JETRACER SOCCER LEAGUE

01

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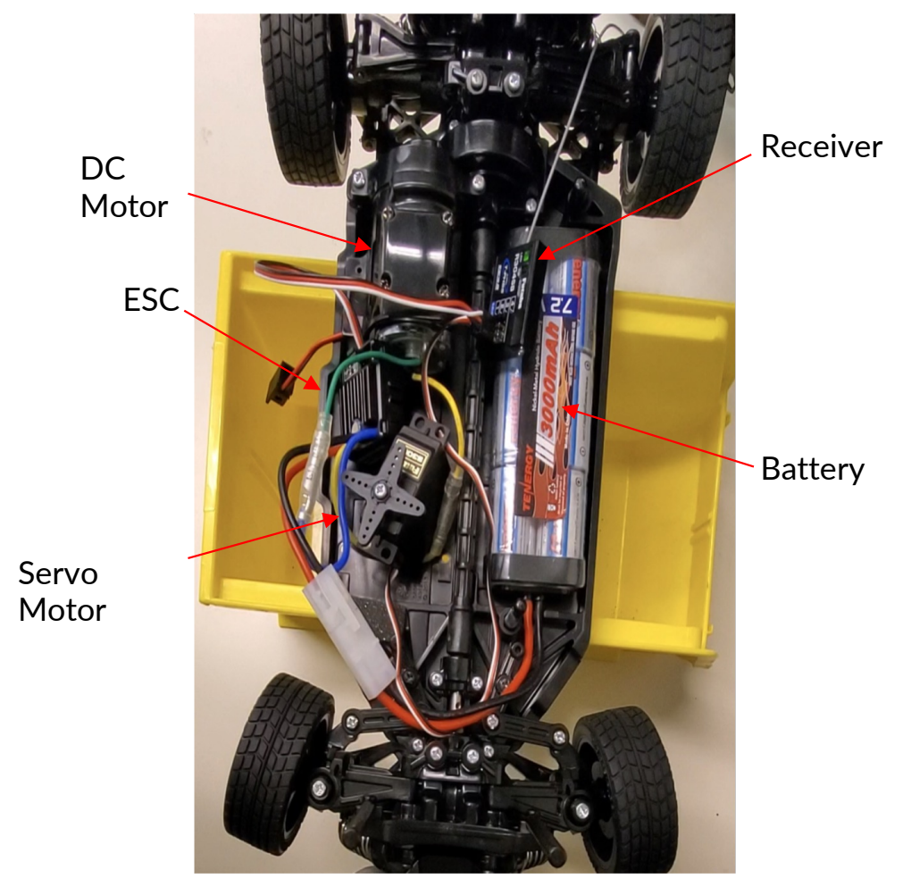
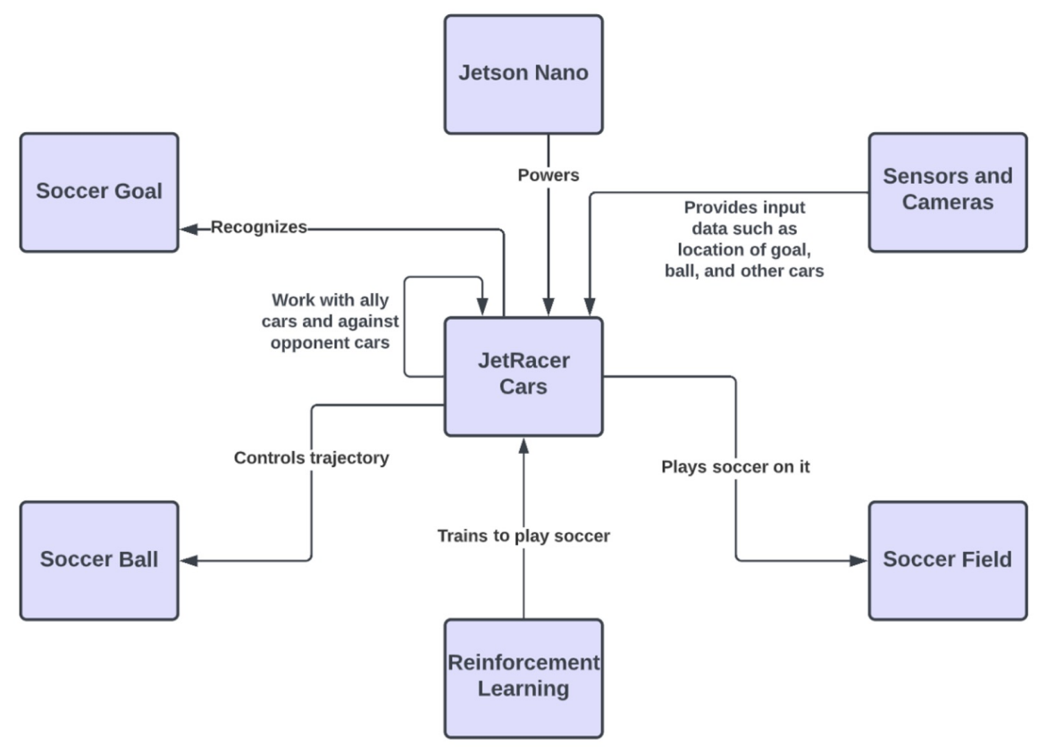
Objectives

