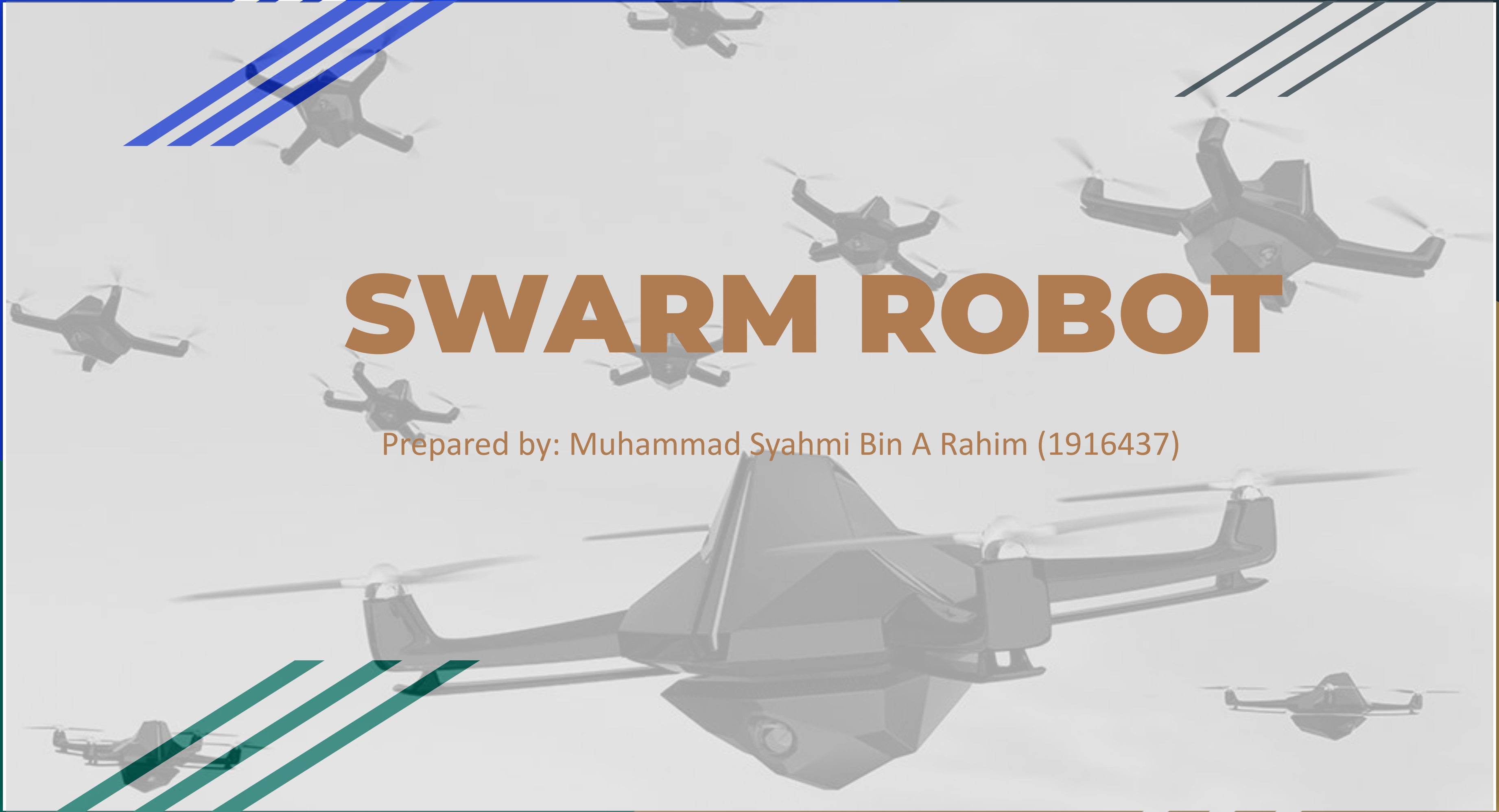

SWARM ROBOT

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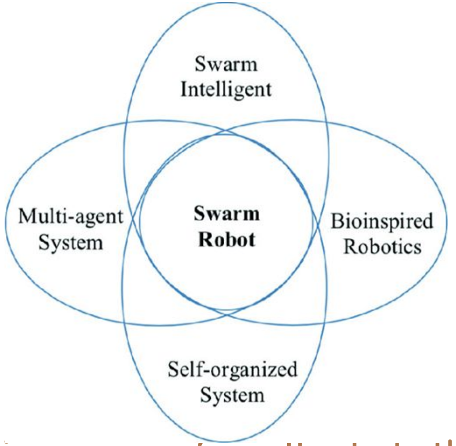
INTRODUCTION



