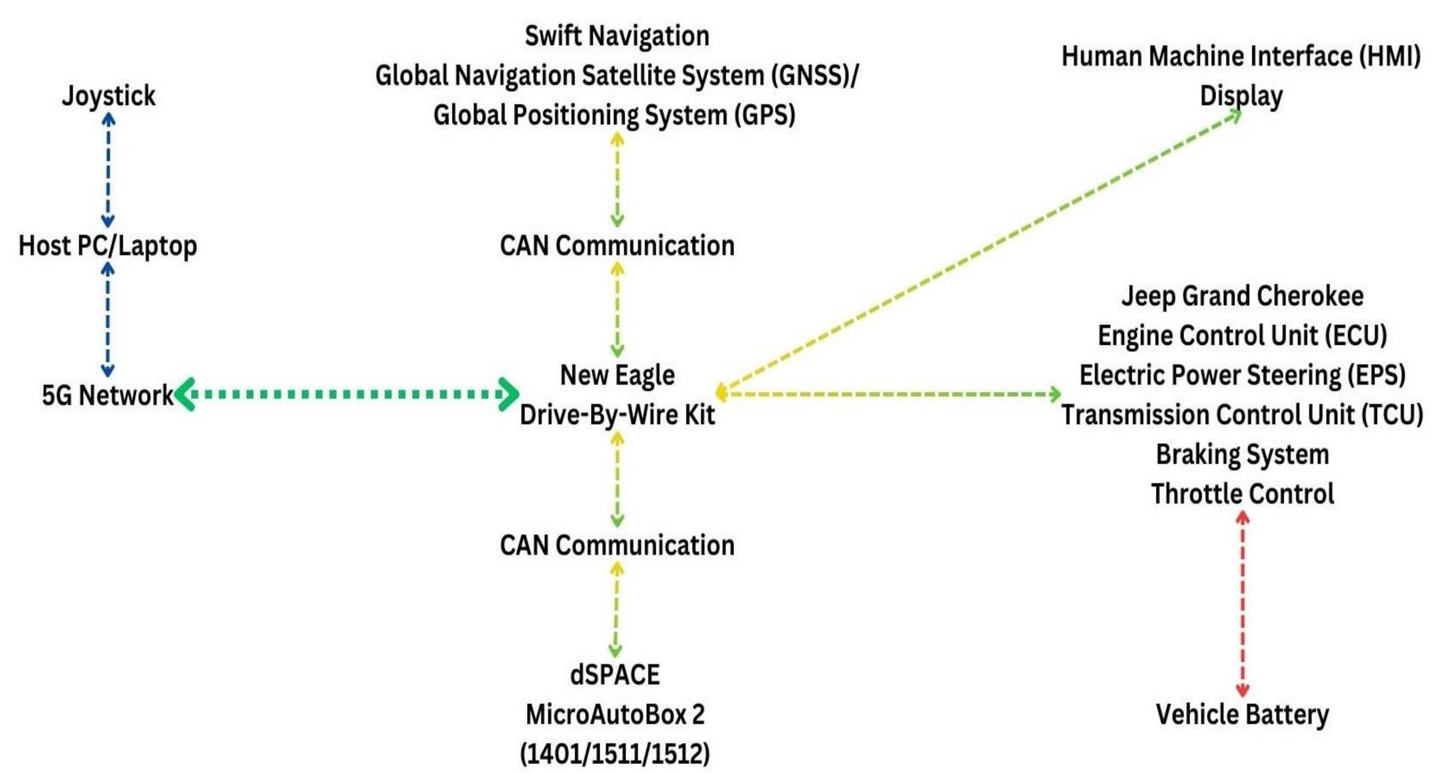
CAN Bus Communication Setup:

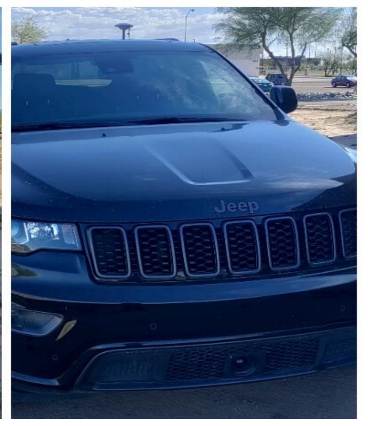
- Implemented CAN bus communication linking the DBW system, dSPACE's MicroAutoBox 2, and Swift Navigation's GNSS/GPS, utilizing a breadboard setup with terminating resistors and CAN_high and CAN_low connections for a robust data exchange infrastructure.
- Conducted initial CAN network diagnostics using a CAN sniffer and PCAN software from PEAK System to monitor, analyze, and log data packets, ensuring reliable and seamless communication among vehicle system components.

