Newtwoked Robotic Systems

Control of Swarm Robots

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Introduction:

The goal of the project "Control Swarm of Robots" is to simulate the swarm of 6 robots to reach the target in formation in PyBullet (A physics simulator). The goal of the robots is to create a formation in the original arena and to switch the formation to cross the passage to the next arena keeping the distance of 1 between each robot. Also, to avoid obstacle (the walls in the environment). Finally, to reach the triangular formation at the end of the target location.

Description:

The controller is designed using the relative state-based control. I used a Single-Integrator dynamic for each agent. The advantages of using a relative state based control is that the robots only need to know the relative positions of the robot neighbors. The proportional control law for single integrator is,

$$u = -KLx + KDz_{ref}$$

The double integrator can be also used, it is more accurate than the single integrator, since we can control the acceleration. The double integrator proportional law is shown,

$$u = -kLx + kDz_{ref} - dL\dot{x} + dD\dot{z}_{ref}$$

Description of the controller,
The controller used is single integrator,

The project is designed using the single integrator.

AS we know the

Formation Control = F_Formation + F_Target

$$F_{formation,i} = \begin{bmatrix} K_F(Dz_{x,desired} - Lx)_i \\ K_F(Ddz_{y,desired} - Ly)_i \end{bmatrix}$$

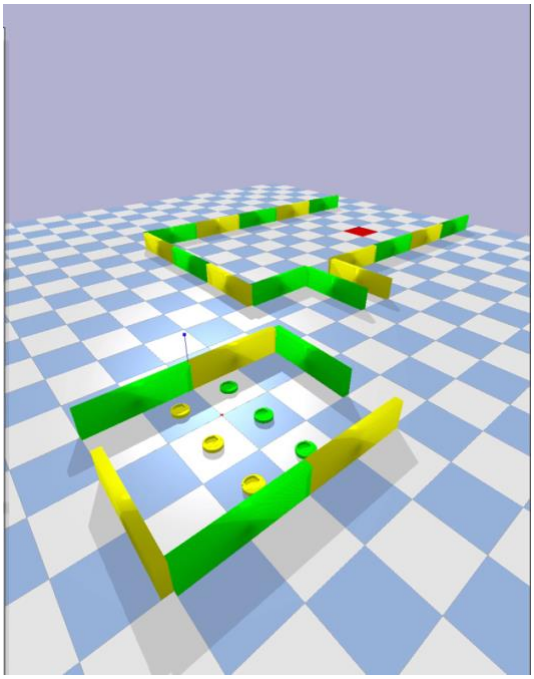
Target Control,

$$F_{target,i} = \begin{bmatrix} K_T * min(x_{goal} - x_i, 1.) \\ K_T * min(y_{goal} - y_i, 1.) \end{bmatrix}$$

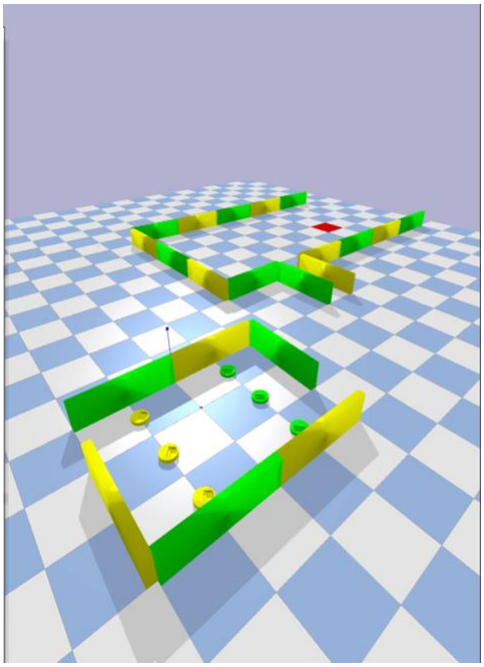
The Laplacian is the difference between the neighboring states (position of the robots). In this project the relative distance between the robots and the target is computed and is updated till the reaching the desired target.

Simulation Results:

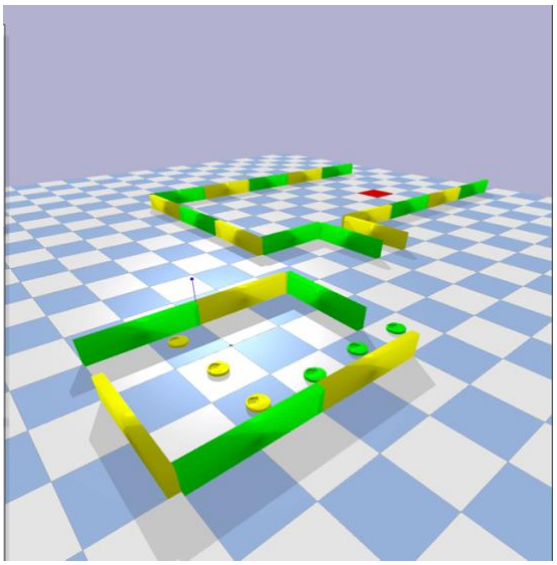
The below pictures show the run time simulation of the project

