Optimization of Autonomous Vehicle Driving Algorithm Based On The F1Tenth Format

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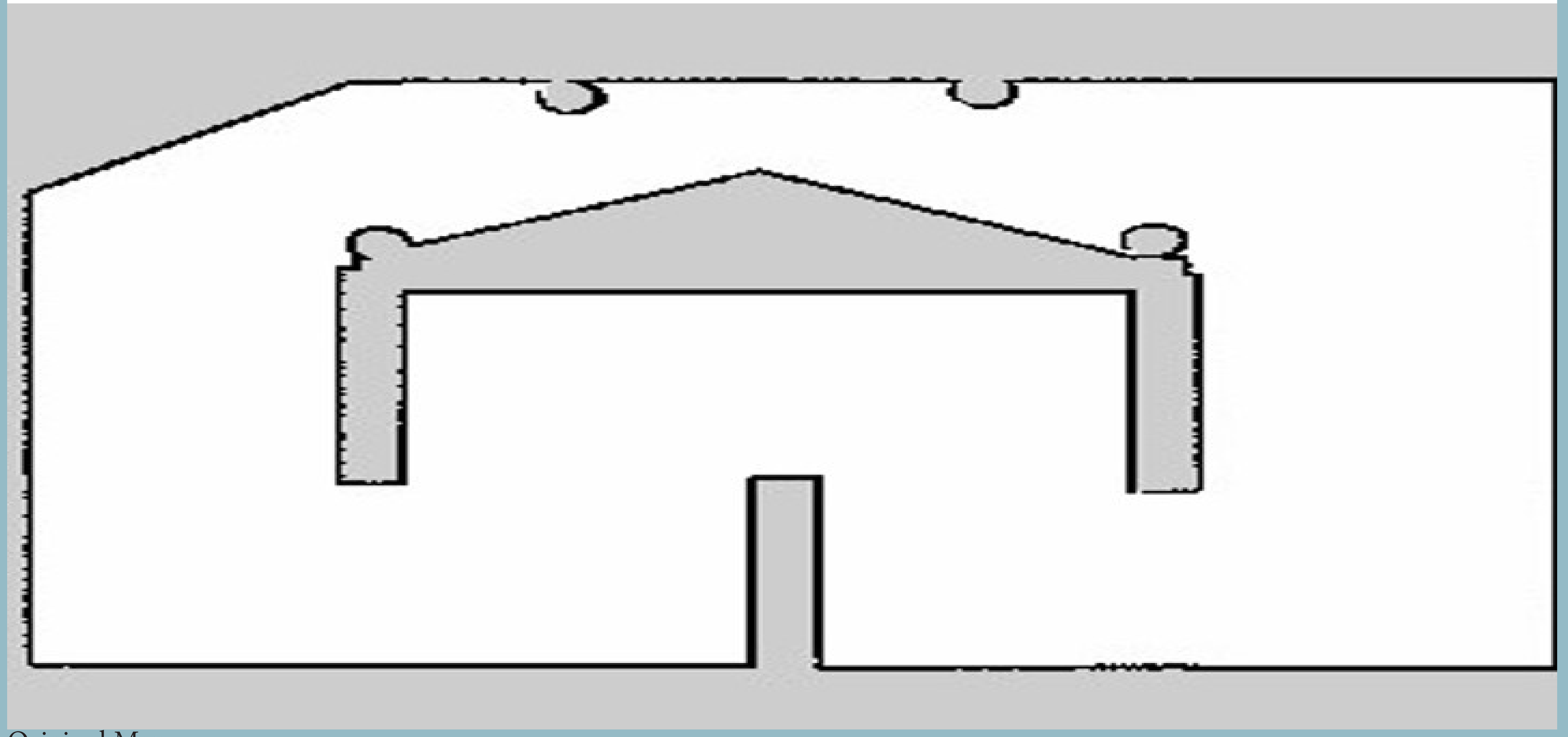
Introduction

