

Preliminary Study on Decentralized Vision-Based Autonomous Drone Swarms

Jordy A. Larrea Rodriguez,^{a)} Brittney L. Morales,^{b)} and Misael Nava^{c)}

*Department of Electrical and Computer Engineering
University of Utah, Salt Lake City, Ut, USA*

Abstract.

INTRODUCTION: Conventional technology for autonomous unmanned aerial vehicle (UAV) swarms involves a centralized system for control of all units. Take drone light shows, the choreography observed in these kind of spectacles is planned, simulated, and then loaded into individual adequately spaced drones. A number of fail-safes are deployed in order to minimize damages from a rouge drone failing to keep to its pre-planned path. The state of art in autonomous swarms employs a decentralized model consisting of multi-agent networks. These multi agent systems hold the potential to adapt to new environments and optimize individual performance to specific tasks without having to deal with global systems prone to single points of failure. Our team's focus lies therein decentralized multi agent quad-rotor swarms.

METHODS: The decentralized multi agent system will consist of two medium sized quad-rotors consisting of open source flight controller hardware and software (PX4) interfaced through MAVlink by raspberry pi 4 companion computers for edge specifications. A central system is still beneficial for assignment of global objectives; thus, our proposed decentralized system will employ a central bay station to communicate objectives for the agents to complete. GPS modules, infrared sensors, and low-resolution cameras will be procured for real time decision making by the agent(s). Our development stack will leverage the Robot Operating System (ROS) for project management, simulation capabilities, navigation libraries, and native server client model in robotics applications.

DISCUSSION: Flocking behavior observed in nature leverages vision for spatial awareness; thus, our decentralized agents will leverage edge computing and on-board cameras to interact with themselves and the environment. Decentralized swarms allow for a set of agents to act as more than distributed actuators: i.e., more like your white blood cells rather than your limb.

SIGNIFICANCE: Drone Swarms hold the potential to gather large quantities of data for monitoring and area mapping that would otherwise prove too costly to collect. Furthermore, UAV's hold a potential to greatly simplify and reduce manpower in search-and-rescue, disaster recovery, or security scenarios [3]. Swarms essentially hold the capability to replace humans in potentially dangerous and normally costly tasks.

REFERENCES

1. W. Chen, J. Liu, H. Guo, and N. Kato, "Toward robust and intelligent drone swarm: Challenges and future directions," *IEEE Network*, vol. 34, no. 4, pp. 278–283, 2020.
2. R. Cooley, S. Wolf, and M. Borowczak, "Secure and decentralized swarm behavior with autonomous agents for smart cities," in *2018 IEEE International Smart Cities Conference (ISC2)*. IEEE, Conference Proceedings, pp. 1–8.
3. S. Engebråten, K. Glette, and O. Yákimenko, "Field-testing of high-level decentralized controllers for a multi-function drone swarm," in *2018 IEEE 14th International Conference on Control and Automation (ICCA)*. IEEE, Conference Proceedings, pp. 379–386.
4. T.-K. Hu, F. Gama, T. Chen, Z. Wang, A. Ribeiro, and B. M. Sadler, "Vgai: End-to-end learning of vision-based decentralized controllers for robot swarms," in *ICASSP 2021-2021 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP)*. IEEE, Conference Proceedings, pp. 4900–4904.
5. P. McEnroe, S. Wang, and M. Liyanage, "A survey on the convergence of edge computing and ai for uavs: Opportunities and challenges," *IEEE Internet of Things Journal*, 2022.
6. S. Qamar, S. H. Khan, M. A. Arshad, M. Qamar, and A. Khan, "Autonomous drone swarm navigation and multi-target tracking in 3d environments with dynamic obstacles," *arXiv preprint arXiv:2202.06253*, 2022.
7. P. Tosato, D. Facinelli, M. Prada, L. Gemma, M. Rossi, and D. Brunelli, "An autonomous swarm of drones for industrial gas sensing applications," in *2019 IEEE 20th International Symposium on A World of Wireless, Mobile and Multimedia Networks (WoWMoM)*. IEEE, Conference Proceedings, pp. 1–6.

^{a)}Contact: Jordy.LarreaRodriguez@gmail.com

^{b)}Contact: brittneymrls@gmail.com

^{c)}Contact: misaelnava812@gmail.com