JETRACER SOCCER LEAGUE

LOCKHEED MARTIN

43

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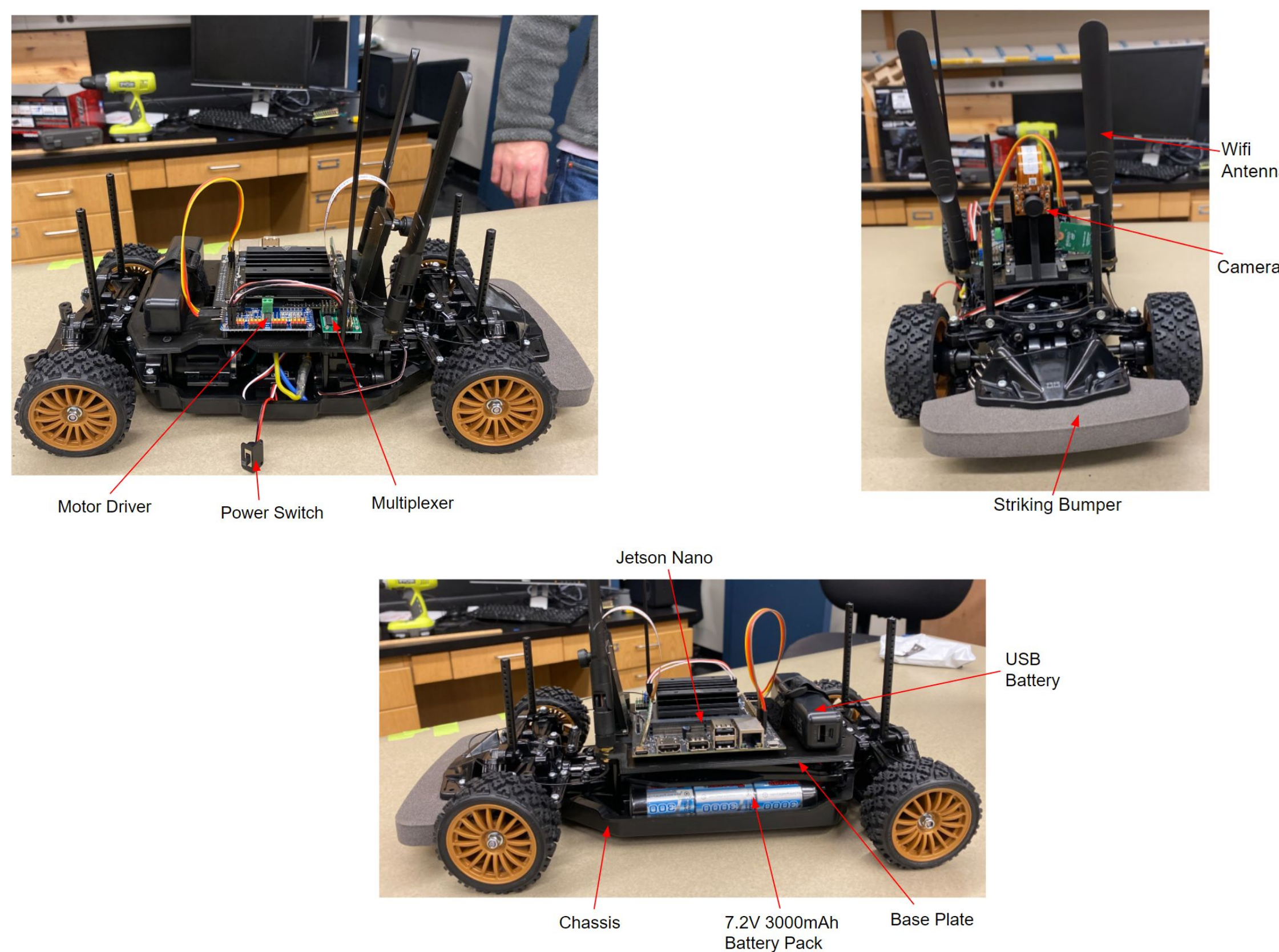
Objective

- Play 1v1 and 2v2 soccer using 1/10th scale autonomous vehicles
- Utilize machine learning to identify a ball, goal, and opponent
- Use artificial intelligence to improve the capability of a vehicle to score a ball in a goal
- Design simulation environment to train the agent safely
- 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
- 2GB 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

