Tools For Assured Autonomy
(Applications of ROS and CNNs in F1Tenth Autonomous Racing)

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F1Tenth

F1Tenth Race Car

About F1Tenth

F1Tenth is an international community of researchers interested in collaborative, fun research in the field of autonomous racing. Pioneered by the University of Pennsylvania, this initiative has spread to colleges worldwide and each year, schools from all over the US and overseas compete in the F1Tenth autonomous racing competition. The mission of this initiative can be broken down in four pillars:

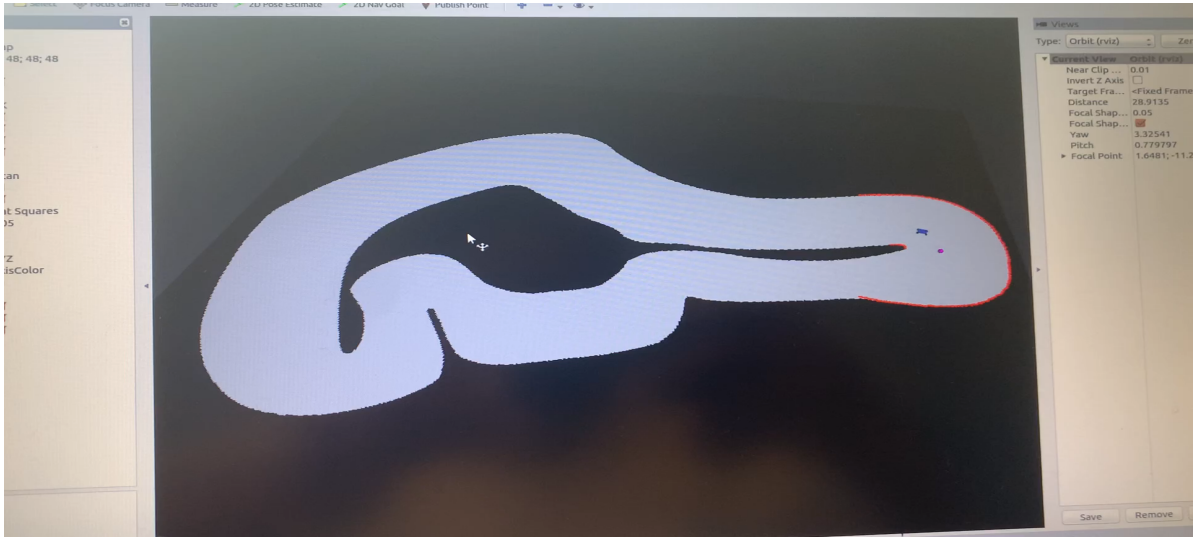
1. **Build**: A standard F1tenth car is built by competing teams to level the playing field in terms of hardware, making the competition a battle of algorithms. (This stage was skipped due to the competition going virtual).
2. **Learn**: Learned how to implement ROS nodes to drive the car. Built simple safety nodes and popular racing algorithms.
3. **Race**: Competed in my 1st ever virtual race during IFAC 2020 in Germany against 8 other teams for the grand prix.
4. **Research:** Used convolutional neural network models to race the car (more on that later).

F1tenth website

Racing Algorithms

Pure Pursuit (Used by many of the competing teams)

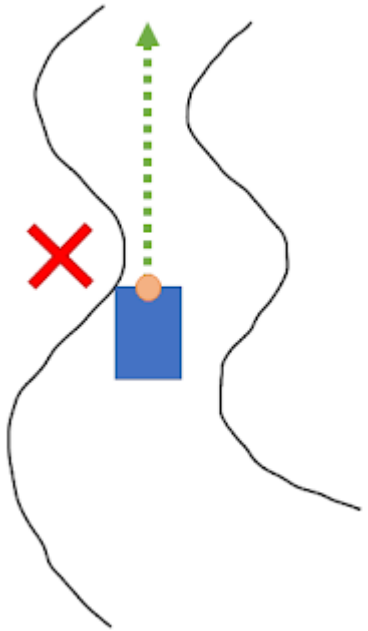
- Determine the current location of the vehicle (this is done through lidar)
- Find the path point closest to the vehicle
- Find goal point
- Calculate vector distance and direction to the point.
- Race car to that position



