Autonomous RC Rally Car for Jump and Drift Racing

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Abstract:
This project focuses on the development of a low-cost, modular, and autonomous 1/16 scale RC car platform, designed to serve as an attritable research vehicle for complex multi-agent off-road navigation, specifically addressing the unique autonomy dynamics introduced by jump and drift racing. A primary objective is to enable the development of accessible autonomous vehicle research platforms, reducing the cost barrier for advanced robotics studies. The platform's architecture leverages an affordable RC car chassis, integrating a Jetson Nano or Raspberry Pi 5 for high-level compute and microcontrollers for precise low-level control, targeting a unit cost of approximately $1000 per car. The system's core components include an Arducam RPi camera with IMU for robust perception, Traxxas motors and Electronic Speed Control (ESC), a PCA PWM 9685 servo controller, and a Crazyradio PA with Spektrum Transmitter for reliable communication. All these elements are orchestrated by a ROS2-based control and perception software stack. The development process encompassed rigorous milestones: custom circuit board design and soldering, comprehensive testing of power and switch functions (including buck converter validation), 3D printing of custom mounts and casings for durable component integration, and meticulous electromechanical assembly and chassis wiring, notably incorporating a second servo for enhanced steering critical for jump and drift maneuvers. Furthermore, the Raspberry Pi 5 and Jetson Nano were successfully configured with Ubuntu 22.04/24.04.2 LTS and ROS2, and a robust control software codebase was developed to enable precise Ackerman steering and throttle control. Successful low-level control testing via Spectrum Radio Wireless and PCA culminated in full teleoperation capabilities, demonstrating the platform's readiness. Autonomous capabilities are achieved through Simultaneous Localization and Mapping (SLAM), which is paramount for real-time environment mapping and localization, particularly for re-localization post-jump and improving control during drifts via IMU fusion. The F1Tenth Simulator is actively utilized for virtual testing and validation of SLAM, planning, and control algorithms, significantly mitigating development costs and risks prior to physical deployment. Future work involves collecting extensive sensor data for various drift and jump scenarios, integrating an off-the-shelf SLAM codebase, and connecting it to the developed low-level controller, with an aim to contribute to a research publication. As part of this project, a comprehensive, step-by-step assembly guide is being developed to facilitate the construction of these vehicles by high school students as part of a robotics outreach program. This project not only advances ongoing research in off-road terrain adaptation and jump racing but also provides an accessible and engaging entry point into the practical application of autonomous systems and robotics. A research platform for RC jump and drift racing is now ready for autonomy, with a fully functional autonomous low-level controller prepared for use.