- Swarming robot is a group of small robots that when acts and coordinated together will perform an awesome task.
- Swarming robots are generally taking inspiration from animals and from nature, how the swarm moves in group, the pattern of the movements, the goals to achieve by the movement etc.
- The communication of these robots is similar to living things moving in nature.

HISTORY

Era	Year	Description
Early	1980s	The concept of swarm intelligence, which inspired swarm robotics, was first proposed by Gerardo Beni and Jing Wang.
	1989	The first swarm robotic system, called the "Grobot," was developed by Michael Mataric at MIT.
Developmental	1990s	Researchers began exploring the use of artificial life and evolutionary algorithms to develop swarm robots.
	1995	The first swarm robotic system with decentralized control, called "Antbots," was developed by Marco Dorigo.
	Late 1990s	Swarm robotics became a popular research topic, with a focus on developing algorithms for swarm behavior.

HISTORY

Continued...

Era	Year	Description
Practical	2000s	Swarm robotic systems were developed for practical applications, such as search and rescue and environmental cleanup.
	Present day	Swarm robots continue to be studied and developed for a variety of applications, with a focus on scalability and robustness.

APPLICATIONS

- Swarm robots can be used in a wide range of applications where a single robot may not be sufficient or efficient enough to complete a task.
- The general idea is that by coordinating the actions of multiple robots, swarm systems can accomplish tasks that would be difficult or impossible for a single robot or a human operator.

APPLICATIONS

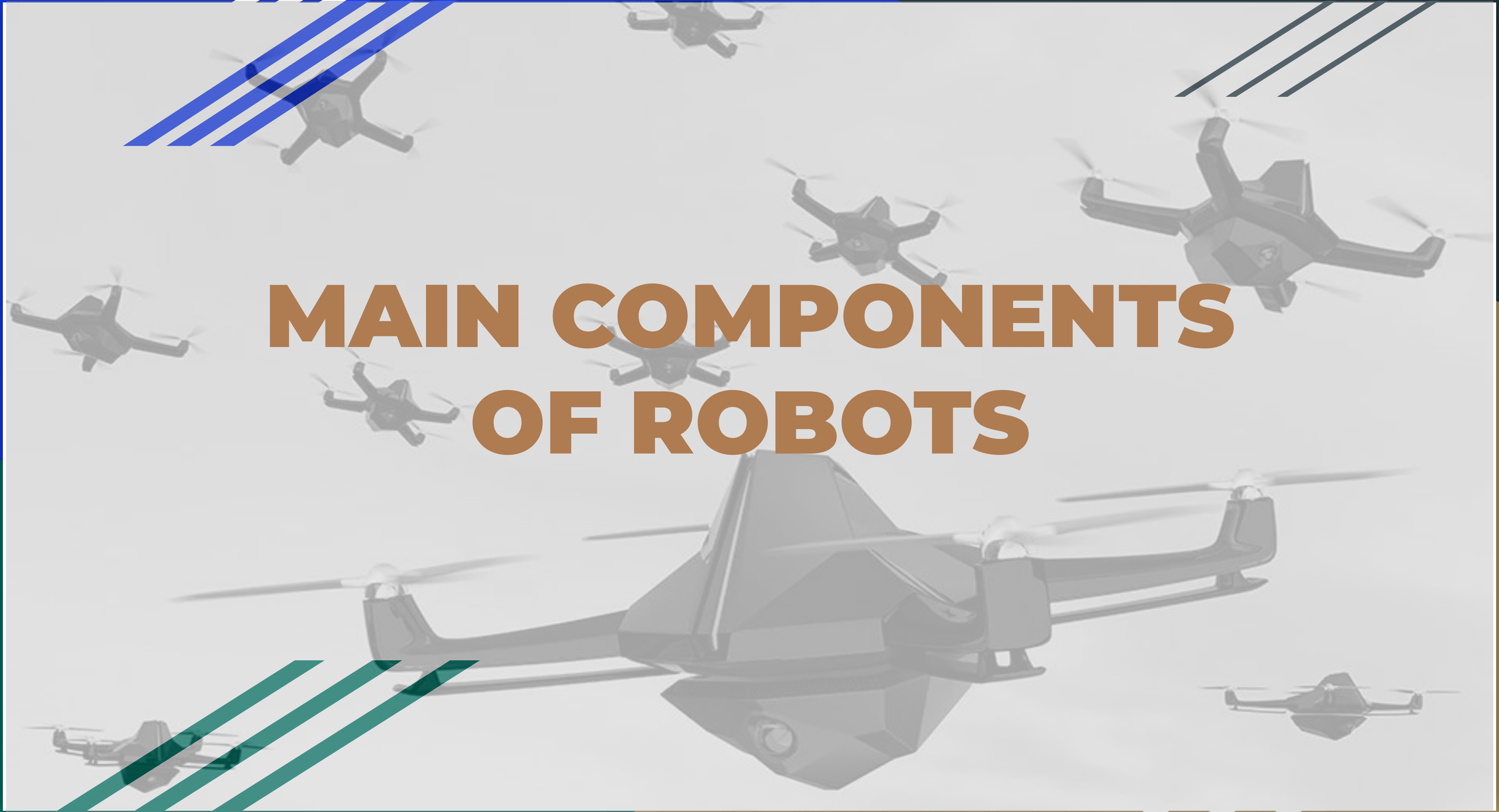
Application	Description
Environmental Monitoring	Swarm robots can be used to monitor pollution, water quality, and other environmental factors.
Search and Rescue	Swarm robots can be used to search for and rescue people in disaster zones or other hazardous environments.
Agriculture	Swarm robots can be used for precision farming and crop monitoring.
Construction and Maintenance	Swarm robots can be used to build and repair structures, including bridges and buildings.
Exploration	Swarm robots can be used to explore unknown environments, such as the depths of the ocean or other planets.

