SWARM ROBOT
MCTE 4362

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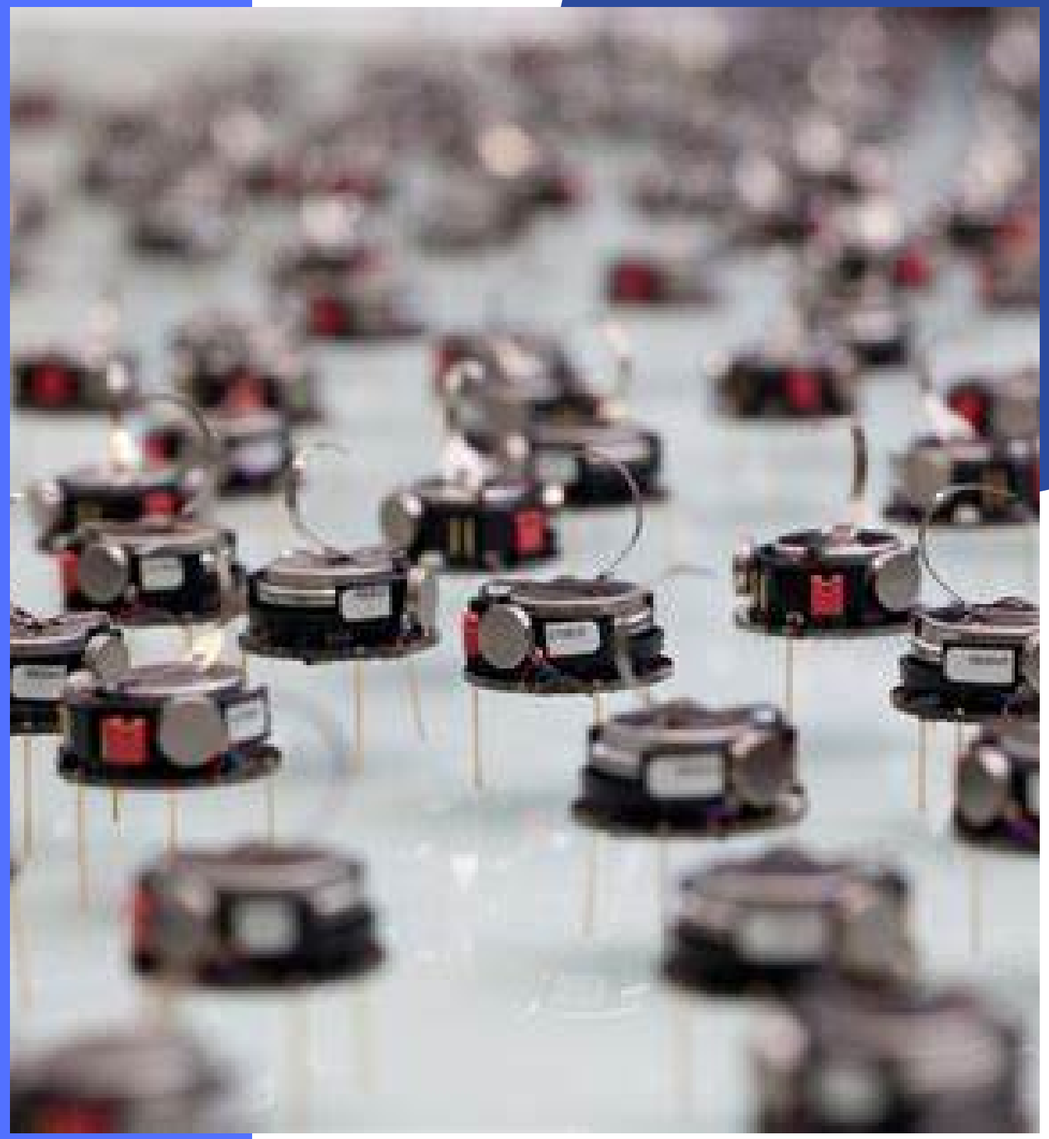
INTRODUCTION

SWARM ROBOTS ARE A TYPE OF ROBOTS THAT OPERATE IN A GROUP OR SWARM TO ACCOMPLISH A TASK. IT IS INSPIRED BY THE SOCIAL INSECTS SUCH AS ANTS AND BEES, WHICH WORK TOGETHER IN A COLONY TO ACHIEVE A COMMON GOAL.

