Robotic Hardware System:

SWARMING ROBOT

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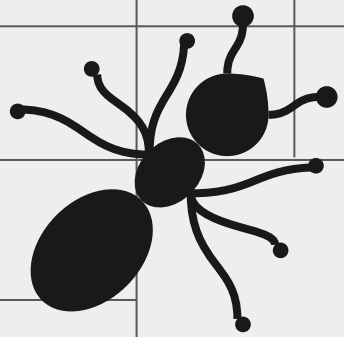
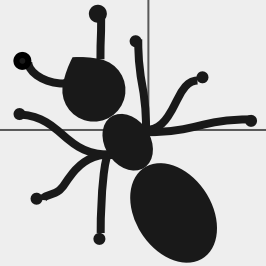
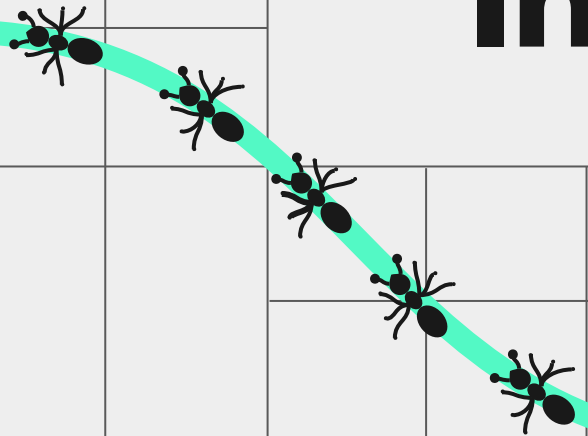
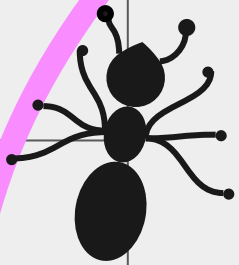
Table of contents

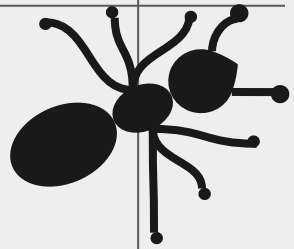





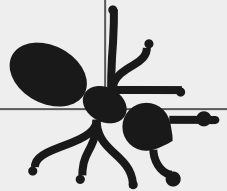
01

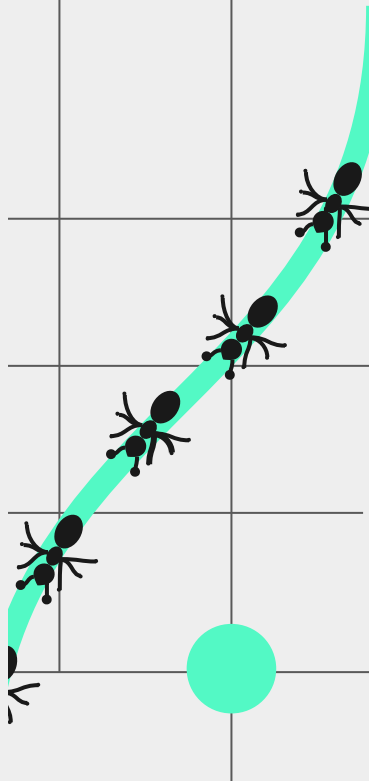
Introduction

What is Swarming Robot

- Swarming robots area a group of autonomous robots that are programmed to work together in a coordinated manner to achieve common goal.
- These robots communicate with each other to coordinate their movement and actions, allowing the to operate as a single entity with many different parts.
- Swarming robots can be used for a variety of tasks such as search and rescue missions, environmental monitoring and military operations.
- Swarming robots is their ability to adapt to changing environments and situations as they can communicate with each other, hence they can quickly adjust their behavior in response to new information or changing conditions.