- Play 2v2 and 3v3 soccer using autonomous RC vehicles
- Utilize ML object detection to identify soccer ball, goal, ally, opponent, and boundaries
- Use reinforcement learning in a simulation environment to train agents to autonomously play soccer
- Develop hardware and software tools as part of an ongoing project that demonstrates artificial intelligence for STEM outreach

JetRacer Features

- Tamiya TT-02 RC car provides 1/10th scale chassis
- 4GB Jetson Nano board for ML computation
- CSI camera views surroundings with 136 degree FOV up to 60 fps
- Motor driver and multiplexer control steering and throttle
- 7V 3000mAh battery pack powers car
- All hardware mounted on custom 3D printed base plate





Field Design

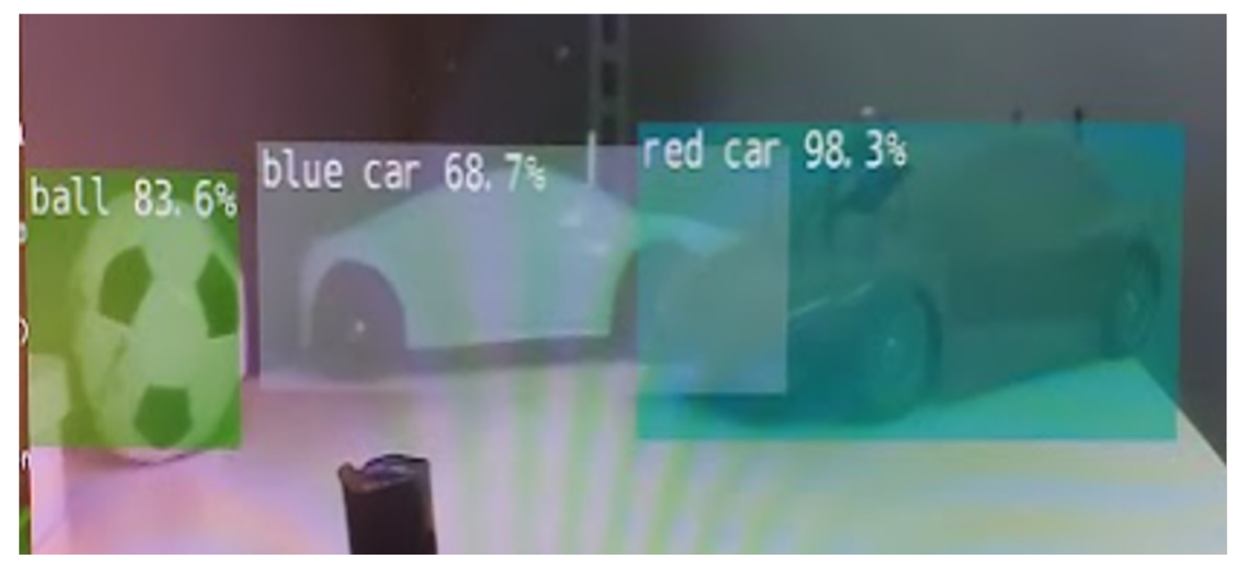
- 30’ x 20’ x 1’ (L x W x H) surrounding wall to contain ball and vehicles during match
- Transportable and modular setup using different lengths
- Sections connected via detachable hinges to allow stacking and easy connection/disconnection
- Cut-outs to slot in soccer goals
- Color selected to facilitate object detection

