PathFinder: Novel Inverse Kinematical Path Tracking for Autonomous Vehicles Using Pure Pursuit and Bezier Curves

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Autonomous cars have the potential to become a safer and more efficient alternative to driver-operated vehicles, preventing death and disability. Existing motion planners for autonomous cars frequently follow trajectories without precise real-time correction. The result can be vehicle movements that fail to accurately respond to a dynamic environment. To resolve this problem, I created PathFinder, a Pure Pursuit algorithm that follows a smooth Bezier Curve to efficiently track a given path. By including Pure Pursuit as the method of path tracking, the vehicle can readjust onto target paths in real-time, allowing accommodation for errors and slippage in an everchanging environment. Using a generated Bezier Curve, defined by four control points, PathFinder determines a point on the Bezier Curve using Newton's Method Calculus. Upon calculating a point, PathFinder will travel to that point using the most efficient inverse kinematics for the robot being operated, such as a vector-based travel to pose model. PathFinder was tested on a physical omni-directional chassis and it was proved that PathFinder is an effective means of path tracking and adjustment. PathFinder was able to reach target points through Bezier smooth trajectories with an error of less than an inch, excluding outliers, and also traveled to target points approximately twice as fast as control methods in simulation (P-Value=0.006). Thus, the PathFinder algorithm using Pure Pursuit is effective and efficient at following smooth trajectories, allowing for safer navigation in a dynamic environment. The potential impact includes the saving of lives and billions of dollars relating to vehicular accidents.

Awards Won:
Air Force Research Laboratory on behalf of the United States Air Force: Glass trophy and USAF medal for each recipient
Air Force Research Laboratory on behalf of the United States Air Force: First Award of $750 in each Regeneron ISEF Category
International Council on Systems Engineering - INCOSE: Certificate of Honorable Mention, a 1-year free student membership to the INCOSE, and free virtual admission to the 2022 International Symposium of the INCOSE