1. Collaboration: Swarm robots rely on collaboration to achieve a task.
2. Decentralized Control: swarm robots operate in a decentralized manner. Each robot makes decisions based on local information and interacts with its neighbors to achieve the desired result.
3. Scalability: Swarm robotics systems are highly scalable, meaning that they can work with large numbers of robots. This allows for greater flexibility and adaptability in completing a task.
4. Robustness: Swarm robots are highly robust because if one robot fails, the swarm can continue to function without it. The system is designed to be fault-tolerant, meaning that it can operate even if some robots are not functioning correctly.
5. Applications: Swarm robots have a wide range of applications, including search and rescue operations, environmental monitoring, and agricultural tasks. They can also be used in industrial settings, such as manufacturing and warehouse operations.



HISTORY & APPLICATION

1980 - 1990

- INTRODUCED BY MARCO DORIGO, ERIC BONABEAU, AND GUY THERAULAZ
- INSPIRED BY SOCIAL INSECTS
- COMPLEX BEHAVIORS AND DECISION-MAKING PROCESSES THAT ARE DISTRIBUTED ACROSS THE ENTIRE COLONY.

1990-2000

- COORDINATION BETWEEN ROBOTS ARE IMPROVED
- THE FIRST SWARM ROBOTICS EXPERIMENTS ARE CONDUCTED USING SMALL GROUPS OF ROBOTS. THESE EXPERIMENTS DEMONSTRATE THE POTENTIAL OF SWARM ROBOTICS FOR COMPLEX TASKS.

2000-2009

- SCALABILITY OF SWARM ROBOT ARE FOCUSED
- DEVELOPMENT OF ALGORITHMS TO COORDINATE LARGE NUMBERS OF ROBOTS
- ROBOTS CAN PERFORM COMPLEX TASKS, SUCH AS FORMATION FLYING AND FLOCKING BEHAVIOR.
- SWARM ROBOTICS IS APPLIED TO SEARCH AND RESCUE OPERATIONS, ENVIRONMENTAL MONITORING, AND AGRICULTURAL TASKS.

2010

- SWARM ROBOTICS TECHNOLOGY CONTINUES TO ADVANCE, AND RESEARCHERS INVESTIGATE NEW APPLICATIONS OF THE TECHNOLOGY. THERE IS ALSO INCREASING INTEREST IN THE DEVELOPMENT OF SWARM ROBOTICS SYSTEMS THAT CAN OPERATE IN COMPLEX AND DYNAMIC ENVIRONMENTS.

ROBOTIC HARDWARE COMPONENTS

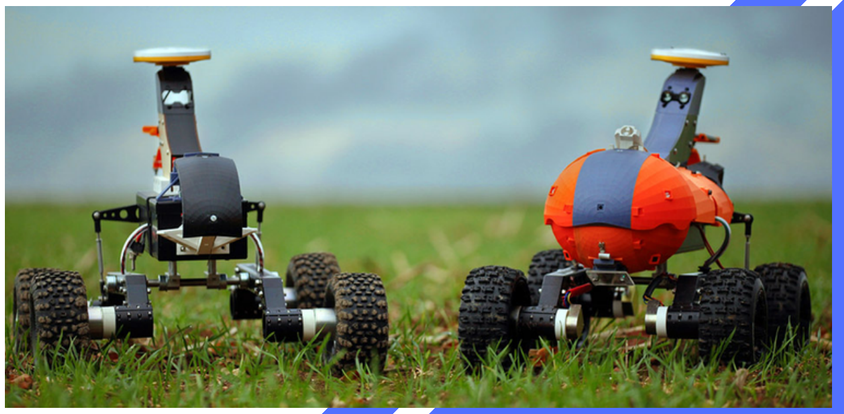
ROBOT BODY AND TASKS

COMPACT SIZE

typically small in size, allowing them to move quickly and efficiently through complex environments.

SIMPLE STRUCTURE

simple structure that is easy to manufacture and repair. They are designed to be robust and durable, able to withstand the wear and tear of repeated use.



