SWARMING ROBOT

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HISTORY

01

EARLY RESEARCH: JAMES MCLURKIN AND MARCO DORIGO, AMONG OTHERS, LAY THE FOUNDATION FOR SWARM ROBOTS IN THE LATE 1980S AND EARLY 1990S. THEY CREATED MODELS AND ALGORITHMS THAT DREW INSPIRATION FROM ANT COLONIES AND FLOCKS OF BIRDS, TWO EXAMPLES OF COLLECTIVE BEHAVIOURS IN NATURE.

02

THE KILOBOT PROJECT WAS ANNOUNCED IN 2011 BY A TEAM FROM HARVARD UNIVERSITY. THEY CREATED INEXPENSIVE, SMALL ROBOTS THAT COULD COOPERATE WITH ONE ANOTHER. KILOBOTS WERE CREATED WITH SCALABILITY IN MIND AND SHOWED WHAT LARGE-SCALE ROBOT SWARMS WERE CAPABLE OF.

03

ROBOCUP: SINCE ITS INCEPTION IN 1997, THE ROBOCUP TOURNAMENT HAS INCLUDED A VARIETY OF SWARM ROBOTICS EVENTS. TEAMS ARE ENCOURAGED BY ROBOCUP TO CREATE COOPERATIVE SOCCER-PLAYING ROBOT TECHNIQUES. SWARM ROBOTICS RESEARCH AND DEVELOPMENT HAVE BENEFITED FROM THIS OCCASION.

APPLICATIONS

- Mapping
- Distributed sensing
- swarm-based search
- Rescue mission
- Environmental monitoring

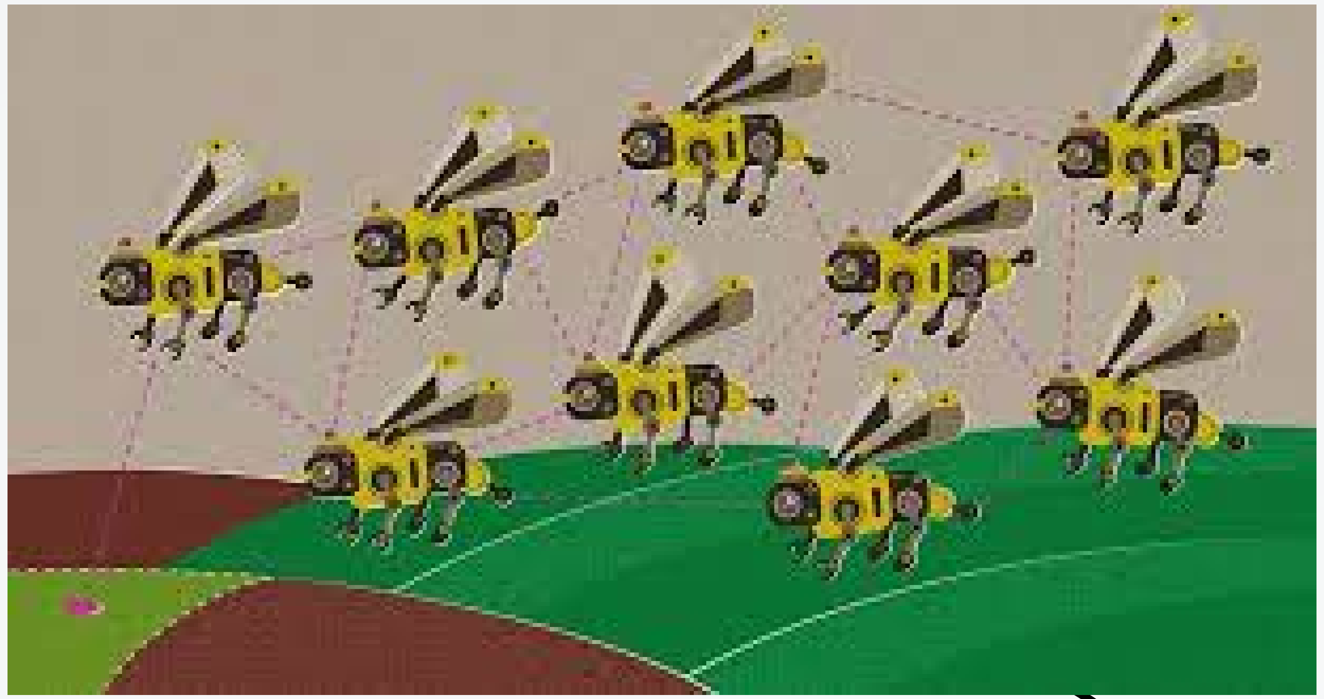
Hardware, communication, and algorithmic advances throughout time have helped swarm robots go even farther. Researchers have created more competent robots, better communication protocols, and advanced swarm control systems.