APPLICATIONS

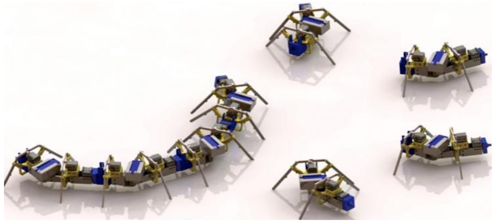
Continued...

Application	Description
Military	Swarm robots can be used for reconnaissance, surveillance, and other military applications.
Entertainment	Swarm robots can be used for artistic displays, such as light shows or dance performances.
Healthcare	Swarm robots can be used for medical applications, such as targeted drug delivery or minimally invasive surgery.

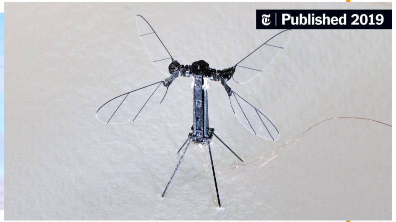
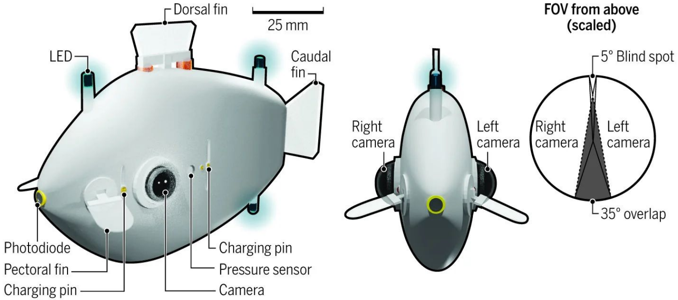
MAIN COMPONENTS OF ROBOTS



1. Body Design

Body Design	Description	Inspiration	Example
Wheeled Robots	These robots have wheels or tracks and are useful for navigating smooth, flat surfaces.	Conventional wheeled vehicles	
Legged Robots	These robots have legs or similar appendages and are useful for navigating rough terrain.	Animals with legs, such as insects or dogs	