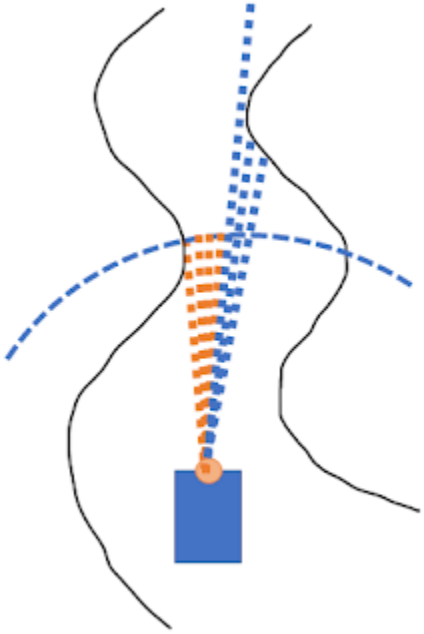
Link to paper

Disparity Extender (Implemented by last year's winners UNC)

- Find the longest safe path
- Drive as fast as possible to that path



Account for the width of the car



Half the width of car and tolerance to avoid clash

Link to article

Race

Virtual Race day July 15

Strategy:
Disparity when opponent was ahead
Pure pursuit when ahead

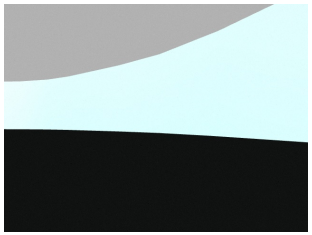
Lost to University of Modena (Italy)

Won by Vienna University of Technology (used reinforcement learning)

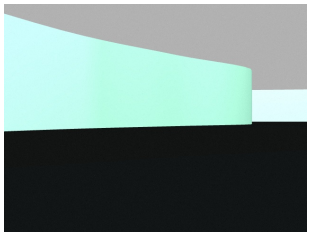
Great collaborative society with teams sharing feedback and strategies

Research

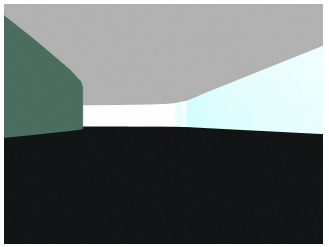
- Applied Convolutional Neural Networks (CNNs) to classify images of track.
- Classified 5 classes (right, left, straight, weak left & weak right).
- Used the disparity extender to move car around to capture images for training using OpenCV.
- Used Tensorflow's Keras API to classify images using MiniVGGNet (VGG 7).