Motor Driver   Power Switch   Multiplexer   Wifi Antenna   Camera   Striking Bumper

Jetson Nano   Chassis   7.2V 3000mAh Battery Pack   Base Plate   USB Battery
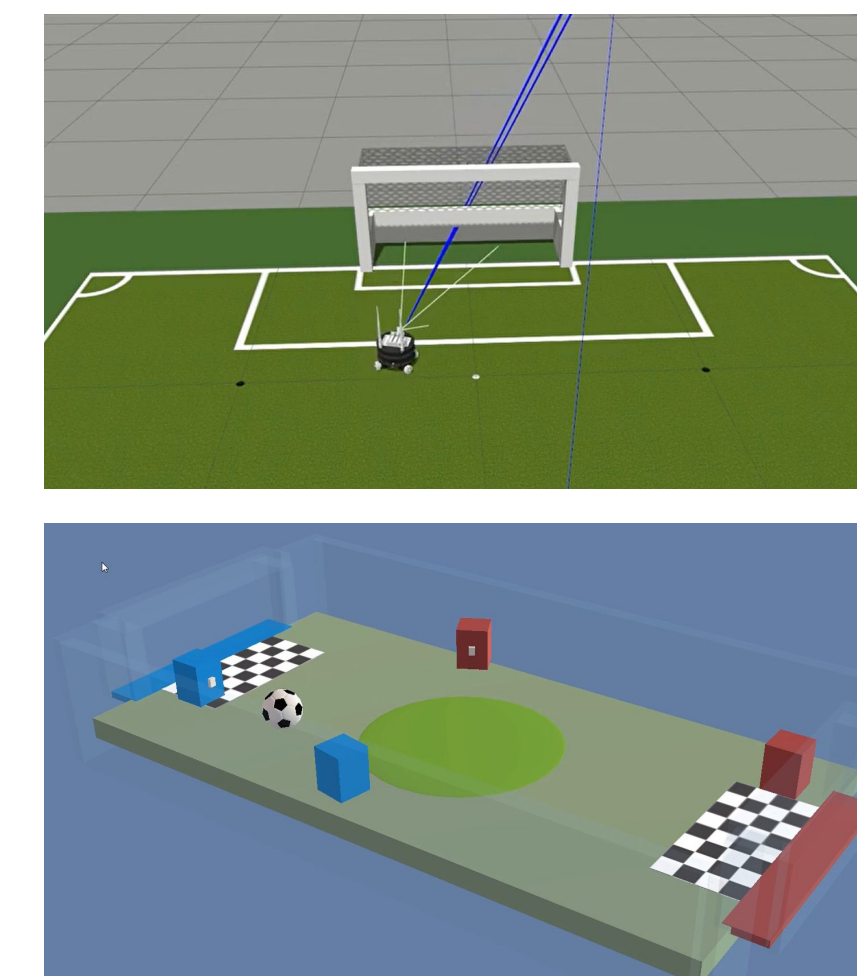
Field Design

- 30' x 20' x 1' (L x W x H) surrounding wall to contain ball and vehicles during match
- Transportable and modular setup using 4ft long sections
- Sections connected via detachable hinges to allow stacking and easy connection/disconnection
- Cut-outs to slot in soccer goals
- White color selected to facilitate object detection

Simulation Environment

- DeepSoccer environment used to mimic the real world to safely and efficiently train agents
- Reward system structured and successfully implemented it using Multi-Agent Actor-Critic framework with Proximal Policy Optimization in Unity's Soccer Twos Environment

| Keeper	Striker
• -1 when ball enters team's goal • +0.1 when ball enters opponent's goal • +0.001 existential bonus • -0.003 when ball is not in view	• -0.1 when ball enters team's goal • +1 when ball enters opponent's goal • -0.001 existential bonus • -0.03 when ball is not in view • +0.3 when striker kicks ball