BODY DESIGN

Design type

Typically, swarming robots are tiny, have a straightforward design, and are inexpensive. Since insects typically travel in swarms, they served as the inspiration for the body design.

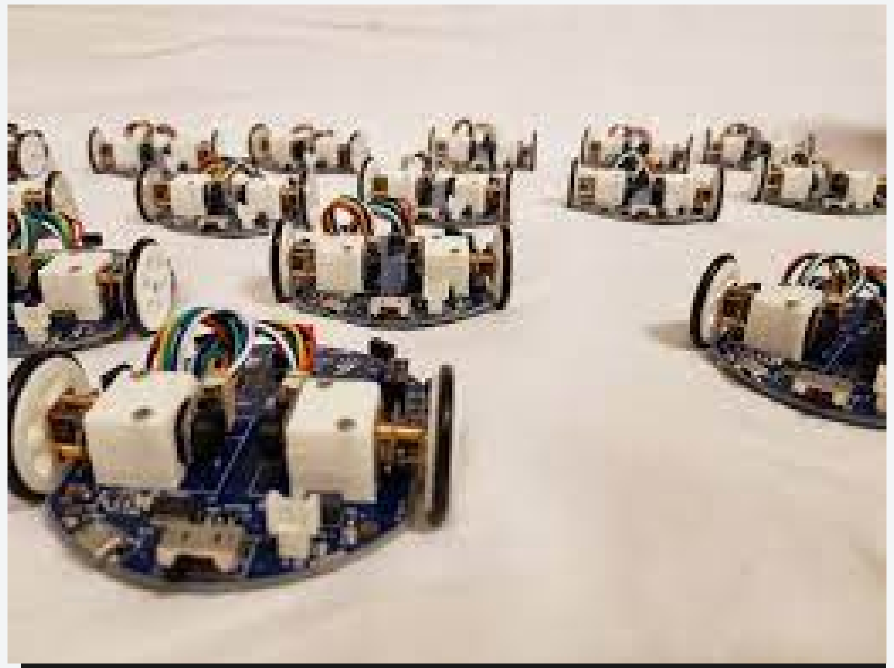
Design like bees



Functions

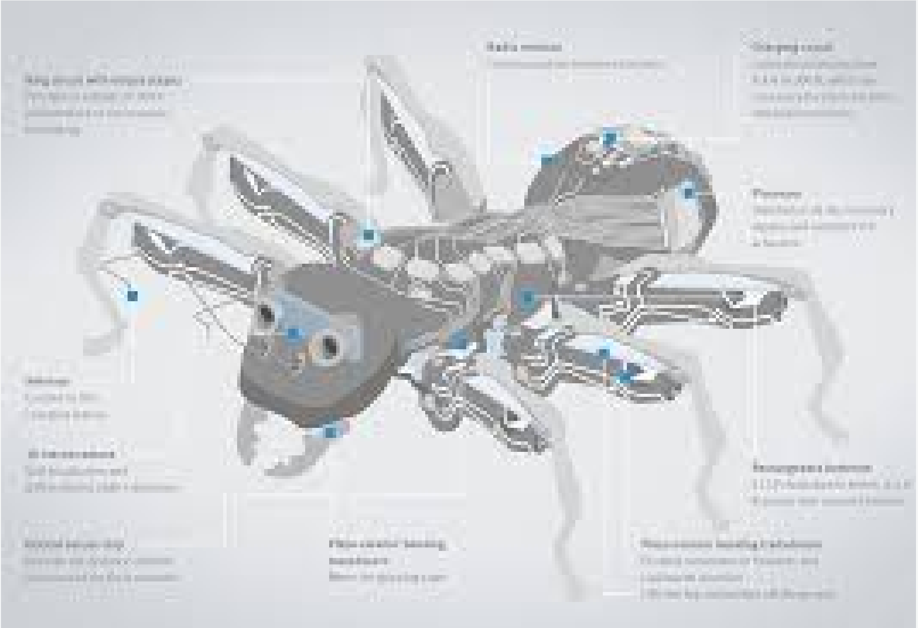
Quantity over quality is a key concept in swarm robotics. You can do more chores as you have more robots. The task or purpose determines the ideal size.