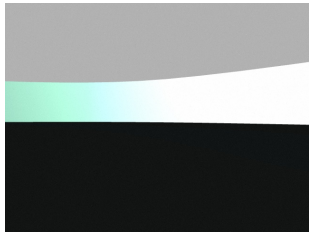
Left



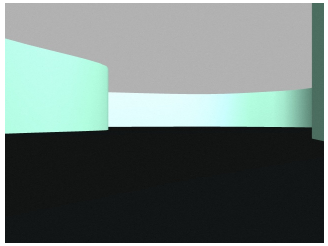
Right



Straight

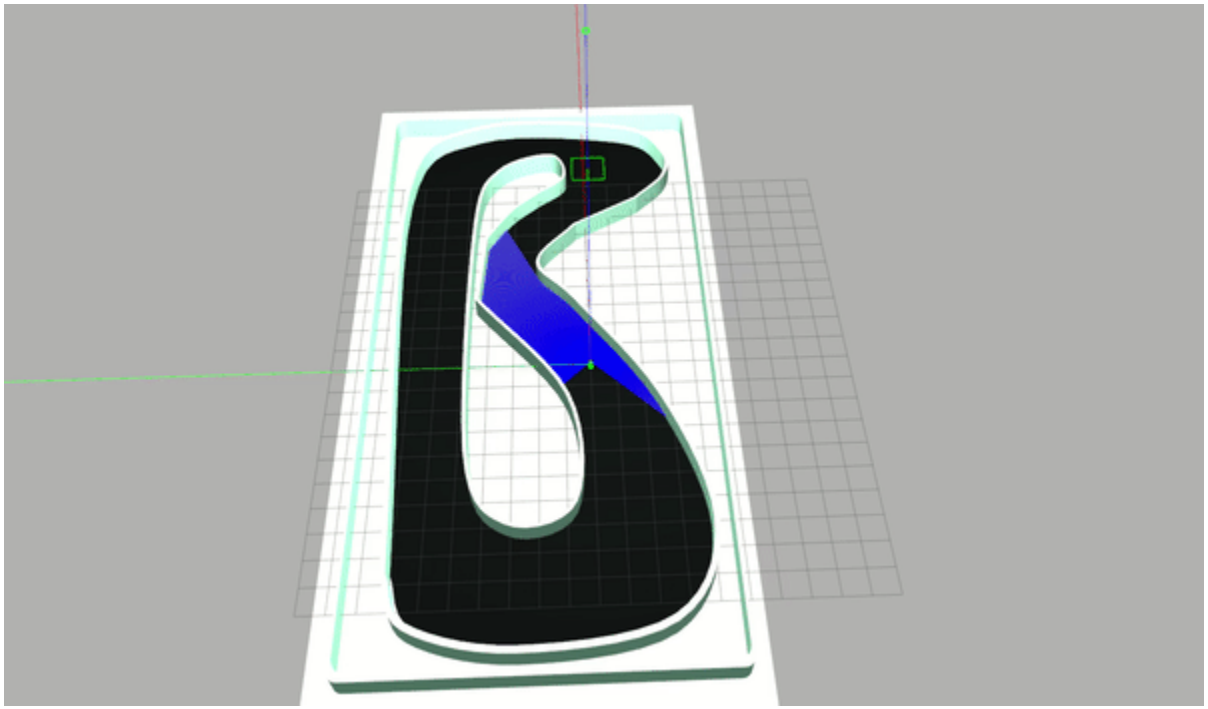


Weak left



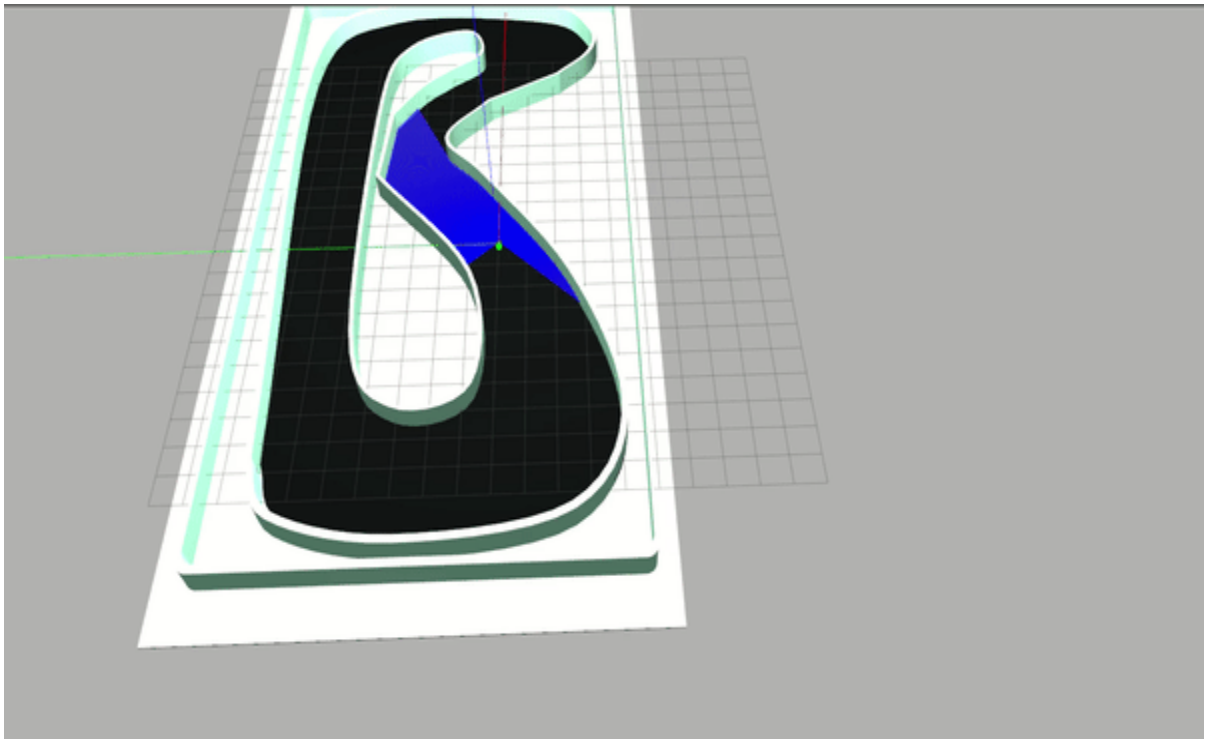
Weak right

Results



Model 1 (~2000 images per class)

Results



Model 2 (~250 images per class)

Differences?

Model 1

- 1000 images per class
- SGD optimizer
- Learning rate 0.05

Model 2

- 250-300 images per class
- Adam optimizer
- Learning rate 0.001

Data isn’t everything after all

Takeaways

Lessons Learned

- More data isn't always the solution in deep learning
- Deep learning is an iterative process and very long without a GPU
- Data collection is not so fun

Challenges Faced

- ROS has a steep learning curve
- Collecting good data for training
- Work life balance

Successes

- Competing in an international competition composed mainly of grad students was fun
- Getting my CNN model to work (though there's more that could be done)

DIDN'T WIN BUT THIS WAS WORTH IT!

THANK YOU!