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
  - 11 discrete steering directions
 - 7 practical throttle speeds
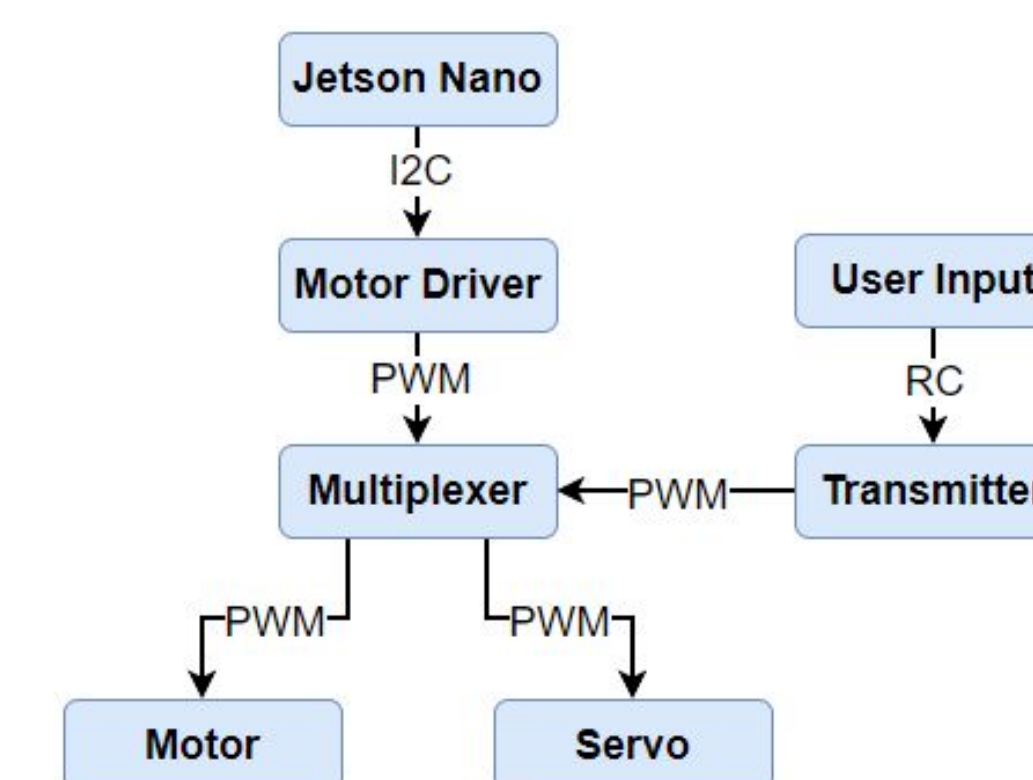
Object Detection

- Nvidia's deep learning institute used to create image dataset
- ~750 total images taken of ball, goal, and opponent 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
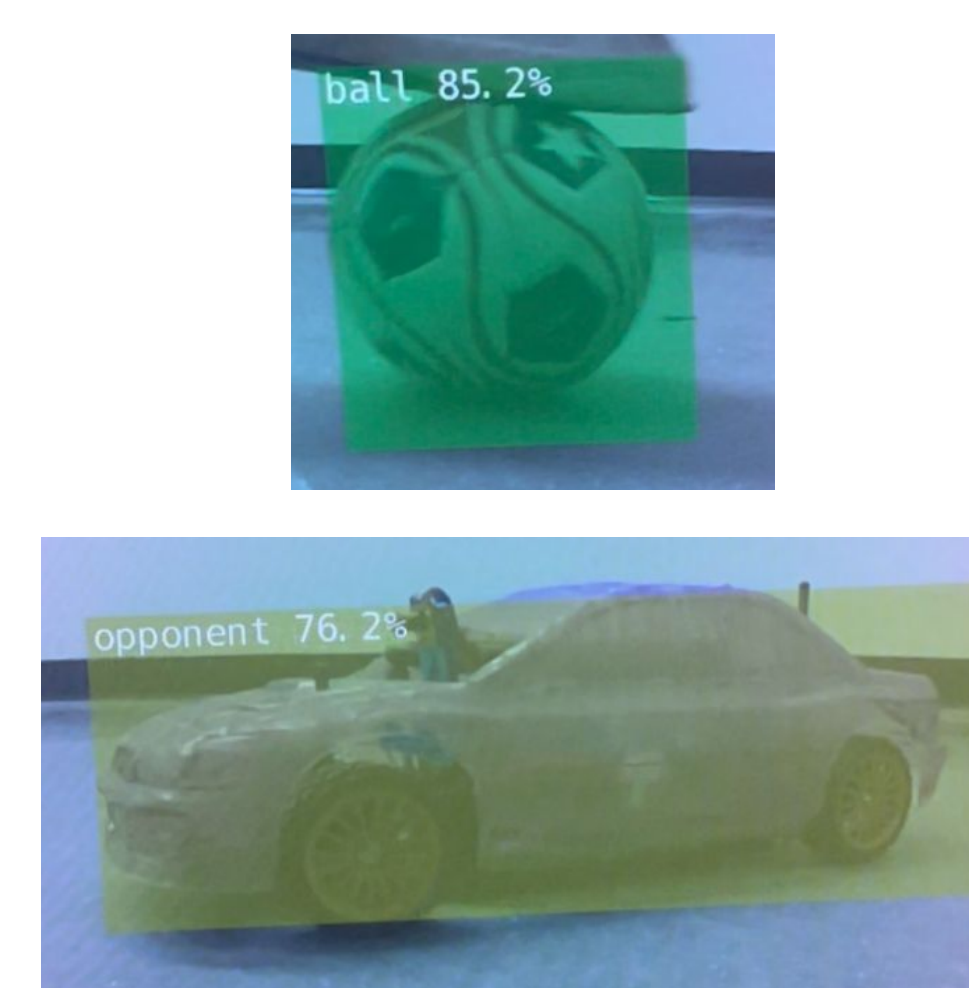
Object Following