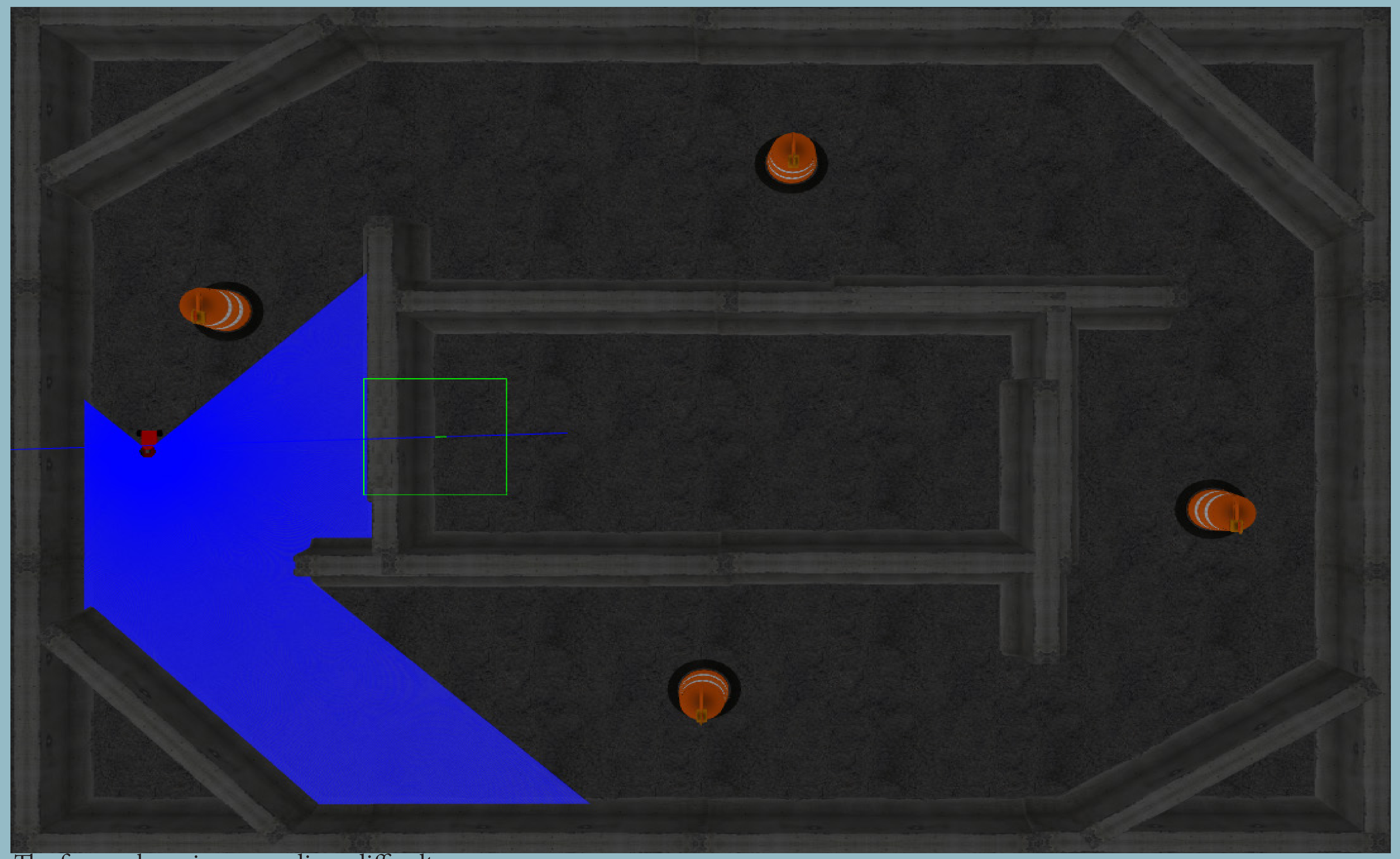
There is a huge void with autonomous driving algorithms in academia as it is costly and time consuming to build a fullsized autonmous car. F1Tenth has seeked to encourage students to research in the area through the F1Tenth competition. Students are tasked with building autonomous driving algorithms for smaller RC cars that need to be able to avoid collisons, track walls/lanes, pass obstacles, and make turns, while going as fast as possible. Our research builds upon the base algorithm that was given, which was wall following using the lidar on the car. Using the base algorithm, we added a method that identifies the furthest area in front of it and goes towards that direction. This method yielded a lap time of 16.4 seconds in comparison to the original algorithm not being able to finish a lap. The two benchmarks that the competition uses are the fastest possible lap and how many laps a car can complete, without crashing, in a given time. Our ultimate goal is to compete at the F1Tenth racing competition in April 2020.