SENSOR ARRAY

Swarm robots are equipped with a variety of sensors that allow them to perceive their environment. These sensors can include cameras, microphones, accelerometers, and infrared sensors.

COMMUNICATION SYSTEM

Swarm robots are able to communicate with each other to coordinate their behavior. They use a variety of communication methods, including wireless networking and infrared signals.

ACTUATORS & LOCOMOTIONS

IN SWARM ROBOTICS, ACTUATORS ARE USED TO MOVE THE ROBOTS AND MANIPULATE THEIR ENVIRONMENT.

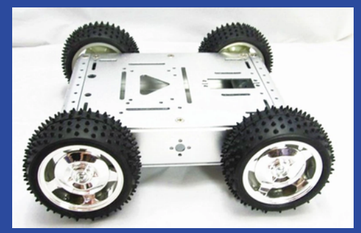
IN SWARM ROBOTICS, LOCOMOTION IS AN IMPORTANT CONSIDERATION BECAUSE IT AFFECTS THE ROBOT'S ABILITY TO NAVIGATE COMPLEX ENVIRONMENTS AND INTERACT WITH OTHER ROBOTS

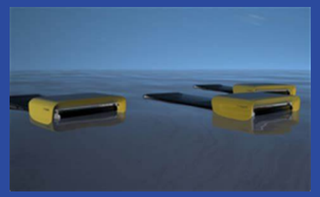
actuators

1. ELECTRIC MOTORS: ELECTRIC MOTORS ARE USED TO GENERATE ROTATIONAL MOTION, WHICH IS THEN USED TO DRIVE WHEELS OR OTHER MECHANICAL COMPONENTS.
2. PIEZOELECTRIC ACTUATORS: PIEZOELECTRIC ACTUATORS USE AN ELECTRIC FIELD TO DEFORM A PIEZOELECTRIC MATERIAL, GENERATING MOTION.
3. SHAPE MEMORY ALLOY ACTUATORS: SHAPE MEMORY ALLOY ACTUATORS USE A SHAPE MEMORY ALLOY MATERIAL TO GENERATE MOTION. WHEN HEATED, THE MATERIAL UNDERGOES A PHASE CHANGE AND CONTRACTS, GENERATING MECHANICAL MOTION.

locomotions

1. WHEELED LOCOMOTION: WHEELED LOCOMOTION IS THE MOST COMMON TYPE OF LOCOMOTION USED IN SWARM ROBOTS. IT IS SIMPLE, RELIABLE, AND ALLOWS THE ROBOT TO MOVE QUICKLY OVER FLAT SURFACES.
2. LEGGED LOCOMOTION: LEGGED LOCOMOTION IS USED IN ROBOTS THAT NEED TO NAVIGATE UNEVEN OR ROUGH TERRAIN. IT ALLOWS THE ROBOT TO CLIMB OVER OBSTACLES AND MOVE THROUGH COMPLEX ENVIRONMENTS.
3. FLYING LOCOMOTION: FLYING LOCOMOTION IS USED IN ROBOTS THAT NEED TO MOVE THROUGH THE AIR. IT ALLOWS THE ROBOT TO ACCESS AREAS THAT ARE DIFFICULT OR IMPOSSIBLE TO REACH WITH WHEELED OR LEGGED LOCOMOTION.
4. SWIMMING LOCOMOTION: SWIMMING LOCOMOTION IS USED IN ROBOTS THAT NEED TO MOVE THROUGH WATER. IT ALLOWS THE ROBOT TO NAVIGATE RIVERS, LAKES, AND OTHER BODIES OF WATER.





Navigation system

1 **LOCALIZATION**

A process by which a robot determines its position in its environment. This can be achieved using a variety of sensors, including cameras, GPS, and inertial sensors.

2 **PATH PLANNING**

A process by which a robot determines the optimal path to reach its destination. This can be achieved using algorithms such as A or Dijkstra's algorithm, which calculate the shortest path between two points.*

CONTROLLER

THE CONTROLLER IS RESPONSIBLE FOR MANAGING THE BEHAVIOR OF THE ROBOTS IN THE SWARM. IT RECEIVES INPUT FROM THE SENSORS AND THE NAVIGATION SYSTEM AND GENERATES OUTPUT COMMANDS THAT CONTROL THE MOTION OF THE ROBOTS. THE CONTROLLER CAN BE EITHER CENTRALIZED OR DECENTRALIZED

- One example of a navigation system and controller used in swarm robotics is the Kilobot system, developed at Harvard University.
- The Kilobot system uses infrared communication to allow the robots to coordinate their movement and accomplish tasks
- The navigation system is based on a combination of local sensing and global information provided by a centralized controller.

