EE106A/206A / BIOE125

Simulating Soccer

Fall 2020

1 Contact Information

Name	SID	Email
Brett Bussell	3033366039	bbussell24@berkeley.edu
Haochen Gao	3034125813	haochengao@berkeley.edu
Casper Max	3032714193	cmax@berkeley.edu
Nithin Raghavan	3033077257	rnithin@berkeley.edu
Trevor Voth	3033359760	tvoth@berkeley.edu

2 Abstract

Recent advances in the fields of path planning, artificial intelligence, and computer vision have opened up the possibility for far more accurate autonomous algorithms in an industrial sense. In the spirit of exploring how the intersections of these fields leads to new insight, we look to the game of soccer, where teams of robots collaborate to accomplish an objective (scoring a goal) while constrained by an adversary (the opposing team). In order to accomplish this, the robots must perceive their dynamic environment, develop a strategy to obtain an optimal benefit, and then perform an action. Constraints that have to be measured include how to balance speed and agility with more kinetically-optimal path-planning algorithms and coordination. By doing this, we hope to elucidate new insight as to how these fields interact and converge, measure how well algorithms within these fields can be implemented in the context of ROS and other robotic simulators, and observe how effective modern-day AI pipelines can work in simulation.

3 Project Description

RoboCup is an annual robotics soccer tournament. We will be using an existing RoboCup simulation which provides the RoboCup environment and robots. This will allow us to focus more on path planning, vision, and decentralization and less on the initial setup. We will start with perfect state knowledge of 2 robots. The idea is to use a master node and the state knowledge to modify the motion of a soccer ball and robots, plan the trajectory of each robot, and send control commands to each robot. Once this is working well, we will increase the number of robots and refine path planning until we have a more realistic soccer experience. For additional goals, we hope to utilize the vision systems incorporated in each robot to measure the state of the ball and other robots and eventually move toward decentralized planning and control.

4 Tasks:

1. **Setting up the simulation environment**
   (a) **Making a single robot:** move, shoot, pass, and dribble the ball.
   (b) **Making two robots:** play against each other.
   (c) **Making multiple robots:** move, shoot, pass, and dribble the ball and between each other.
2. **Strategies/Path Planning**

(a) **Develop game strategy** Design a set of roles to assign to each robot including attacker, defender, goalkeeper, etc. In addition, design the logic that chooses a robot's role and allows for dynamic reassignment of roles during the game.

(b) **Decide on planning approach** Conduct initial research and come to decision on which path planning algorithm(s) would be most efficient/applicable (A*, RRT, subtargets+B-spline, etc.)

(c) **Develop planning algorithm(s)** Apply the planning algorithm to each of the roles in the set developed earlier, tuning each to match the desired behavior for that role.

3. **Control:**

   (a) **Decide on control approach** Conduct initial research and come to decision on which control algorithm(s) would be most efficient/applicable (PID Control, MPC, etc).

   (b) **Develop control approach** Develop the algorithm(s) based on the optimal strategy found in the initial research.

   (c) **Integrate Control Algorithm** Integrate the control algorithm into the sim/ROS environment.

   (d) **Tune** Tune the control algorithm based on the tested results in the simulator.

4. **Vision:**

   (a) **Research/decide on object recognition and object tracking algorithm(s).** Research and explore object-detection algorithms.

   (b) **Implement chosen algorithm.** Implement the chosen algorithm using rospy so that it will be compatible with the simulation environment and robot sensors.

   (c) **Benchmark chosen algorithm.** Measure the overall average accuracy of each algorithm for internal analysis.

5 Milestones

- **Task 0** (Oct. 31):
  - Run the simulation and implement the basic functions of an individual robot.
  - Research and decide on path planning algorithm(s) beyond A*
  - Research and decide on control algorithm to use beyond PID.
- **Task 1** (Nov. 8):
  - Assuming perfect knowledge of players and ball, implement basic strategy and path planning using A*.
  - Research more intricate path-planning algorithms such as RRT.
  - Run the simulation and implement multiple robots.
- **Task 2** (Nov. 15):
  - Implement the more advanced path planning algorithm. Benchmark the more advanced planning algorithm.
  - Implement a basic computer vision algorithm, by coloring the ball orange, the teams blue and red, and measuring pixel color discontinuity for image segmentation.
- **Task 3** (Nov. 22):
  - Research the viability of other CV algorithms, as well as potentially deep-learning algorithms such as YOLO and Faster R-CNN. Compare and benchmark these algorithms with the segmentation algorithm.

  - Finish the MVP by this time.

- **Task 4** (Nov. 29): Final integration.
  - Integrate all operational nodes and begin debugging of the entire system as a whole.
- **Task 5** (Dec. 6): First 5 vs. 5 game.
- **Final deadline** (Dec. 10): Create project website.

6 Assessment

How will you test or assess your project? What constitutes a success? What are some realistic goals? What are some "reach" goals?

Our project will consist of a minimum viable product combined with several stretch goals. The minimum viable product will constitute a valid path-planning algorithm that will allow two robots, combined with an overhead tracking camera, to play soccer, and we will consider this to be a success. Realistic goals include incorporating multiple robots, each fitted with their own vision systems, as a generalization of the MVP. A reach goal would be decentralizing the planning algorithm from an overhead camera to each individual robot, letting each robot plan its own trajectory based on what it can see.

7 Team Member Roles

- Brett will be in charge of Controls. Brett has background in linear systems, classical and optimal control theory (including model predictive control).
- Haochen will be in charge of Path Planning. His background is drone flight path planning and object detection/classification.
- Casper will be in charge of Vision/Path Prediction. His background is in signal processing and basic path planning algorithms.
- Nithin will be in charge of Vision/Path Planning. His background is in autonomous vehicle path planning, drone flight path planning, deep learning for object detection and semantic segmentation, and computer vision.
- Trevor will be in charge of Controls/Sim. Trevor has background in computer vision, classical and optimal control theory.

8 Bill of Materials

8.1 Use of Lab Resources

Not applicable.

8.2 Other Robotic Platforms

Simulation platforms: RoboCup Simulator, NuBot (Gazebo visualization, robot code, and sending game commands to robots)

8.3 Items for Purchase

Not applicable.

9 Other

The project will be based mostly on a RoboCup simulator called NuBot. This also contains general background information and more details about the implementation of the simulator.