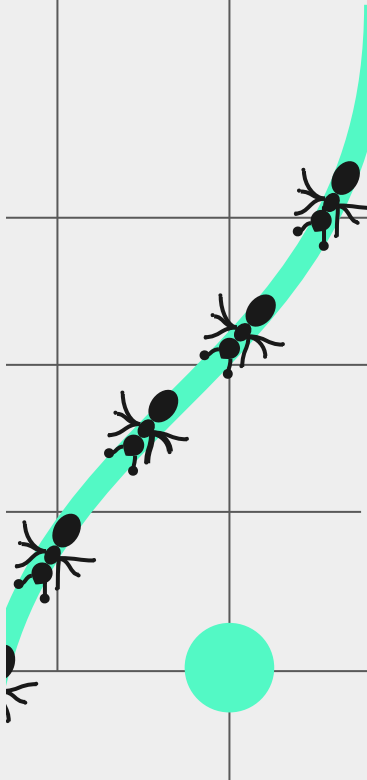


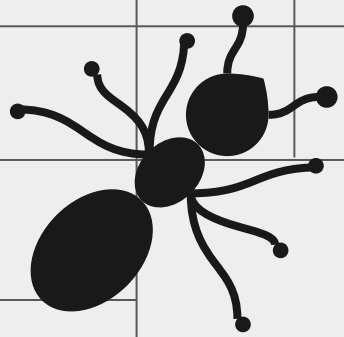
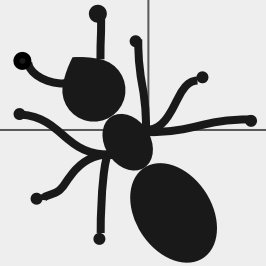
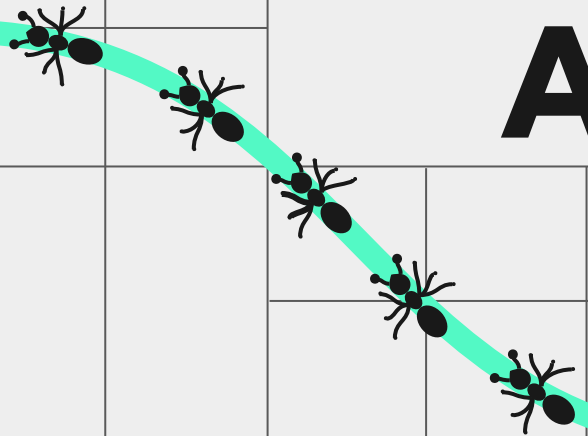
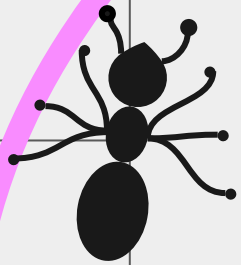




Research Background

- One of the earliest examples of swarming robots was developed in the 1990s by roboticist at MIT.
- The robots were called "Cogbots", designed to mimic the behavior of insects, with each robot performing a specific task and communicating with its neighbors to achieve a common goal.
- Researchers have explored various algorithms for coordinating swarms, including behavior-based approaches, artificial neural networks, and particle swarm optimization.
- Swarming robots have been used widely, including disaster response, environmental monitoring, and precision agriculture.
- It also used for military purposes, such as surveillance and reconnaissance.



02

History & Application

History

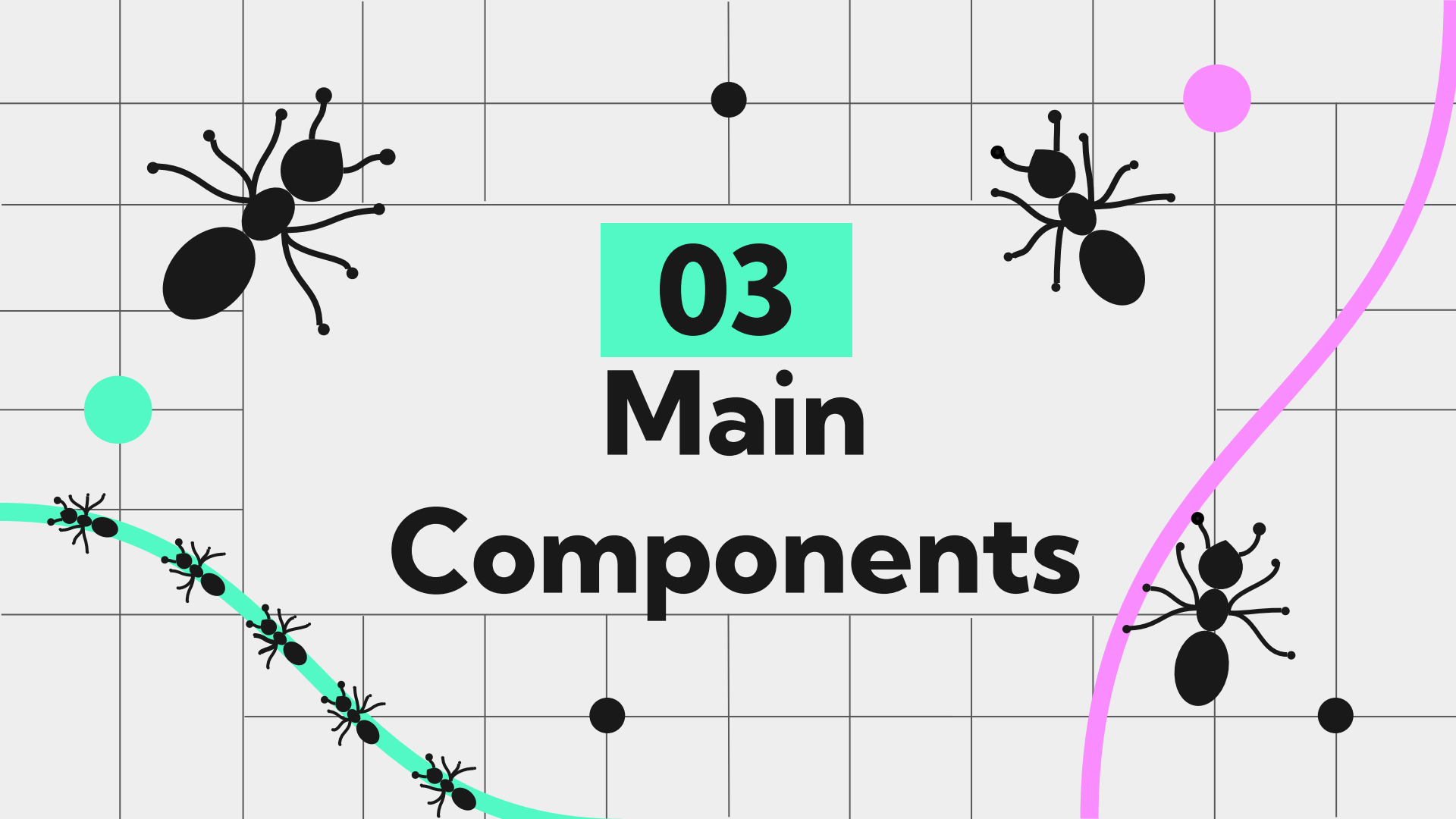
Years	Events
1980s	researchers began to apply this idea to artificial systems, developing algorithms and strategies to enable groups of robots to work together in a coordinated and intelligent manner.
1993s	C. Ronald Kube and Hong Zohng constructed a multi-robot system inspired by the collective behaviors of natural swarms.
1997s	One of the earliest examples of swarming robots was the "RoboCup," an annual international competition began Over time, the scope of the competition expanded to include other tasks, such as rescue and exploration missions.
2000s	Researchers began to focus on developing swarming robots that could be used for military applications, such as surveillance, reconnaissance, and search-and-rescue missions. The Defense Advanced Research Projects Agency (DARPA) launched several initiatives to develop these types of robots, including the Swarm Robotics program and the Distributed Robotics program.
Nowadays	Today, swarming robots continue to evolve and improve, with researchers exploring new algorithms, communication strategies, and hardware designs to enable even more sophisticated and effective swarm behavior.