LOCOMOTION



Robot swarms may travel over flat terrain by using wheels. This mode of mobility combines efficiency, steadiness, and simplicity. Robots on wheels can move independently or work together to coordinate their motions and perform collective behaviours.

WHEELED LOCOMOTION



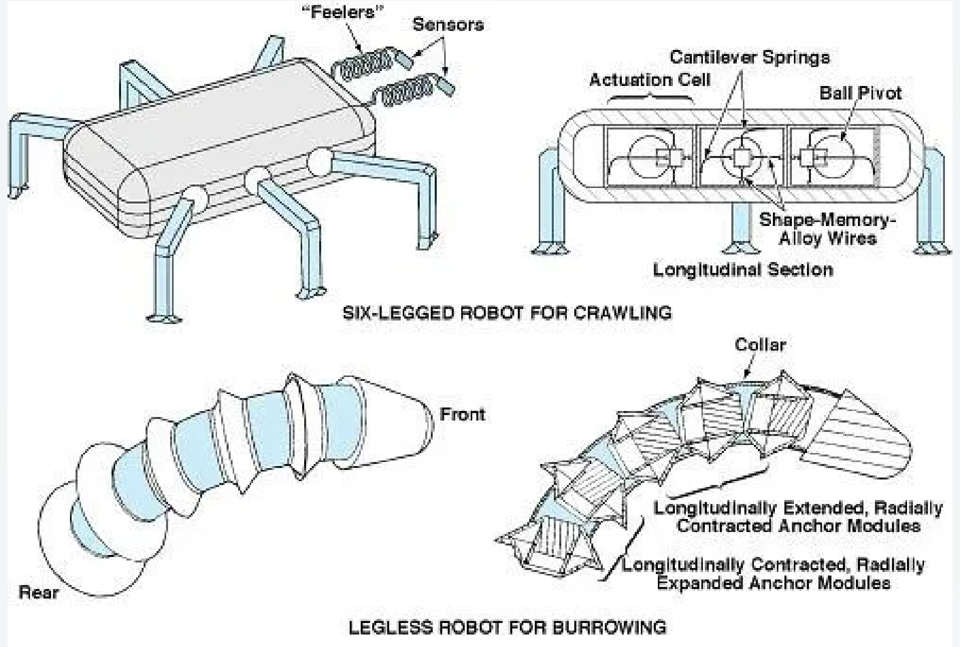
Swarming robots can scale barriers, negotiate uneven terrain, and adapt to difficult settings thanks to their legs. Different leg arrangements, such as quadrupedal, hexapodal, or even more intricate designs, are possible for legged robots.

LEGGED LOCOMOTION

Aerial capabilities, such as rotor-based drones or flapping-wing devices, are used by certain swarming robots. Robots can move in three dimensions, travel great distances, and get over ground barriers by using aerial locomotion.