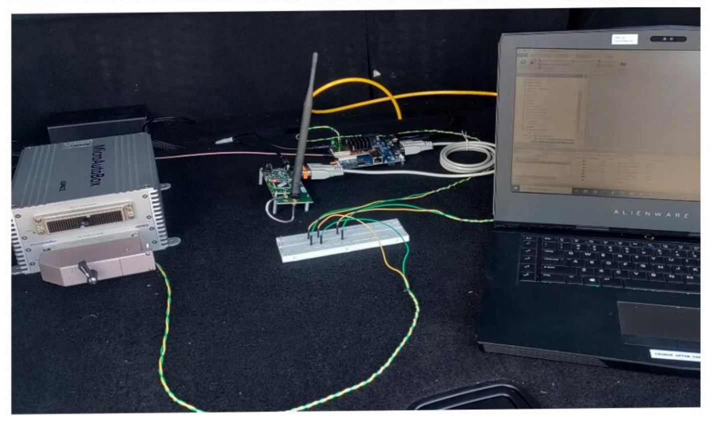
Software Development and Simulation:

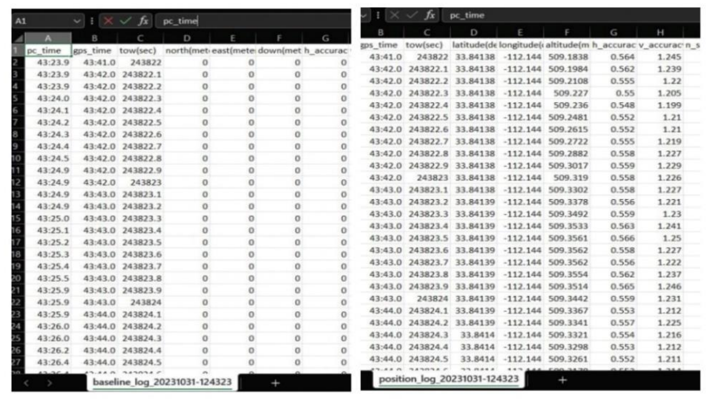
- Currently working on software development using dSPACE's ControlDesk and MATLAB/Simulink for model-in-the-loop (MiL) and hardware-in-the-loop (HiL) simulations. Initially, I focused on validating control logic and system behavior within a simulated environment, eliminating the need for physical hardware. Now, I'm moving into HiL testing, deploying the validated control model onto the dSPACE MicroAutoBox II. This stage aims to test software and hardware interactions under realistic conditions to ensure system integrity and performance.

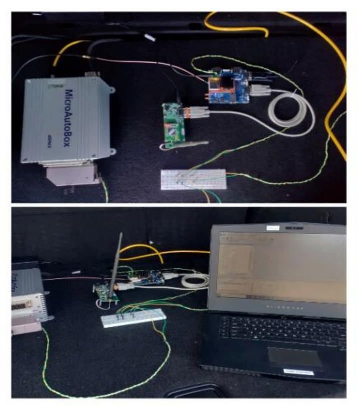
SYSTEM ARCHITECTURE

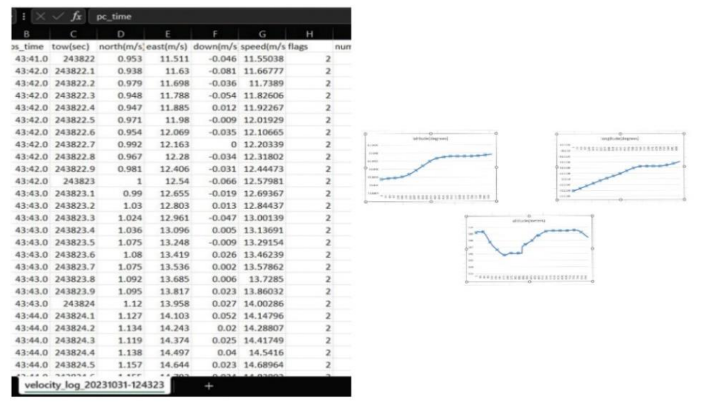












FURTHER RESEARCH:

The next steps for this project involve several key enhancements and expansions:

- **5G Network Integration for Tele-operation.**
- **Integration of Joystick, Camera and Pivotal Sensors.**
- **System Testing.**
- **Enhanced Communication Protocols:** Research on Optimizing 5G Latency and Bandwidth, Redundant Communication Systems.
- **Advanced Sensor Integration and Data Fusion:** Improved Sensor Technologies, Data Fusion Algorithms.
- **Autonomous Systems and Artificial Intelligence:** Machine Learning for Autonomous Decision-Making, Enhanced AI for Terrain Analysis.
- **Cybersecurity Measures:** Advanced Security Protocols, Secure Data Transmission.
- **User Interface and Experience:** Immersive Remote Driving Experience, Adaptive User Interfaces.
- **Energy Efficiency and Sustainability:** Power Management Systems, Sustainable Practices.
- **Regulatory and Ethical Considerations:** Legal Framework, Ethical Guidelines for Autonomous Decision-Making.
- **Integration with Other Technologies and Infrastructures**: Smart Cities and Internet of Things (IoT), Inter-Vehicle Communication.

APPLICATIONS:

This system's innovative features and capabilities open up several compelling applications across different fields:

- **Remote Exploration and Research:** Geological and Environmental Studies; Archaeological Surveys.
- **Emergency Response and Disaster Management:** Search and Rescue Operations; Wildfire Mapping and Monitoring.
- **Military and Defense Applications:** Reconnaissance Missions; Remote Transportation of Goods.
- **Autonomous Agricultural Operations:** Precision Farming.
- **Infrastructure Monitoring and Maintenance:** Pipeline and Power Line Inspections.
- **Entertainment and Media Production:** Remote Filming in Unreachable Locations.
- **Teleoperation Training and Simulation:** Driver Training Programs.
- **Public Safety and Law Enforcement:** Monitoring and Surveillance.

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