Applications

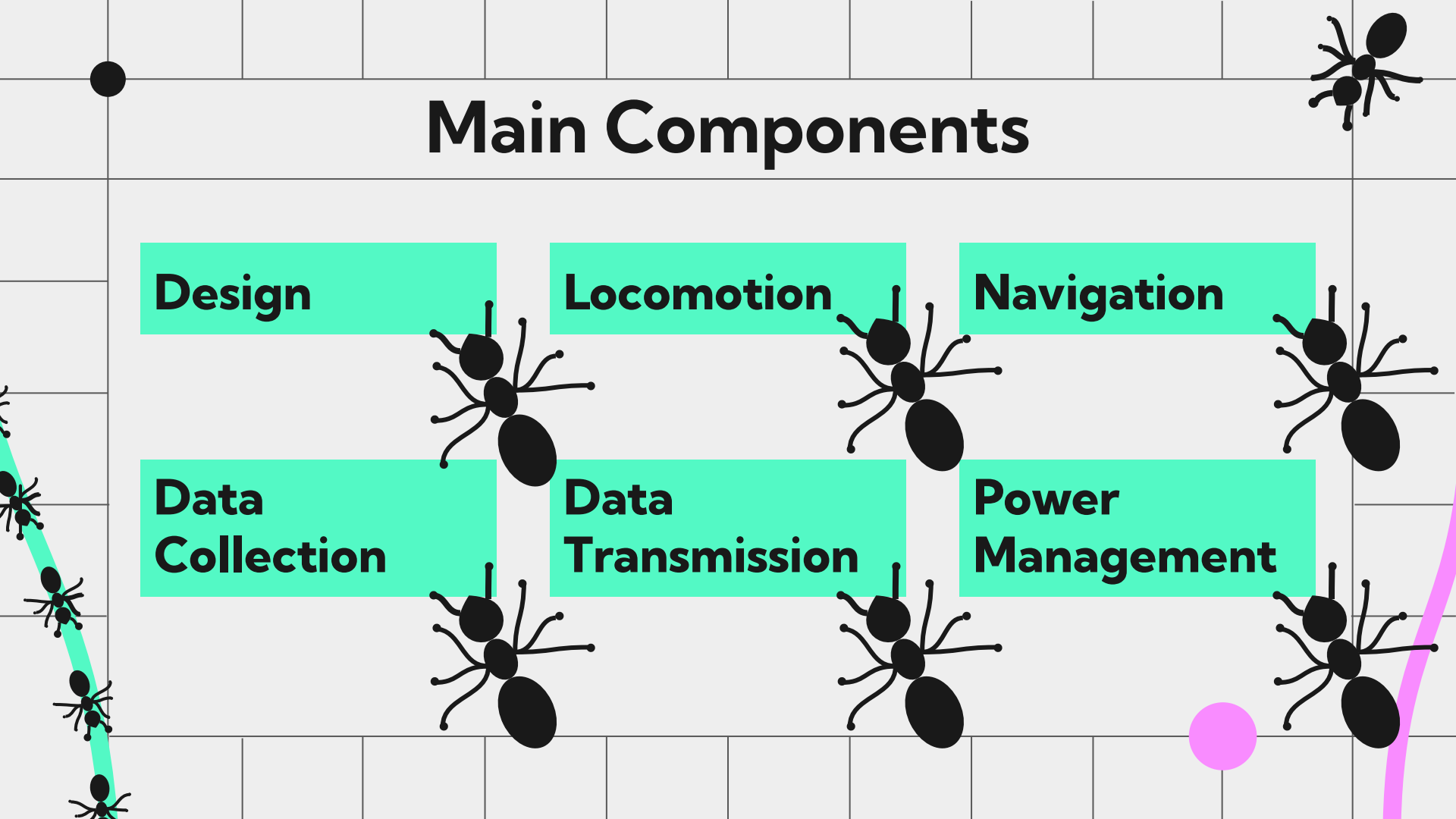
Missions	Description
Search and rescue missions	Search for survivors in disaster zones, where human rescuers may not be able to safely enter.
Environmental monitoring	Monitor pollution levels, track wildlife populations, and gather other data on the environment.
Agriculture	Automate tasks such as planting, watering, and harvesting crops. They can work together to cover large areas quickly and efficiently.