AERIAL LOCOMOTION

LOCOMOTION

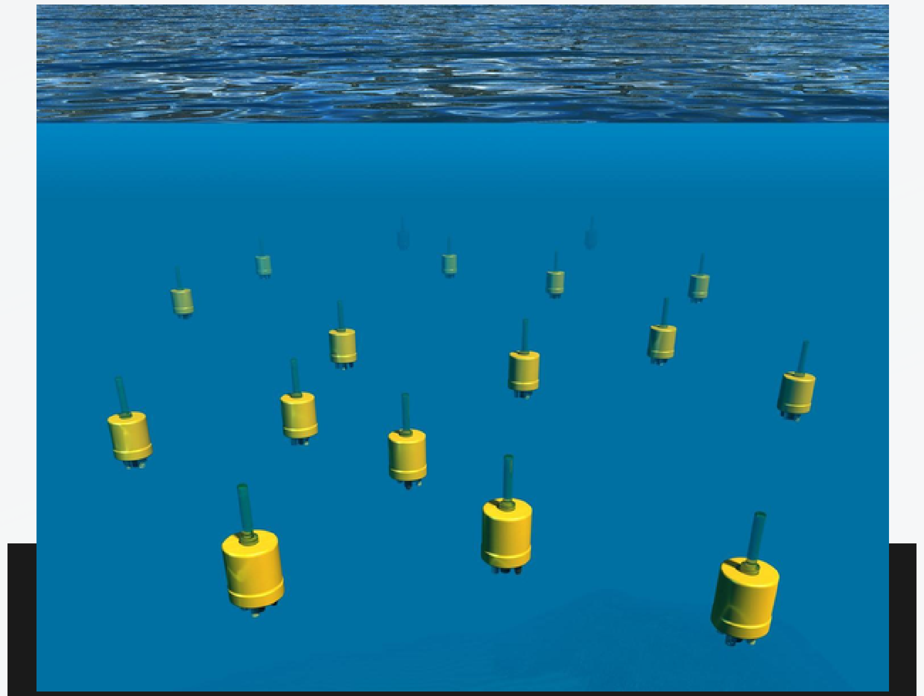


Swarming robots may be made to bury themselves in the ground or squeeze through small openings. For jobs like subsurface investigation, soil sampling, or infrastructure inspection in constrained areas, this kind of movement is helpful.

BURROWING AND CRAWLING

Multiple movement strategies can be combined by swarming robots to increase their versatility. For instance, a robot may feature wheels for smooth travel on level ground and legs or tracks for navigating obstacles or difficult terrain.

HYRBRID LOCOMOTION



Using devices like propellers, fins, or undulating bodies for swimming or floating, swarming robots may be created for aquatic situations. These robots are capable of carrying out duties such as ocean monitoring and underwater exploration.

