Giulia’s part

Intro:

We're faced with a challenge concerning rendez-vous and tracking among three mobile robotic agents. These agents need to agree on a rendez-vous point and upon reaching proximity to this point, they must initiate a tracking task along a circular trajectory centered around it.

In this scenario, we're dealing with unicycle robots, which are planar vehicles equipped with a single orientable wheel. It's important to note that these robots are treated as independent entities. To address this challenge effectively, we've established certain constraints. Firstly, the environment in which the agents operate is a 12x12 2D grid. Additionally, initial conditions are randomly selected. The radius of the final trajectory is set to 1, while the radius of the proximity circle is 4.

To simplify matters, we're not considering collisions; instead, we view them as indicative of failure within the specific set of initial conditions. This approach enables us to analyze the performances of the different tracking control approaches.

The model for the unicycle is outlined by the relationship between translational and rotational coordinates, which can be found in the accompanying slides.

We have split out the problem solution approach in different steps : the first thing we need to care of is finding a consensus for the three agents, then it’s applied a first control called regulation until the proximity circle that delimitates the closeness to the rendez-vous point and lastly the tracking control makes the agents move along a circular trajectory towards the consensus. It’s important to point out once again that the control procedure has been applied on each robot independently. We have applied different types of regulation and tracking control and made separate behaviors analysis of the unicycle system.

Consensus:

The consensus problem refers to the challenge of achieving agreement or alignment among multiple autonomous agents or robots in a decentralized system. In essence, it involves ensuring that all robots in a group reach a common decision or converge to a shared state despite differences in their starting conditions or local observations. Consensus is described by an autonomous system of the form ,where is the position of the agent at time In our specific case we chose to apply the average consensus and to do so the matrix needs to be doubly stochastic (meaning that all the rows and columns of the matrix sum to 1) and also primitive to ensure convergence; given this two conditions it’s possible to find the rendez-vous point as the average of the initial conditions. The matrix we adopted is the one converging in one step and not shrinking to a solution over time.

Regulation:

We applied and tested to types of regulation control:

* Cartesian regulation

Cartesian control could also be called position control since it drives the unicycle to a desired position regardless the orientation, as can be seen from the block scheme is not controlled.

Looking at the control law we can distinguish the feedback loop on linear velocity that aims to take the projection of over to zero, where is the sagittal axis unit vector whose components are and ; and the feedback loop on angular velocity that takes the misalignment of and to zero, in other words drives the pointing error to zero. The tuning of the gains for this control was made by trial and error, in these plots were both set to 2. Another notable implementation choice was to add the “unwrap” block, with tolerance immediately after the “atan2” function to avoid discontinuities in the computed angle values; this is due to the periodicity of the function.

In this plot we reported the behavior of the three robotic agents under cartesian regulation only and it’s interesting to point out that the final orientations of the three agent are randomly achieved.

* Posture regulation

Posture regulation provides a polar representation of the unicycle pose and aims to bring these quantities to zero. Here we have reported the state and input transformation and the control law applied. We chose to implement posture regulation without singularity that is generally more straightforward and predictable since the system can move in its workspace without encountering any critical points.