Applications

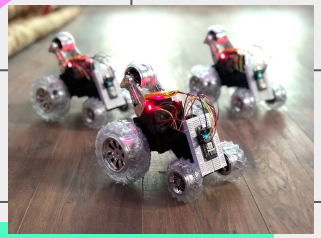
Industrial automation	Inventory management and assembly tasks. They can work together to move products and materials around the facility.
Military applications	Surveillance and reconnaissance missions. They can work together to cover large areas and provide real-time information to military personnel.
Construction	Work on large construction projects. They can work together to move materials, lay bricks, and perform other tasks.
Entertainment	Swarming robots can be used in entertainment, such as drone light shows or synchronized robotic dance performances.


03
Main
Components

Main Components



i. Design

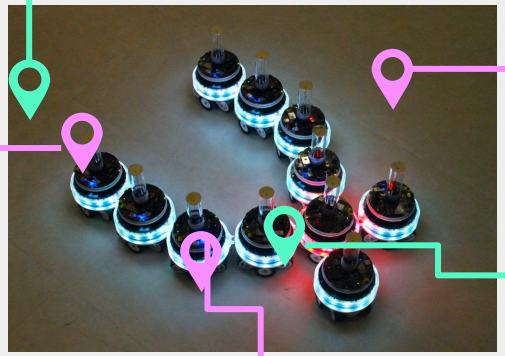


Wheeled

- Suitable for operating on flat surfaces.

Legged

- Suitable for operating in rough terrain.



Flying

- Suitable for operating in aerial environments.

Hybrid

- Combine multiple types of locomotion to achieve greater versatility and adaptability.

Swim

- Use fins or propellers for propulsing and are suitable for operating in underwater environments

ii. Locomotion System

Wheels

- Wheels are driven by motors and provide movement on flat surfaces.
- Fast and efficient and its speed can be controlled easily

Legs

- Used in rough terrains such as forests, mountains, or disaster zones.
- Slower than wheeled robots, but can navigate difficult terrain.
- The legs can be designed to walk, crawl or climb.

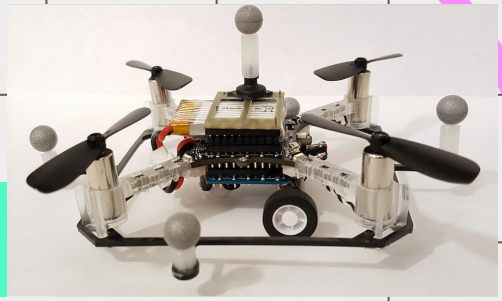
Propellers

- Flying swarm robots use propellers or rotors to generate lift and thrust for flight.
- Efficient and fast, and can operate in aerial environments such as skied or indoor spaces.

ii. Locomotion System

Fins

- Swimming swarm robots use fins or propellers to generate propulsion in water.
- Slower than wheeled of flying robots, but can operate underwater.



Hybrid

- Some swarm robots use a combination of propulsion systems to achieve greater versatility and adaptability

iii. Navigation & Control System

Navigation System

Sensing

cameras, lidar, radar, and ultrasonic sensors.