SWIMMING OR AQUATIC

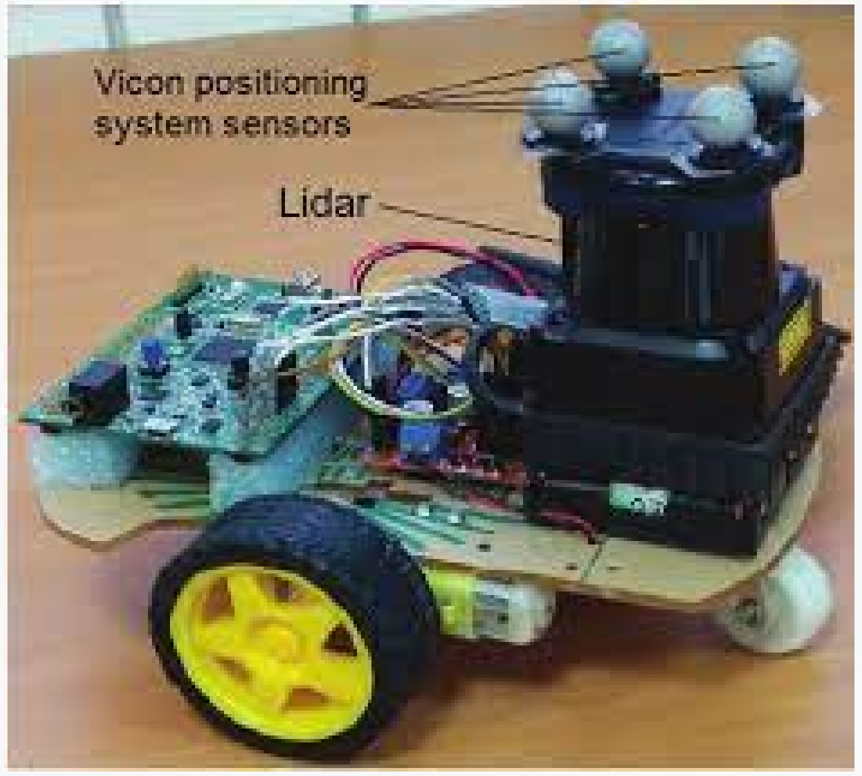
NAVIGATION SYSTEM & CONTROL

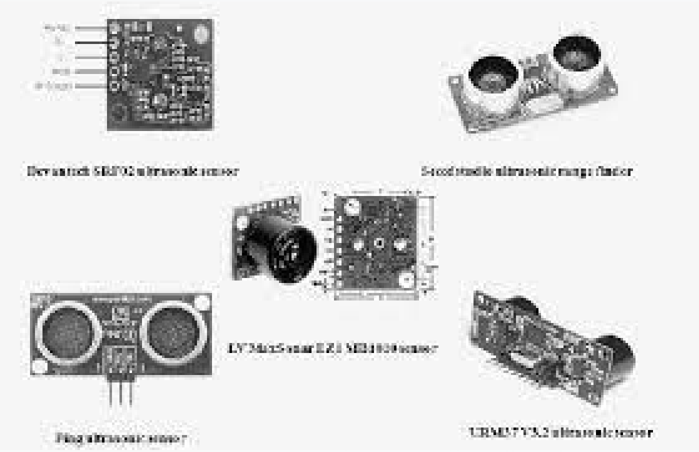
Localization

Robot swarms must be aware of their position in relation to their environment. Inertial measuring units (IMUs), GPS, optical odometry, or range sensors like LiDAR or ultrasonic sensors are some examples of localization techniques.

Mapping

Swarming robots could draw a map of their surroundings to help them navigate and avoid hazards. Robots may create maps while determining their locations on them using simultaneous localization and mapping (SLAM) techniques.





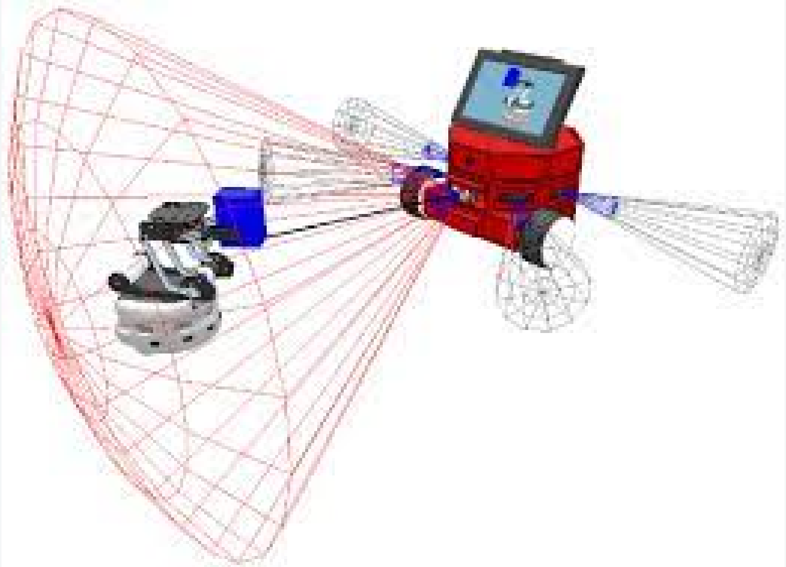
Collision avoidance

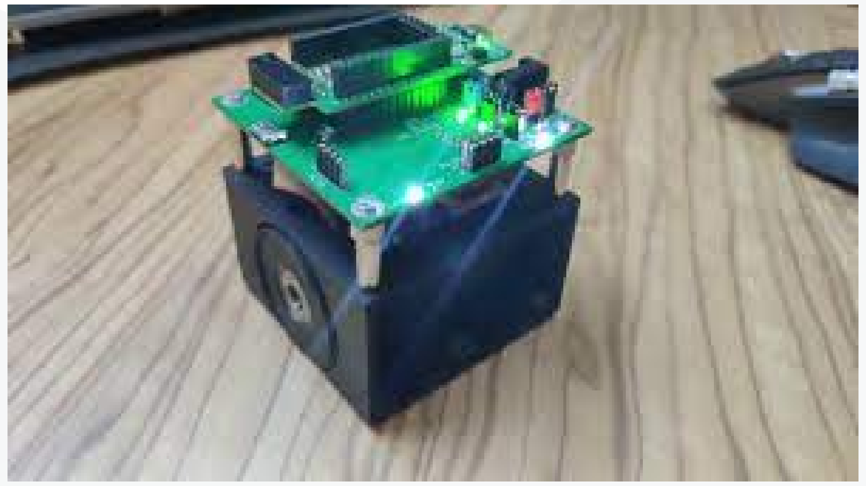
Collision avoidance algorithms are used to stop collisions between members of the swarm and with barriers. These algorithms make adjustments to the robot's trajectory or speed to prevent collisions by using sensor data to identify probable collisions.

DATA COLLECTION

CAMERA

Robots can observe their surroundings, find things, and navigate thanks to cameras like RGB or depth ones. From camera photos, data may be extracted using computer vision techniques such as object localisation, object identification, and mapping.