DATA COLLECTION

A CRITICAL ASPECT OF SWARM ROBOTICS, AS IT ALLOWS THE ROBOTS TO GATHER INFORMATION ABOUT THEIR ENVIRONMENT AND MAKE DECISIONS BASED ON THAT INFORMATION

IN SWARM ROBOTICS, DATA COLLECTION IS TYPICALLY ACHIEVED THROUGH A COMBINATION OF LOCAL AND GLOBAL SENSING.

LOCAL SENSING: INVOLVES USING SENSORS ON THE INDIVIDUAL ROBOTS TO COLLECT DATA ABOUT THEIR IMMEDIATE SURROUNDINGS, SUCH AS TEMPERATURE, HUMIDITY, OR LIGHT LEVELS.

GLOBAL SENSING: INVOLVES USING EXTERNAL SENSORS IN THE ENVIRONMENT TO COLLECT DATA THAT IS RELEVANT TO THE BEHAVIOR OF THE SWARM AS A WHOLE, SUCH AS AIR QUALITY, WATER LEVEL, OR WEATHER CONDITIONS.

One example of data collection in swarm robotics is the use of autonomous underwater vehicles (AUVs) to collect data on the ocean environment. A fleet of AUVs can be used to collect data on temperature, salinity, and other ocean parameters.

DATA TRANSMISSION

A CRITICAL ASPECT OF SWARM ROBOTICS, AS IT ALLOWS THE ROBOTS TO SHARE INFORMATION WITH EACH OTHER AND WITH A CENTRAL CONTROLLER.

IN SWARM ROBOTICS, DATA TRANSMISSION CAN BE ACHIEVED THROUGH A VARIETY OF METHODS, INCLUDING WIRELESS COMMUNICATION, INFRARED COMMUNICATION, AND ACOUSTIC COMMUNICATION.

WIRELESS COMMUNICATION: USE RADIO WAVES TO TRANSMIT DATA BETWEEN THE ROBOTS AND THE CENTRAL CONTROLLER. TYPICALLY ACHIEVED USING PROTOCOLS SUCH AS WI-FI, BLUETOOTH, OR ZIGBEE,

INFRARED COMMUNICATION: USES INFRARED SIGNALS TO TRANSMIT DATA BETWEEN THE ROBOTS. TYPICALLY USED IN ENVIRONMENTS WHERE RADIO WAVES ARE NOT EFFECTIVE, SUCH AS UNDERWATER OR IN HIGHLY CLUTTERED ENVIRONMENTS.

ACOUSTIC COMMUNICATION: USES SOUND WAVES TO TRANSMIT DATA BETWEEN THE ROBOTS. TYPICALLY USED IN UNDERWATER ENVIRONMENTS, WHERE RADIO WAVES AND INFRARED SIGNALS ARE NOT EFFECTIVE.

One example of data transmission in swarm robotics is the use of swarm robots to monitor air pollution in urban areas. The robots are equipped with sensors that measure air quality, and they transmit this data back to a central controller using wireless communication.

POWER SYSTEM MANAGEMENT

POWER SOURCES

Common power sources include batteries, solar panels, and fuel cells.The choice of power source depends on the energy requirements of the robots and the availability of power sources in the environment.

POWER STORAGE

power storage is typically achieved using rechargeable batteries. The batteries are designed to be lightweight and long-lasting, to maximize the robot's operating time.

POWER DISTRIBUTION

The power distribution system is responsible for distributing power to the various components of the robot. This involves ensuring that each component receives the power it needs, while minimizing energy waste.

POWER REGULATION

The power regulation system is responsible for regulating the voltage and current of the power supply to ensure that it is compatible with the components of the robot. This involves converting the power from the power source to the appropriate voltage and current levels for the robot's components.