Communication

Bluetooth or Wi-Fi

Decision-making algorithm

use algorithms to make decisions about their movements

Centralized or decentralized control

Centralized = entire swarm following one robot

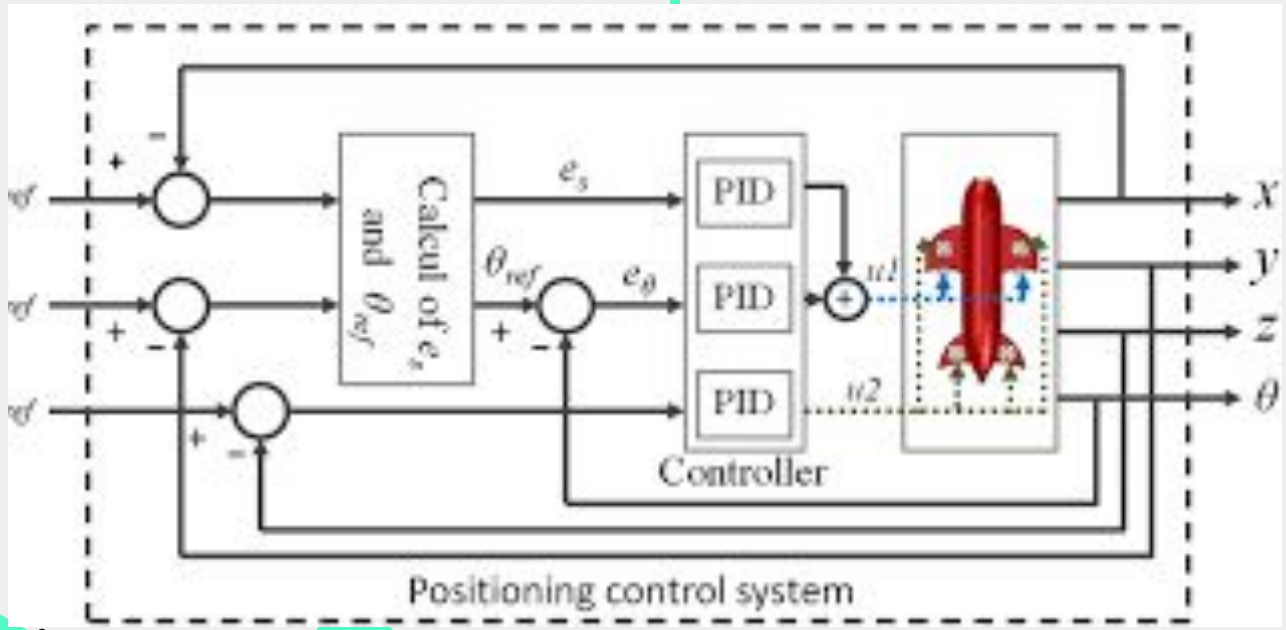
Decentralized = all robot makes it own decision

Path planning

find the best route through a given environment.