Background

- 270 degree field of vision from the lidar
- Lidar sends out 1080 rays every 25 millisceonds
- Python for software language
- Proportional-Integral Derivative (PID) is the controller used to correct the car's path
- Software only takes into account propportional and derivative
- Propportional calculates the error at the present, and derivative control is proportional change in the error over time
- Gazebo is the simulator used to run tests
- Robotic Operating Software (ROS) is used to interact between the code and robotic components
- Uses monte carlo localization to track where the car is in conjunction with a map



Original Map



The figure above is our medium difficulty map

Methodology

The algorithms listed below are the ones that we have test and gone through. The leftwall follow was the original algortihm given to us by the F1Tenth competition. The middlefollow was an algorithm that was included by the F1Tenth organization, but we had to enable it. The wall switching algorithm was our first idea, and we spent a large amount of our time working on it. The Furthest Area algorithm is our most recent and most successful algorithm used.

Leftwall Follow

- Unable to complete a lap
- Strictly stays on leftwall
- Desired distance from wall is set and error is calculated based off of how far from the desired distance
- Speeds are very slow, any increase causes crashes to occur earlier

Middlefollow

- Stays centered between walls
- Turns less optimal, takes a longer path, rather than cutting across
- Able to complete a lap, ability to go faster due focus on staying centered, less crashing

Wall Switching

- Switches between left/right wall follow
- Fixed angle of detecion to signal which wall to follow
- Better turns through early turning, as it switches to the wall that is closer to an upcoming turn
- Obstacle avoidance fails
- Corners confuse the algorithm, as the algorithm mistakens them for an upcoming turn
- Algorithm tailored to only one map, thresholds for turns dependent on the map dimensions