PROXIMITY SENSOR

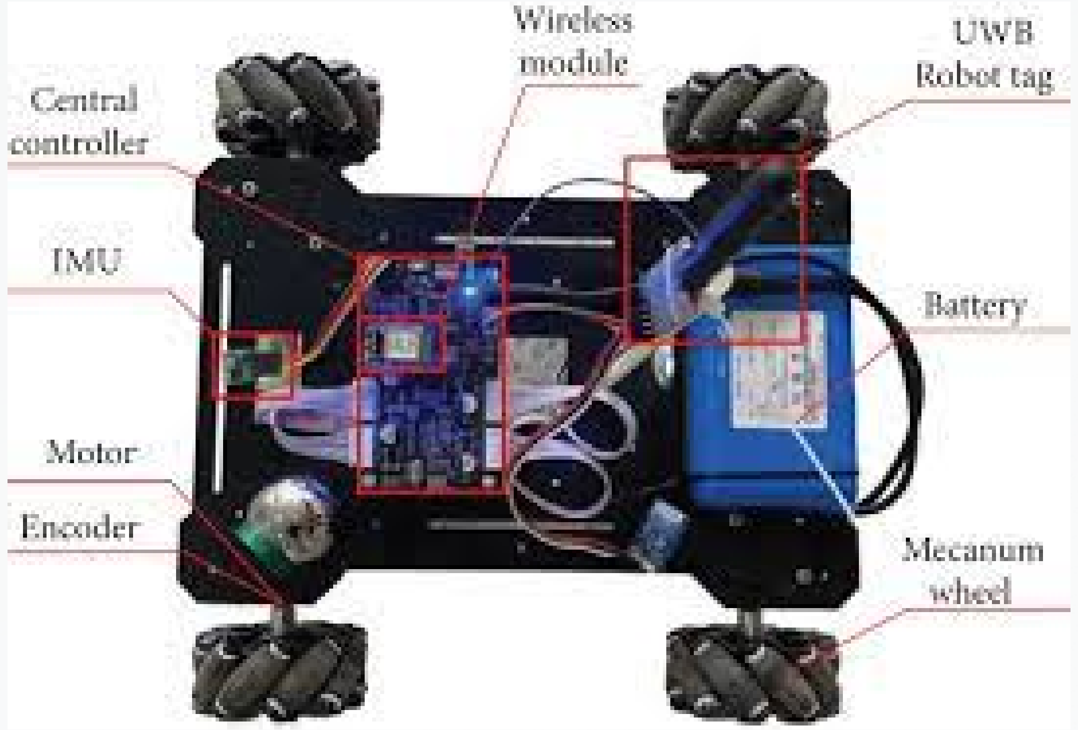
Ultrasonic or infrared proximity sensors may detect the presence of adjacent barriers or items. They aid swarming robots in navigating congested surroundings, avoiding collisions, and maintaining safe distances from other robots and objects.