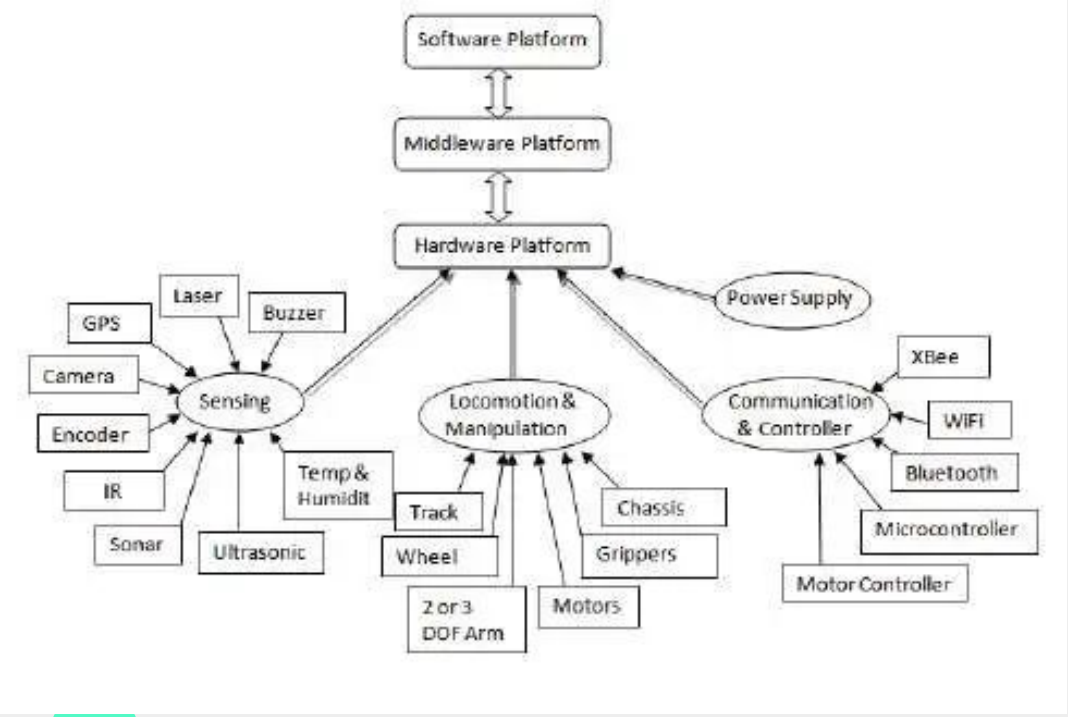
iii. Navigation & Control System

Control System



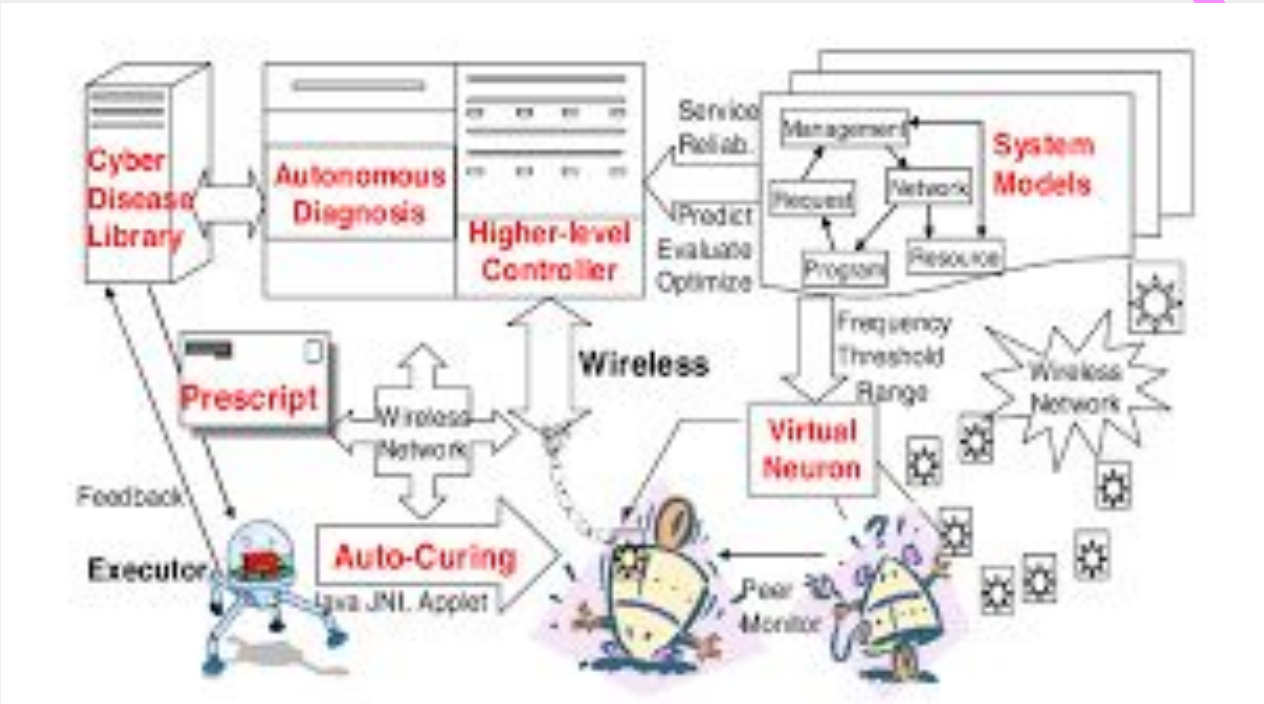
iii. Navigation & Control System

System Architecture



iii. Navigation & Control System

System Architecture



iv. Data Collection

Data Collection Hardwares

Sensors

- Cameras
- LiDaR
- Inertial Measurement Units (IMUs)
- Proximity Sensors
- Microphones

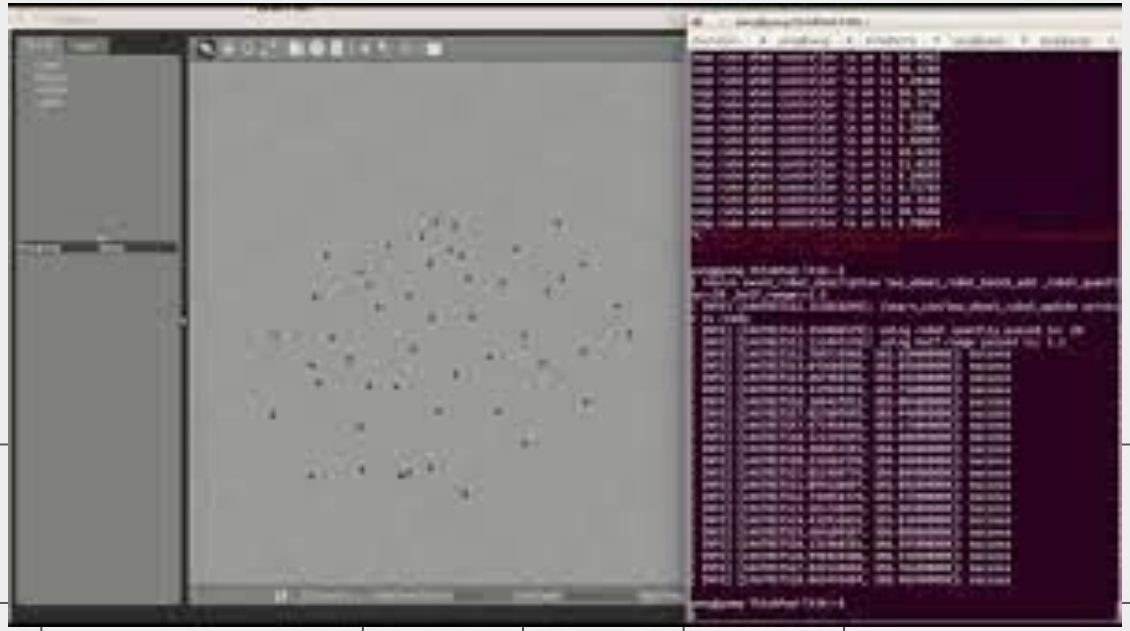
Actuators

- Legs
- Tentacles –Can be used to manipulate objects.
- Pneumatic/ Hydraulic systems
- Gripper
- Electrostatic Adhesion –Can be used to stick to surfaces.