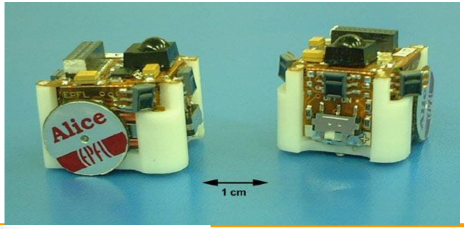
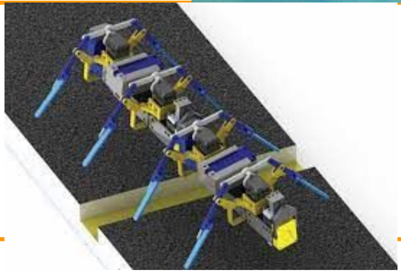
1. Body Design

Body Design	Description	Inspiration	Example
Flying Robots	These robots can fly and are useful for surveying large areas or inaccessible terrain.	Birds, insects, and other flying animals	 
Swimming Robots	These robots can swim and are useful for exploring underwater environments.	Fish, marine mammals, and other swimmers	

1. Body Design

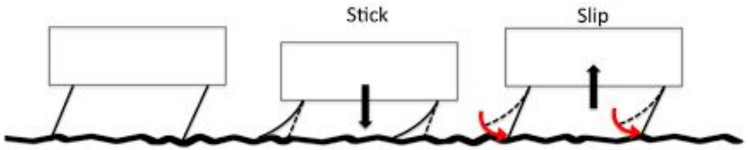
Body Design	Description	Inspiration	Example
Modular Robots	These robots are composed of multiple modules that can be reconfigured for different tasks.	Self-reconfiguring systems, robotics	
Soft Robots	These robots are made of soft, flexible materials and are useful for navigating complex spaces.	Soft-bodied animals, such as octopuses	

2. Locomotion

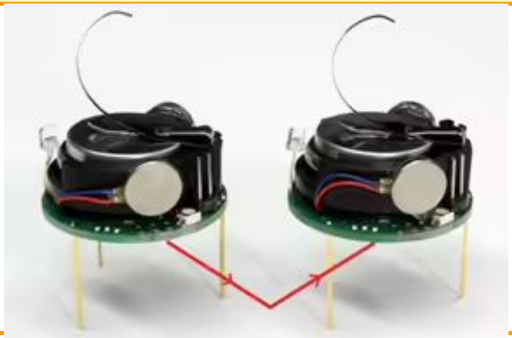
Locomotion	Propulsion Hardware	Advantages	Example of Existing robot
Wheeled	DC motor, wheel	High speed and efficiency on smooth, flat surfaces. Good traction.	Alice Mobile Robot 
Legged	Stepper motor, servo	Can navigate rough or uneven terrain. Good adaptability to different environments.	

2. Locomotion

Locomotion	Propulsion Hardware	Advantages	Example of Existing robot
Flying	DC motor, fan	Can access hard-to-reach areas, survey large areas quickly	Drone 
Slip-Stick	Flexible stick	Can move efficiently over soft, uneven surfaces that would be difficult for other types of locomotion.	I-SWARM 



2. Locomotion

Locomotion	Propulsion Hardware	Advantages	Example of Existing robot
Vibration	vibration motors, supporting legs	2 vibrating motors that shift the robot in circles and in a straight line (the same principle that makes a cell phone move across a table when it vibrates)	Kilobots 

3. Navigation

Sensors:

- **Inertial measurement units (IMUs):** IMUs use accelerometers, gyroscopes, and magnetometers to measure a robot's motion and orientation in space.
- **GPS and localization systems:** GPS receivers and localization systems such as cameras or LIDAR can be used to determine a robot's position relative to a known map or environment.
- **Proximity sensors:** Proximity sensors, such as ultrasonic or infrared sensors, can be used to detect obstacles and avoid collisions.
- **Vision sensors:** Vision sensors, such as cameras or depth sensors, can be used for tasks such as object recognition, obstacle avoidance, and mapping.
- **Light sensors:** Light sensors can be used to detect and follow light sources, such as in swarm robot systems that mimic the behavior of fireflies.
- **Chemical sensors:** Chemical sensors can be used to detect and follow scent trails or other chemical signals, such as in swarm robot systems that mimic the behavior of ants or bees.
- **Tactile sensors:** Tactile sensors, such as pressure sensors or force sensors, can be used to detect and respond to physical contact with objects or other robots.

