iGP: Smart City

iGP Module: Swarm Intelligence in Swarm Robotics

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Swarm robotics is a novel approach to the coordination of large numbers of robots. It is inspired from the observation of social insects - ants, termites, wasps and bees - which stand as fascinating examples of how a large number of simple individuals can interact to create collectively intelligent systems. Social insects are known to coordinate their actions to accomplish tasks that are beyond the capabilities of a single individual: termites build large and complex mounds, army ants organize impressive foraging raids, ants can collectively carry large preys. Such coordination capabilities are still beyond the reach of current multi-robot systems.

The motivation for swarm robotics is driven by:

- **Robustness:** requires that the swarm robotic system should be able to continue to operate, although at a lower performance, despite failures in the individuals, or disturbances in the environment. This robustness can be attributed to several factors; First, redundancy in the system; that is, any loss or malfunction of an individual can be compensated by another one. This makes the individuals dispensable. Second, decentralized coordination; that is, destroying a certain part of the system will not deter the system's operation. Coordination is an emergent property of the whole system. Third, simplicity of the individuals; that is, in comparison to a single complex system that could perform the same task, in swarm robotic system, individuals would be simpler, making them less prone to failures. Fourth, multiplicity of sensing; that is, distributed sensing by large numbers of individuals can increase the total signal-to-noise ratio of the system.
- **Flexibility:** requires the swarm robotic system to have the ability to generate modularized solutions to different tasks. Swarm robotic systems should also have the flexibility to offer solutions to the tasks at hand by utilizing different coordination strategies in response to the changes in the environment.
- **Scalability:** requires that a swarm robotic system should be able to operate under a wide range of group sizes. That is, the coordination mechanisms that ensure the operation of the swarm should be relatively undisturbed by changes in the group sizes.

PROJECT MODULES

- **Machine Learning Module:** responsible for pattern recognition and building different work scenarios for the swarm according to previous trials.
- **Computer Vision Module:** responsible for tracking obstacles and other point of interests for the swarm individuals.
- **Artificial Intelligence:** responsible for making the swarm individuals completely autonomous.
- **Networking Module:** responsible for the communication means of the swarm individuals by choosing the best fit protocol balancing power efficiency and data rate.
- **Embedded Software Module:** responsible for low-level programming and tweaking of the swarm individuals.

REQUIRED QUALIFICATIONS

- **Programming Expertise:**
  - Object-Oriented Mindset (Analysis and Design)
  - Knowledge of Algorithms
  - Test-Driven Development
  - Code Efficiency
- **Programming Languages:**
  - C/C++
  - Python – MATLAB
- **Other:**
  - Familiarity with any network protocol (Ethernet, TCP/IP, ZigBee or equivalent)
  - Familiarity of computer hardware

KNOWLEDGE AREAS TO BE ACQUIRED

- Machine Learning and Pattern Recognition
- Artificial Intelligence and Deep Learning
- Image Processing and Computer Vision
- Embedded Linux
- Embedded Software Development
- Various Communications stacks