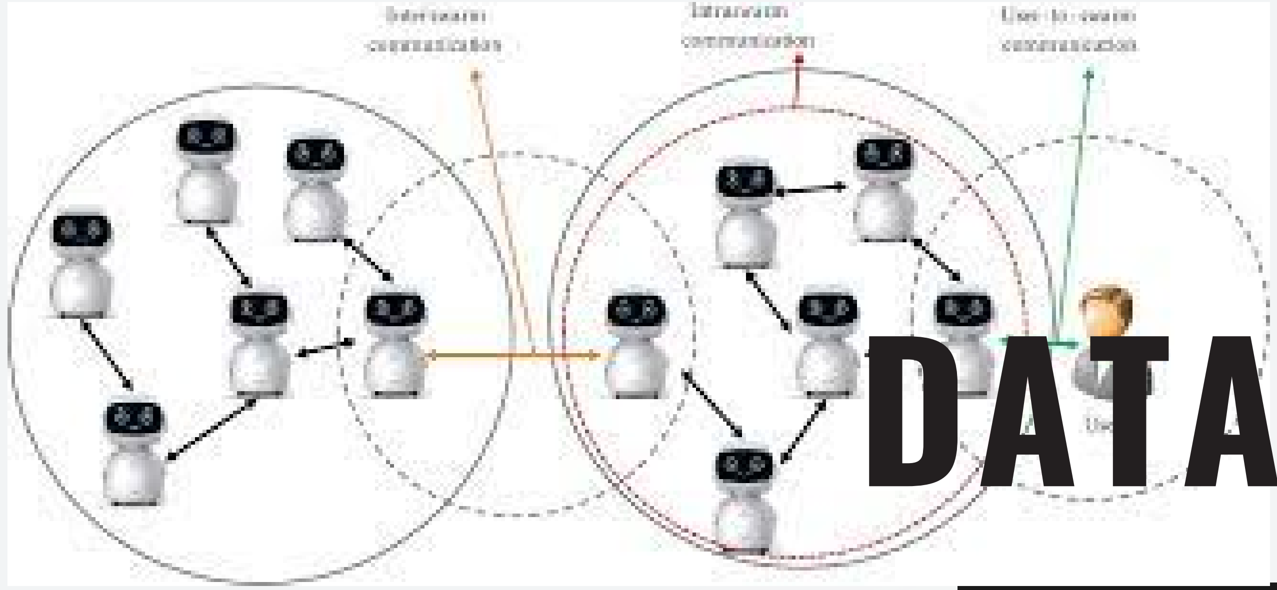
IMU

Robot orientation, velocity, and acceleration are measured using IMUs, which integrate accelerometers, gyroscopes, and magnetometers. In swarming robots, IMUs are utilised for localization, motion tracking, and stability control.

ENVORNMENTAL SENSOR

Various environmental sensors may be incorporated by swarming robots to collect data relevant to their application. Depending on the purpose and environment the swarm is operating in, they might be temperature sensors, humidity sensors, gas sensors, or radiation detectors.





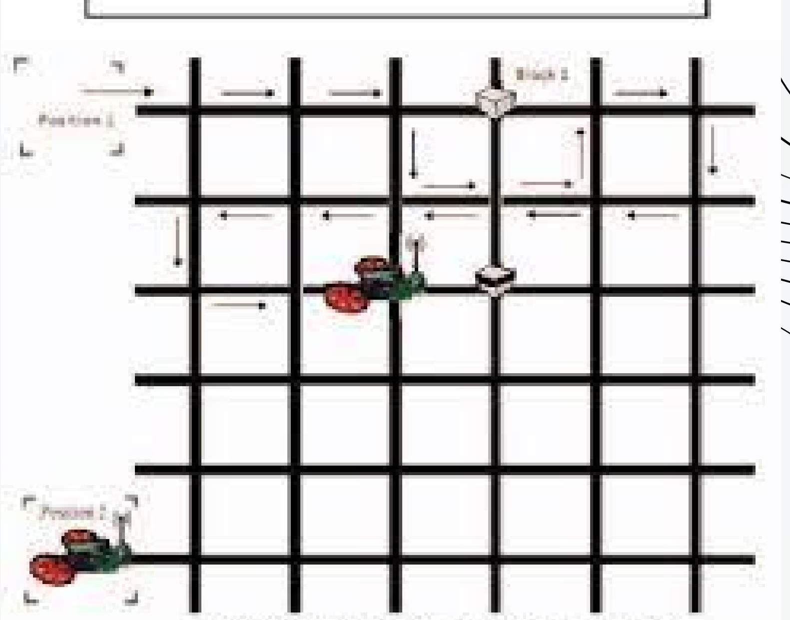


Fig. 2 Demonstration of scout robot operation

DATA TRANSMISSION

Wireless

Wi-Fi, Bluetooth, and Zigbee are a few examples of wireless protocols that swarming robots might use to interact with one another. These protocols enable the robots to communicate and coordinate in a reliable manner.

Ad-hoc networking

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Decentralized

Robots in swarming systems frequently communicate with one another decentralizedly, sharing pertinent information with their immediate neighbours. The swarm becomes more resilient and scalable thanks to this method, which promotes local decision-making and lessens the need for centralised control.

multi-hop

Multi-hop communication is a technique that swarming robots may use to communicate farther and cover more ground. They may create communication linkages that extend beyond the range of their individual transmitters by relaying signals through intermediary robots.

POWER SYSTEM MANAGEMENT

Lithium-ion batteries

These batteries offer a transportable and self-sufficient power source, enabling the robots to function independently.

Solar power

During the day, solar electricity may be used to directly charge batteries or run the robots' systems.