3. Navigation behaviour

Type of Navigation	Description	Example
Collective Exploration	Swarm robots explore an unknown environment collectively, using a combination of local sensing and communication to discover and map the surroundings.	A swarm of robots exploring an area to search for resources or to map the environment, such as a search and rescue mission in a disaster zone.
Coordinated Motion	Swarm robots coordinate their movements and behaviors to accomplish a task or achieve a goal, such as moving a large object or performing a coordinated dance.	A swarm of robots working together to transport a heavy object, such as a large box or piece of furniture.

3. Navigation behaviour

Type of Navigation	Description	Example
Collective Transport	Swarm robots work together to transport an object or payload, using collective behaviors such as clustering, chaining, or swarming.	A swarm of robots transporting a payload
Collective Localization	Swarm robots use collective sensing and communication to estimate the location of each robot in the swarm, enabling them to navigate and perform tasks as a group.	A swarm of robots localizing each other in a GPS-denied environment, such as indoors or underground, to perform search and rescue operations.

3. Navigation behaviour

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Collective Exploration	Swarm robots explore an unknown environment collectively, using a combination of local sensing and communication to discover and map the surroundings.	A swarm of robots exploring an area to search for resources or to map the environment, such as a search and rescue mission in a disaster zone.
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4. Data Collection

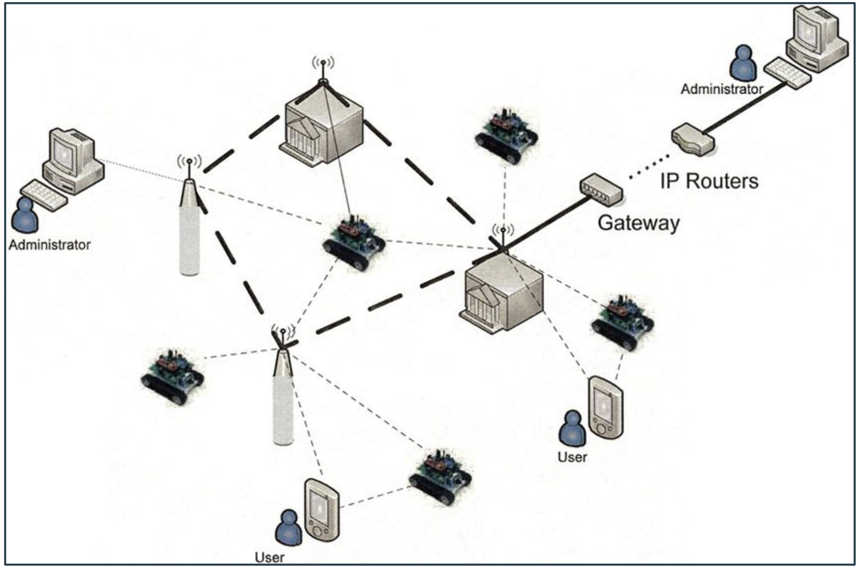
Project	Type of Robot	Type of Data Collected
RoboBees	Flying	Environmental conditions such as temperature, humidity, and air quality
Swarmanoid	Ground and climbing	Visual and spatial data, manipulation tasks such as opening doors and retrieving objects
AquaSwarm	Underwater	Ocean currents, temperature, and salinity
RoboFish	Swimming	Water quality and pollution levels in rivers and other aquatic environments
Swarmlab	Ground	Environmental conditions such as temperature, humidity, and light levels

5. Communication

Types of communication that are commonly used in swarm robotics:

1. **Local communication:** This involves direct communication between nearby robots, typically using short-range wireless technologies such as Bluetooth, ZigBee, or infrared.
2. **Global communication:** This involves communication between all the robots in the swarm, typically using long-range wireless technologies such as WiFi, cellular networks, or satellite communications.
3. **Decentralized communication:** This involves communication between nearby robots without the need for a central control unit. This can be achieved using algorithms such as flocking, where each robot follows a set of simple rules based on the positions of nearby robots.
4. **Centralized communication:** This involves communication between robots and a central control unit, which coordinates the behavior of the swarm. This can be useful for tasks that require more complex coordination or for tasks that involve modular activity.
5. **Visual communication:** This involves using visual cues such as colors, patterns, or flashing lights to communicate information between robots.
6. **Acoustic communication:** This involves using sound signals to communicate information between robots, similar to how animals such as bees or ants use pheromones to communicate.