Furthest Area

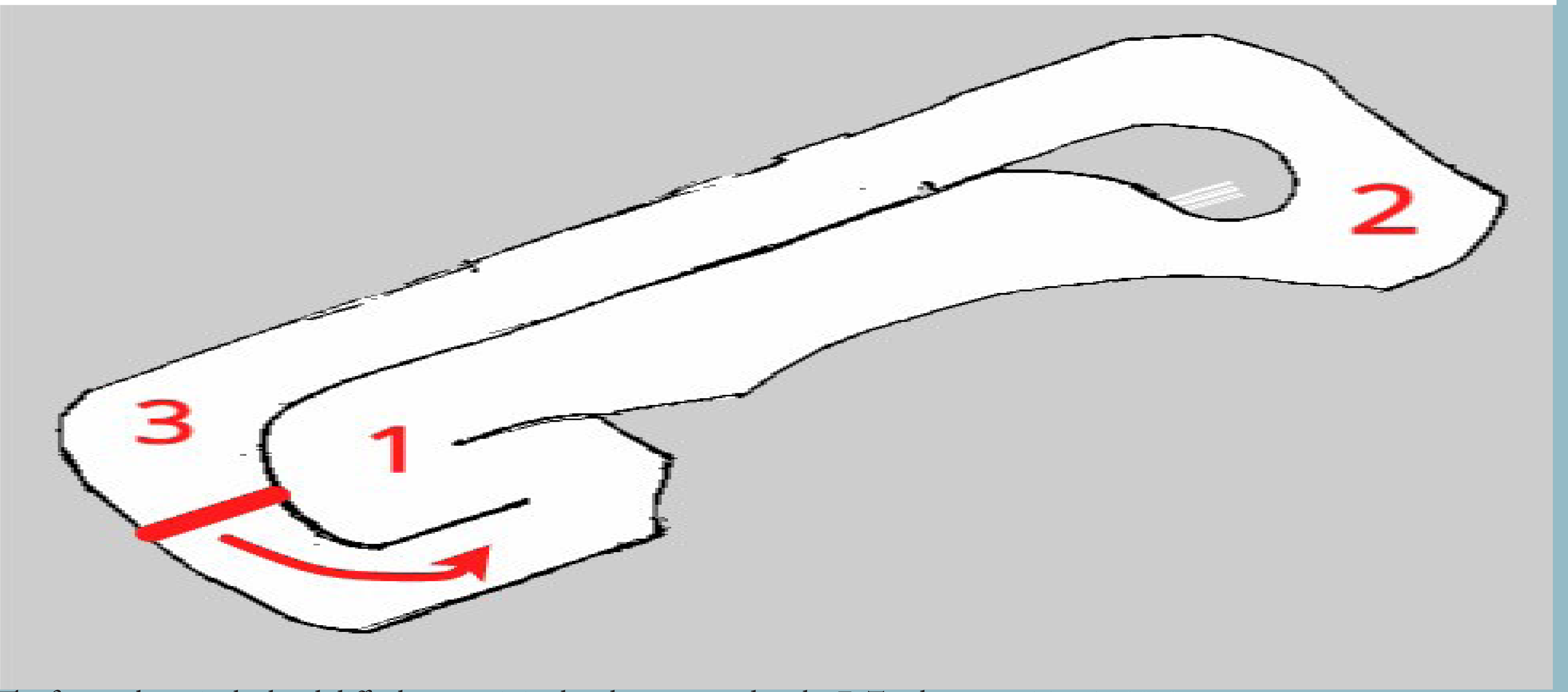
- Splits degree of view into 9 sectors
- Computes average distance in that sector
- Finds the furthest distance sector
- If furthest area is on the left, does a left wall follow, and if furthest area is on right, it does a right wall follow
- Variable desired distance is based off of which sector is the furthest, allows for better turns
- Improved obstacle avoidance
- More reliable and higher ceiling for speed, allowing for faster laps

Results and Conclusion

Algorithms	Fastest Lap (sec)	Most Laps in 3 Minutes (laps)	Lap rate for an Hour (sec)
Leftwall	-	-	-
Middlefollow	26	6	32
Wallswitching 6/26/19	22	6	26
Wallswitching 7/3/19	20.8	8	26
Wallswitching 7/18/19	20.3	8	24.8

- Completition of a lap
- Fastest lap time decreased by 36%
- Number of laps increased by 50%
- Lap Rate for an hour decreased by 26%
- Ability to avoid obstacles and drive through more complex environments

Overall, we were able to increase the performance of the car using our algorithm and improve the reliability. We look forward to continue to improve on it and hopefully see even better results in the future.



The figure above is the hard diffculty map, it is also the map used at the F1Tenth competition in 2018

Future Work

- Begin building the physical car, and begin testing in real life
- Build a race track for testing
- Exploring algorithms that aren't reliant on wall following
- Explore how the algorithm works in a dynamic environment, such as multiple vehicle racing
- Implement a machine learning algorithm for adjusting the speed based on error
- Speed setting of the algorithm needs to be improved

Related Works

- O'Kelly, Matthew, et al. "F1/10: An Open-Source Autonomous Cyber-Physical Platform." arXiv preprint arXiv:1901.08567 (2019).
- Sezer, Volkan, and Metin Gokasan. "A novel obstacle avoidance algorithm:"Follow the Gap Method"." Robotics and Autonomous Systems 60.9 (2012): 1123-1134.

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