- 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
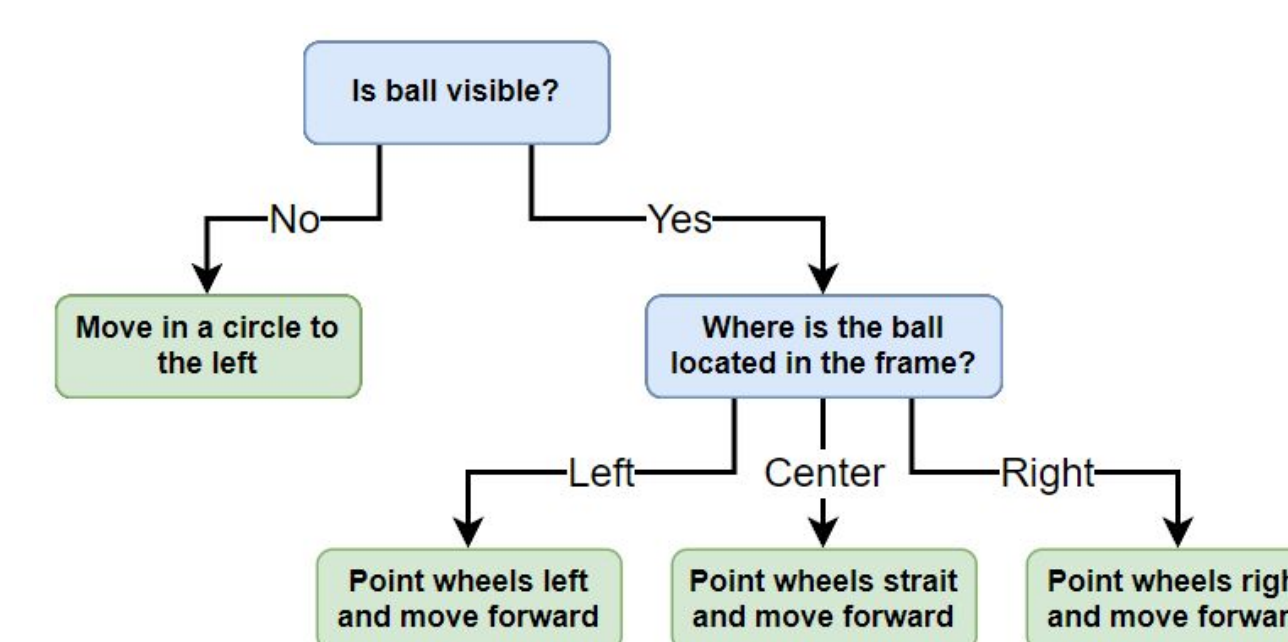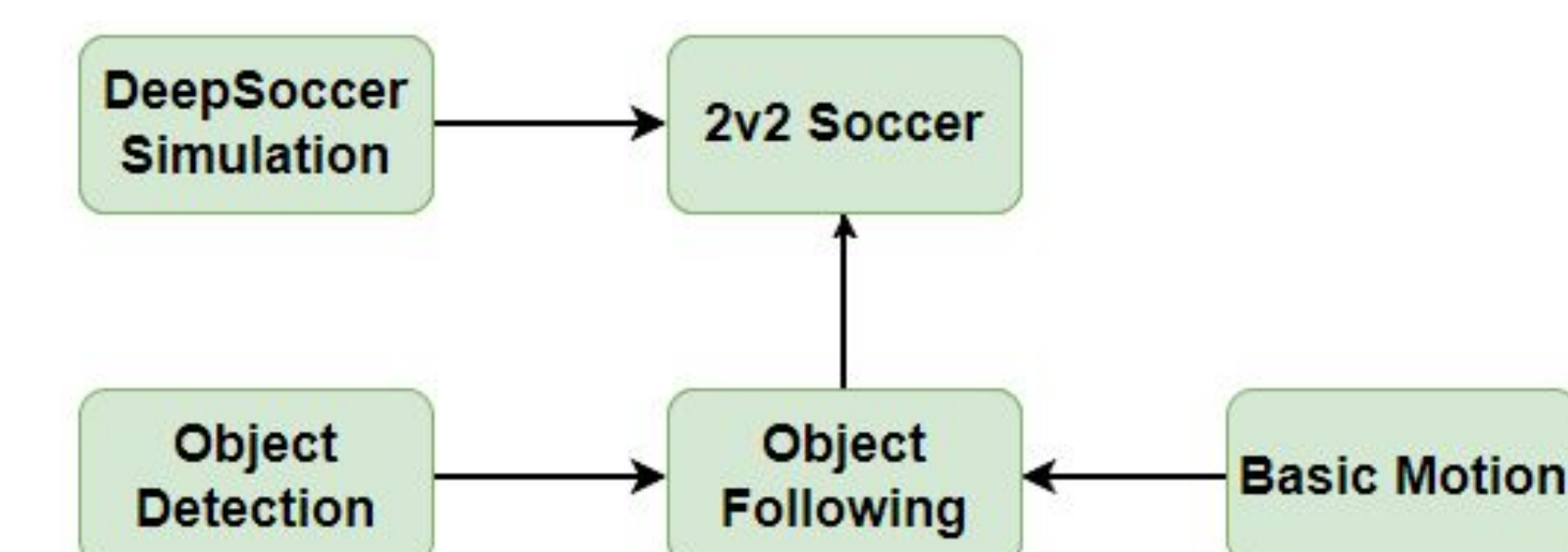

Results

- Built and gained full range of motion of 4 JetRacers using software
- Set up a simulation environment to virtually train the agents
- Structured an efficient reward system for the reinforcement learning model
- Implemented object detection model that identifies a soccer ball, opponent, and goal
- Implemented software to follow and strike a ball
- Developed logic process for striking a ball into a goal
- Simulation results with reward structure demonstrate that agents can be trained to efficiently compete in a 2v2 soccer match
- 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 page with detailed work

Future Work

- Heuristics based graph network that computes the shortest path from the ball to the goal and rewards the agent whenever the agents moves closer to the goal → manhattan distance to score a goal
- Translate Unity's 2v2 soccer simulation into real world results through the DeepSoccer simulation
- Train agents in DeepSoccer environment using reinforcement learning to optimize scoring a goal
- Add an opponent and other actors to build up a soccer match

References, and Acknowledgments

- https://developer.nvidia.com/blog/detectnet-deep-neural-network-object-detection-digits/
- https://github.com/NVIDIA-AI-IOT/jetracer
- https://github.com/kimbring2/DeepSoccer
- https://github.com/NVIDIA-AI-IOT/jetracer
- Thank you to NVIDIA and Dr. Craig M. Wittenbrink, Senior Director, TensorRT at Nvidia