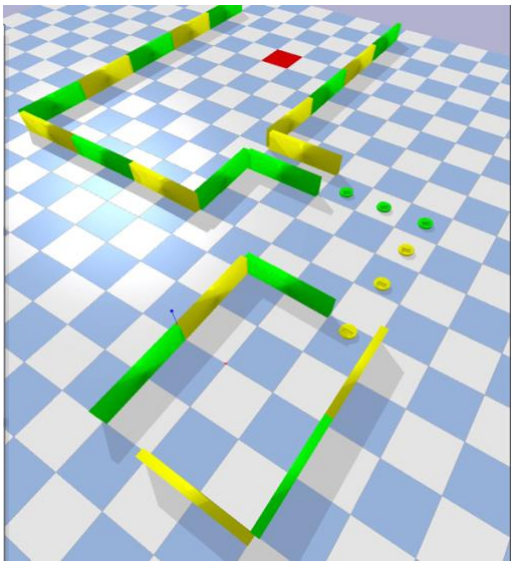


Starting Position

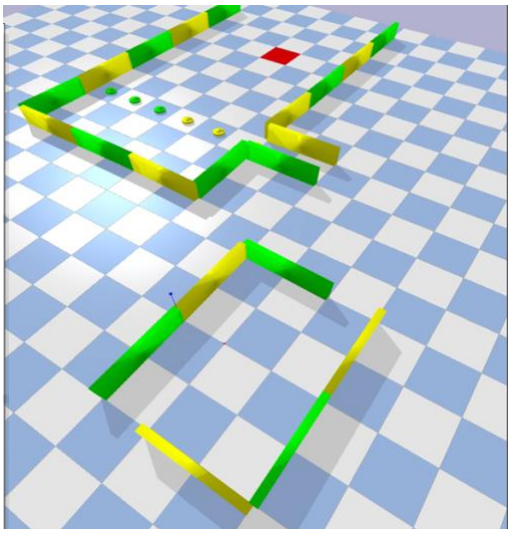


Square Formation

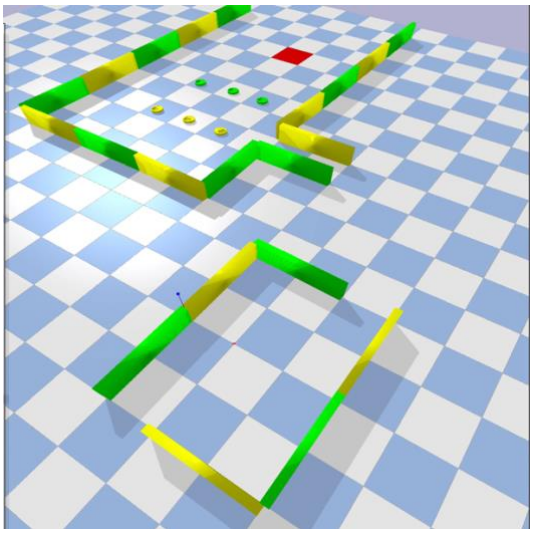




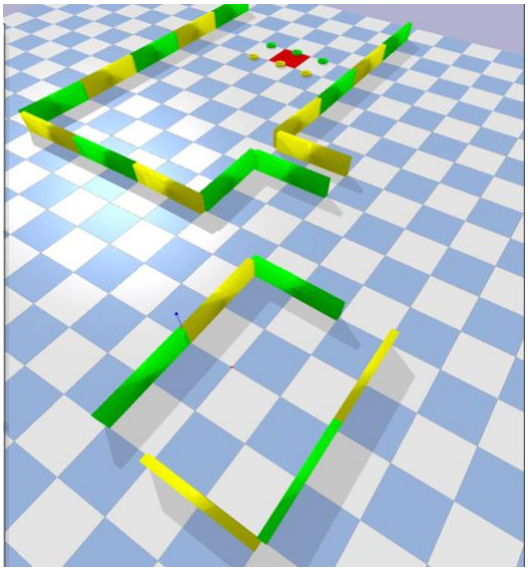
Different formation to navigate



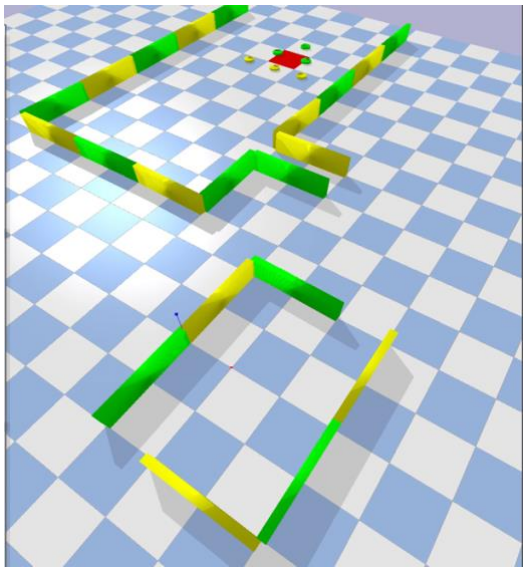
Inside the desired Arena



Square Formation



Reaching the target



Triangular Formation

Pros and Cons:

Pros:

The relative state space control only needs to know the relative neighbors. Thus reducing the complexity and also improving the performance. The formation control is easier when compared to rigidity based control laws, It can also maintain the desired distance between each robots.

Cons:

The double integrator is more accurate and more controllable than the single integrator. We need to know the entire environment for navigation.

Conclusion:

Thus, the project goal is achieved by using a relative State based control law. Thus, it can be seen that relative state based controller for control of swarm robots is more reliable and accurate than many other laws.