Basic JetRacer Motion

- Based off of NVIDIA’s Basic Motion notebook used to control throttle and steering of a JetRacer
- Designed to simultaneously accept user inputs from RC controller and software inputs from Jetson Nano
- User-friendly script created to program JetRacer that accepts inputs of continuous values for steering angle and throttle

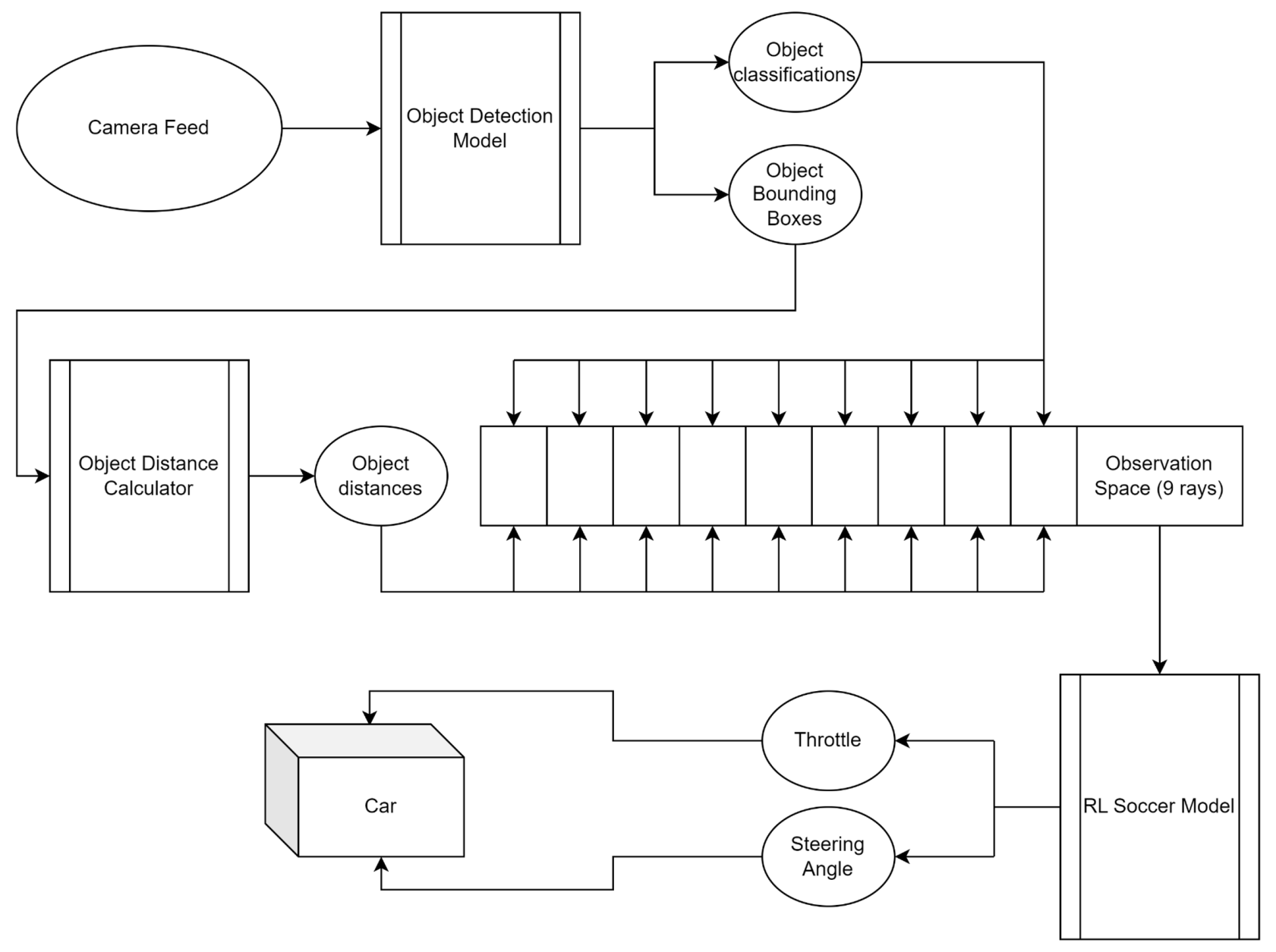
Object Detection

- Roboflow computer vision software used to create image dataset
  - ~6000 total images taken of ball, goals, cars, and boundaries to train object detection model
- Nvidia's deep neural network, DetectNet, enables real time object detection
  - Includes non-maximum suppression for filtering
  - Reduces computational cost by removing the data input layer, pooling layers, and output layer