iv. Data Collection

Data Collection Software

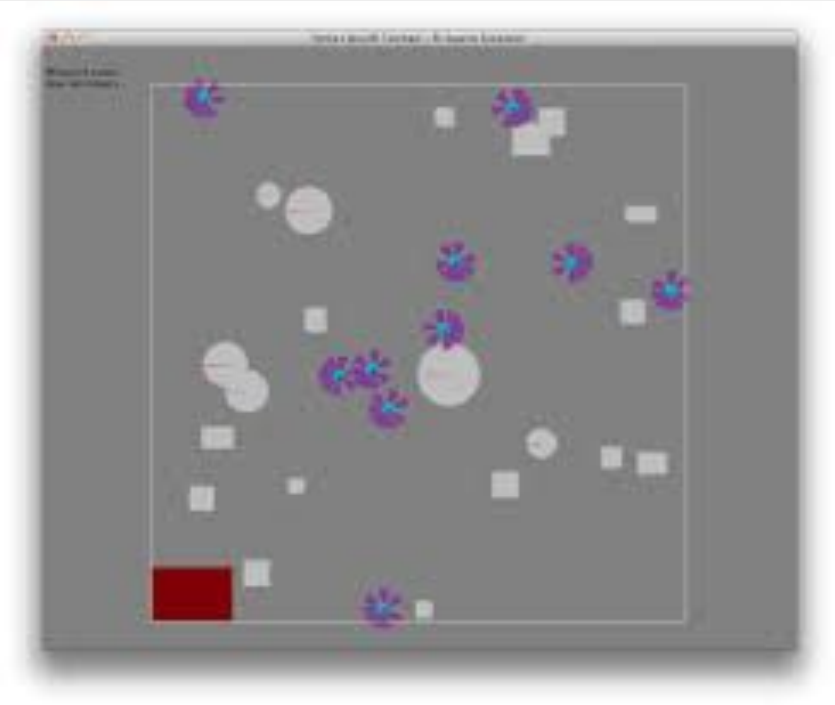
i. ROS



iv. Data Collection

Data Collection Software

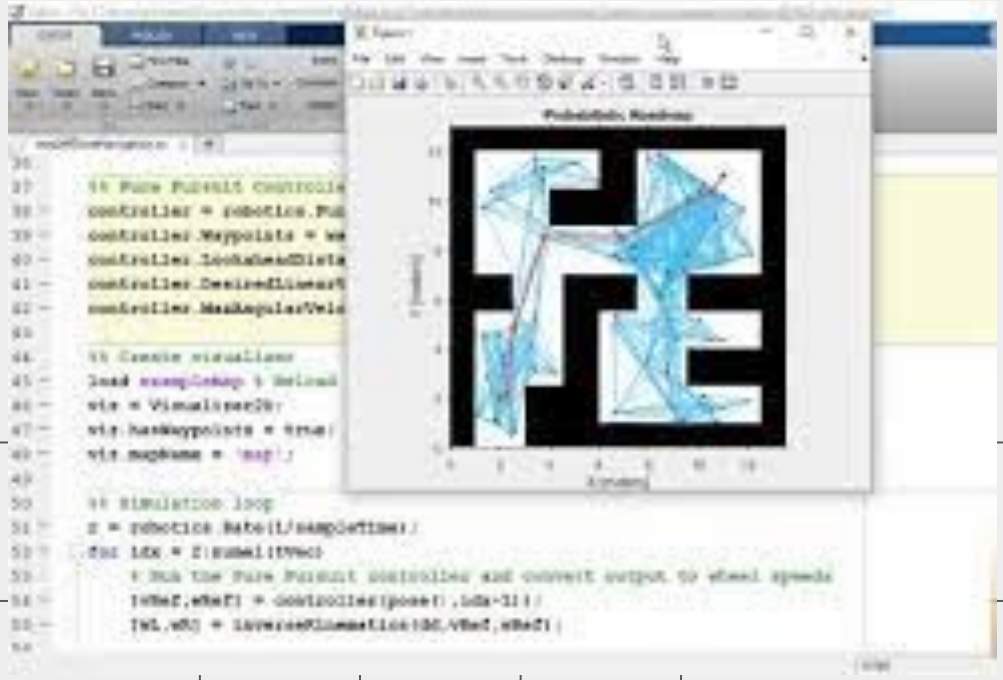
ii. SwarmSwim



iv. Data Collection

Data Collection Software

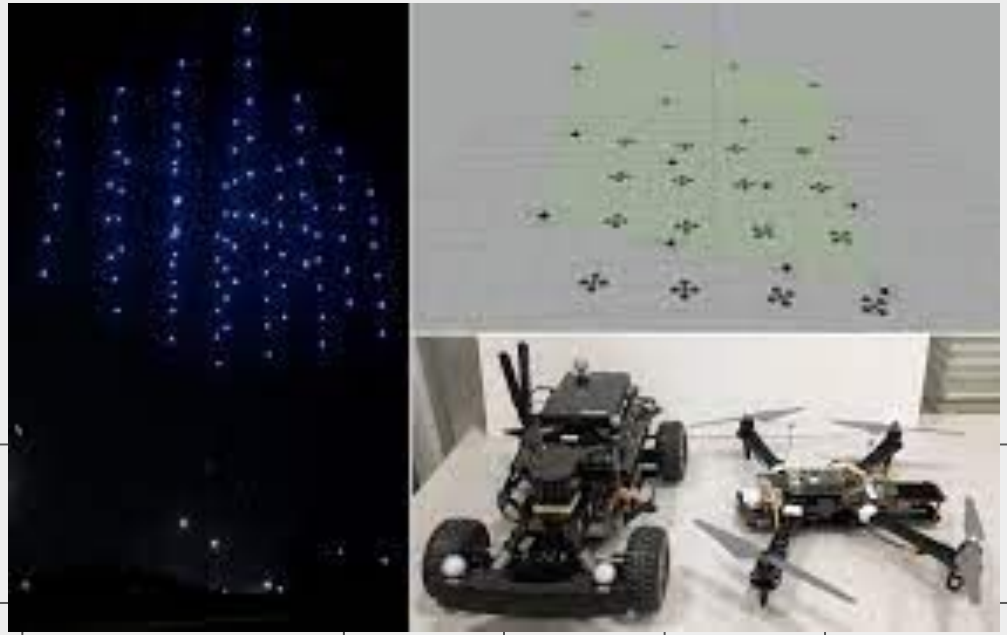
iii. MatLab



iv. Data Collection

Data Collection Software

iv. SLAM



v. Data Transmission

a. Wi-Fi

Provide high-speed communication between robots

b. Bluetooth

Communicate between robots and other devices

c. IR

Used when radio frequency communication is not feasible

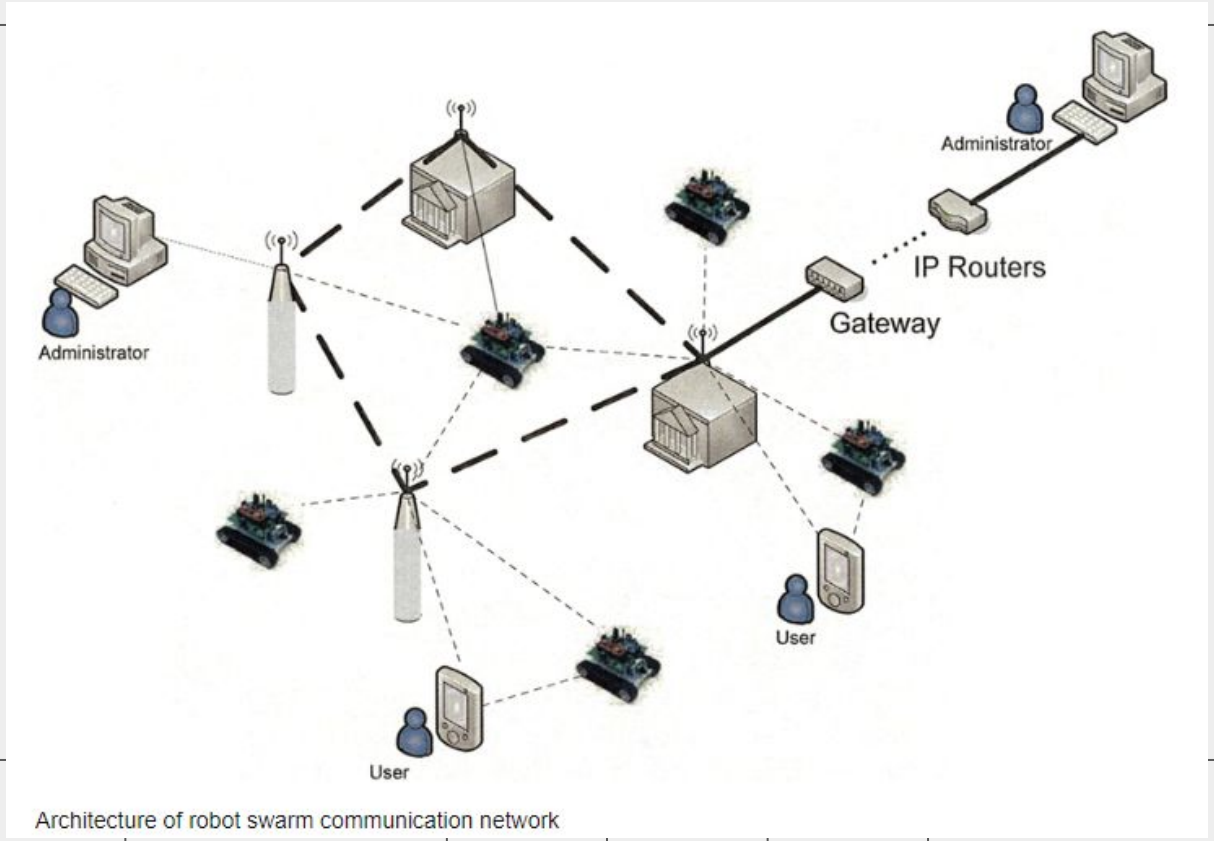
d. Zigbee

wireless communication protocol designed for low-power and low-data rate applications.

e. Radio Frequency

transmit data between swarm robots and the control system.

v. Data Transmission



Architecture of robot swarm communication network

vi. Power Management

small and lightweight, and can provide high energy density.

Batteries

Fuel Cells

Can power the robot longer than batteries

Lightweight and require no fuel, but may not be able to provide sufficient power in low light conditions

Solar Panel

Energy Harvesting

can be used to generate power from environment

used to recharge swarm robots without the need for physical contact.

Wireless Charge

vi. Power Management

Efficient Power Management