Final Project Report

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Introduction stating the goal of the project

1. Make a square formation in the room
2. Get all the robot out of the room and make a circle formation outside
3. Move the purple ball on the purple square
4. Move the red ball on the red square
5. Get back into the room and make a diamond formation

For the first goal, we need to use formation control easily to get a square formation, in which the reference distances represent the desired formation—square's rigid constraints. And we can set K as 1 to simplify the problem. D is the E matrix of our connected graph.

For the second goal, we need to deform our robots as a line, then set one of them as the leader. Use the following control method to move it to a certain position outside the room. The rest of robots obey the line formation control law, so they will move outside the room with respect to the leader. Then change our state with a judgement that if the leader is close enough to the destination. After reach a certain position, the formation changes from a line to circle with using a new desired distance matrix.

For the third goal, we can move the circling robots to surround our target—purple ball. Because we already set the circle large enough to pass the ball avoiding touching it. We can just move a leader robot to a certain position. Then shrink the circle and move the formation carrying purple ball to the certain position which is near purple area. After leader movement, the purple ball will sit in the destination area.

For the fourth goal, after move purple ball, we enlarge the circle back to original width, then move to surround red ball in the same way by two steps. At first step, move down; at second step, move left. Then shrink the circle to carry the red ball to res area.

For the last goal, after moving the red ball, we can use the line formation travel again to go back into the room, and generate a diamond as we wish easily by giving a reference desired distance matrix.

Description of the controller (justifying why it was designed this way)

We can use the basic formation control law using desired position of each robot:

$$\dot{P} = -KL(P - P^{\mathrm{dis}})$$

Set $Z_{12}^{dis} = P_2^{dis} - P_1^{dis}$ then we get $Z^{dis} = \begin{bmatrix} P_2^{dis} - P_1^{dis} \\ \vdots \end{bmatrix} = \begin{bmatrix} Z_{12}^{dis} \\ \vdots \end{bmatrix}$

Therefore, we get the formation control law using reference desired distance as following,

$$\dot{P} = -KLP + KLP^{\mathrm{dis}} = -KLP + KEE^{T}P^{\mathrm{dis}} = -KLP + KEZ^{\mathrm{dis}}$$

Experimental results showing how the system works in the simulator

The result is shown in the video.

Discussion of the pros and cons of the approach and a short conclusion.

Pros:
1 This approach is a decentralized control method. We don't need all of the robots connected to a center base. It saves a lot of computation and complexity.
2 It is linear control law, so it is simple enough to implement.
3 This method only care about the reference distance for the desired formation instead of absolute positions for each robot.

Cons:
X and Y are separated. A little bit inconvenient.

CONCLUSION

In this semester, we learned different kinds of method used in swarm control. For particular questions, we can set the swarm control into centralized control, however, we should implement more decentralized control law for swarm problem, because of computational complexity. In the final project, the most important methods I have used are formation control with reference distance, leader robot control and pushing movement. These are second basic control law for swarm, the most basic control algorithm is absolutely – consensus algorithm. In fact, most of the methods we have learnt in this semester all come from consensus algorithm. For the formation control, except the method we use, we can set rigidity matrix to promise the formation as another method, even we can use potential control law to avoid knock into each other. For the decentralized control, we can set a leader others follow its path to generate a trajectory to destination. Pushing movement is the most basic but important method to change an object's position with a swarm of robot. The project is a great begin for a swarm problem simulation.