5. Communication



Architecture of robot swarm communication network. [link]

6. Power Management

Power management is a critical aspect of swarm robotics, as it is essential to keep the robots powered and charged so they can continue to operate effectively. Here are some of the power management systems that are commonly used in swarm robotics:

1. Battery management: Most swarm robots are powered by batteries, so effective battery management is essential. This can involve techniques such as monitoring battery levels, optimizing power usage, and developing efficient charging systems.

2. Solar power: For outdoor swarm robotics applications, solar power can be an effective way to keep the robots charged and powered. Solar panels can be integrated into the robot's design to allow it to charge during daylight hours.

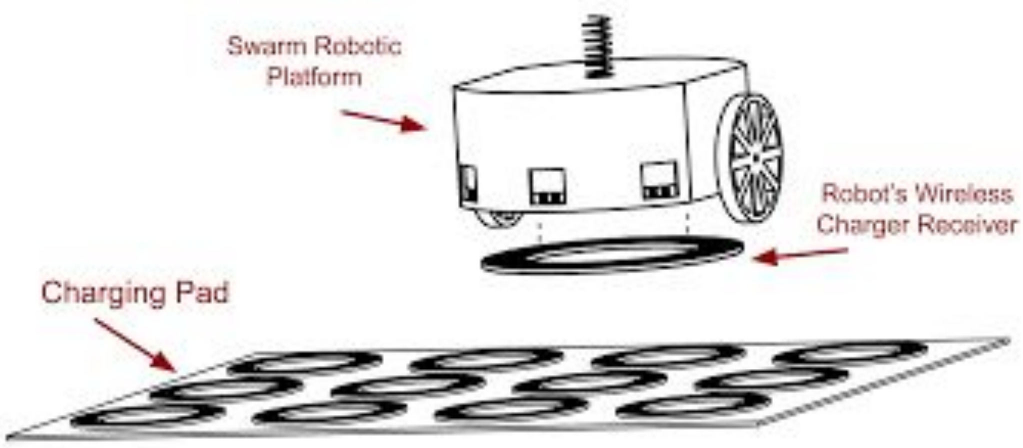
3. Wireless charging: Another approach is to use wireless charging systems, where the robot can be charged wirelessly using a charging pad or other charging system.

4. Docking stations: For stationary swarm robots, docking stations can be used to allow the robot to return to a central location to recharge.

5. Energy harvesting: Finally, energy harvesting techniques can be used to generate power from the robot's environment, such as by capturing the energy from vibrations or temperature differentials.

6. Power Management

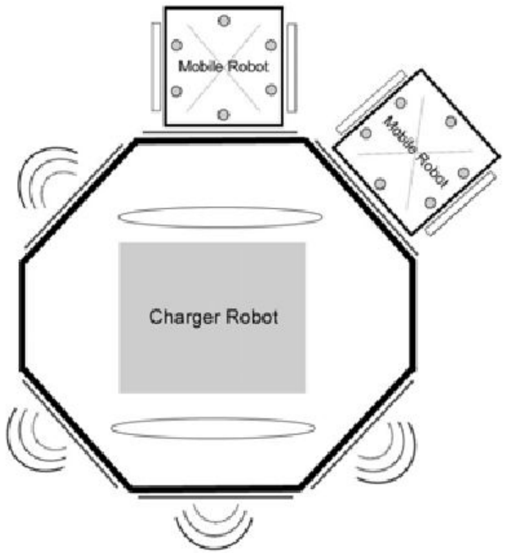
Charging station : Inductive charging



Structure of the proposed system including: i) a)mobile robot, Mona, ii) a wireless charger receiver attached to the robot, and iii) a charging pad including independent charging cells.link

6. Power Management

Charging station : Docking



. Connecting mobile robots to charger robot sides