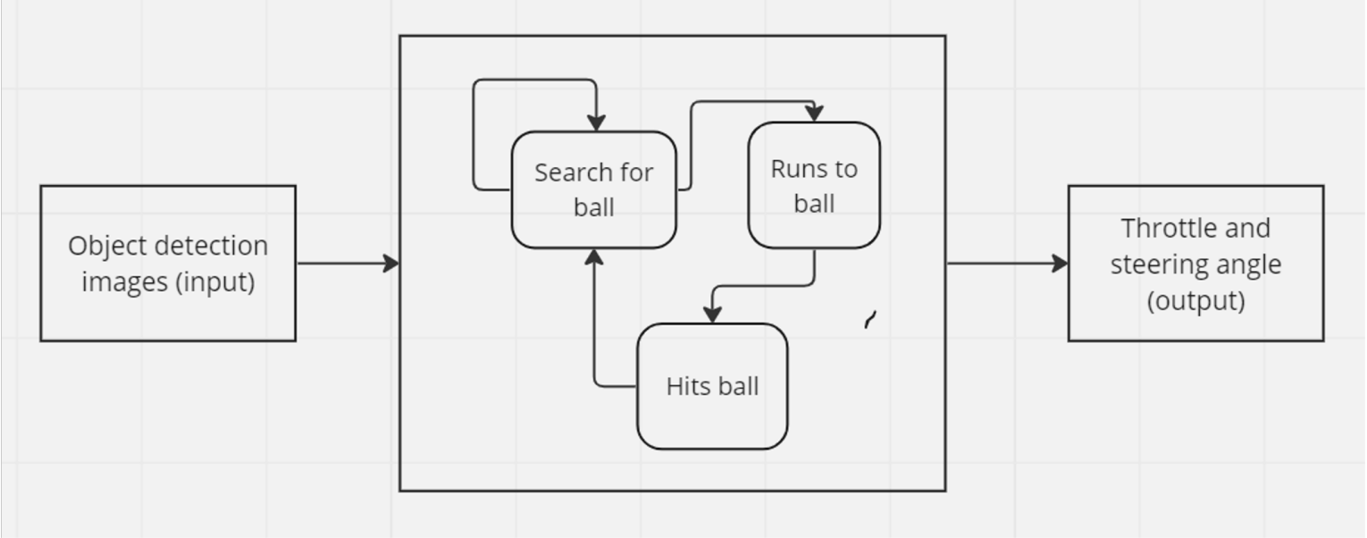
Simulation Environment

- Multi-agent training simulation built in Unity game engine with Unity ml-agents library
- Observation Space:
  - 9 observation rays coming out of the agents at equally spaced intervals
  - Each observation ray detects the class and distance of the object in its view
- Action Space:
  - Steering angle to orient the vehicle at
  - Throttle to apply to the vehicle



Deterministic Model

- Integrated results from basic motion and object detection
  - JetRacer recognizes a target object and moves towards target until point of contact
- Building block of JetRacer reacting to physical environment


Object detection images (input)
Search for ball
Runs to ball
Hits ball
Throttle and steering angle (output)

Result

- Built and gained full range of motion of 4 JetRacers using software
- Set up a simulation environment to virtually train the agents
- Implemented object detection model that identifies soccer ball, goal, ally, opponent, and boundaries
- Implemented software to follow and strike a ball
- Developed logic process for striking a ball into a goal
- Created a GitHub page documenting the hardware and software instructions to setup JetRacers, a summary of the work completed, and plans for future work

GitHub Repository

Future Work

- One to one matching of simulation and real environment
- Training agents in simulation environment
- Middleware for processing object detection model data to proper form for input into soccer playing model
- Implementation of controls on rc cars based on the output from soccer playing model
- Translate current deterministic model to include multiple cars and goal scoring format

[2]

References, and Acknowledgments

https://github.com/NVIDIA-AI-IOT/jetracer

https://github.com/bryanoliveira/soccer-twos-env

Special thanks to Bryan Oliveira for talking us through his simulation environment

https://universe.roboflow.com/jetracer-soccer-league/jetracer-soccer-league

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