Class: Sistem Pengaturan Formasi dan Kolaborasi (EE185523)
Lecturer: Yurid E. Nugraha
Deadline: 2023/05/17

Assignment 4: Graph-theoretical Approach on Mobile Robots

(You can choose which problems to solve. The problems that are attempted while the weight of previous attempted problems has reached 100% **will not be considered**.)

1. (**Weight: 30%**) The problem of modeling the coordination of mobile robots as multiagent systems has become a widely-explored research area recently. Pick **two** of the papers below and summarize each paper in about 400 words.

   - A. V. Savkin and H. Teimoori. Decentralized navigation of groups of wheeled mobile robots with limited communication. *IEEE Transactions on Robotics*, vol. 26, no. 6, pp. 1099-1104, 2010.
   - S. Kim, M. Santos, L. Guerrero-Bonilla, A. Yezzi and M. Egerstedt. Coverage control of mobile robots with different maximum speeds for time-sensitive applications. *IEEE Robotics and Automation Letters*, vol. 7, no. 2, pp. 3001-3007, 2022.
   - S. L. Smith, M. E. Broucke and B. A. Francis. Curve Shortening and the Rendezvous Problem for Mobile Autonomous Robots. *IEEE Transactions on Automatic Control*, vol. 52, no. 6, pp. 1154-1159, 2007.
   - K. Saulnier, D. Saldaña, A. Prorok, G. J. Pappas and V. Kumar. Resilient Flocking for Mobile Robot Teams. IEEE Robotics and Automation Letters, vol. 2, no. 2, pp. 1039-1046, 2017.

2. (**20%**) Consider an edge tension

   $$\mathcal{V}_{ij}(||x_i - x_j||) = 2 - e^{(||x_i - x_j||)}.$$

   What is the node-level dynamics associated with negative gradient flow, i.e., $-\partial \mathcal{V}_{ij}(\Delta, x)/\partial x$? Also, assuming the graph is undirected and connected at all times, do the agents achieve consensus?

3. (**25%**) Consider n agents consisting of m leaders and $n-m$ followers all with scalar dynamics placed at $(0, 0)$ at $t = 0$. Assume that there is a goal in x_g that is known only to the leaders. Let the dynamics of *each* leader with state x_{il} be

   $$\dot{x}_{il}(t) = \sum_{j \in N_{il}} (x_j(t) - x_{il}(t)) + c(x_g - x_{il}(t))$$

   for some positive weight $c > 0$. Moreover, assume that the followers are executing

   $$\dot{x}_{if}(t) = \sum_{j \in N_{if}} (x_j(t) - x_{if}(t))$$

   What are the values of n, m, x_g, and Δ in order for the agents to stay connected from origin initial value to x_g?

4. (**15%**) Discuss what is the maximum edges in a planar Gabriel graph.

5. (**25%**) Discuss what may happen with the control laws and edge-tension for the case of robots with different range, i.e., $\Delta_i \neq \Delta_j$, $i \neq j$.

6. (**15%**) Give example of a paper that addresses a system of mobile robots (or multi-agent systems in general) with inaccurate readings of range sensors. Write a summary of the paper in about 400 words.