# Swarming robots

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# HISTORY

- 1988: Term 'swarm' used in robotics by G. Beni and Fukuda
- 1989: Fukuda describes a swarm as a group of robots that work together like the cells of a human body
- 1989: G. Beni and J. Wang introduce 'swarm intelligence' as a concept
- 1993: C. Ronald Kube and Hong Zohng build a multi-robot system inspired by natural swarms
- 1993: Gregory Dudek defines swarm robotics based on different features of the system
- Early swarm robotic systems explore swarming behaviors in natural species
- Many studies and researches emulate swarming behaviors like foraging, flocking, sorting, stigmergy, or cooperation
- 2004: G. Beni defines a swarm more precisely as simple, identical, and self-organizing robots with scalable systems and only local communication

# INTRODUCTION

- Swarming robots: Multiple robots that work together to achieve a common goal in a robotic system
- The robots cooperate to coordinate and communicate for the purpose of forming collective intelligence that is more intelligent than the sum of their individual intelligences.
- These systems' crucial hardware components are in charge of giving the robots the resources they need to complete their tasks effectively.
- Swarm robotics is the study of developing and controlling scalable groups of simple robots. Individual robots within a swarm only possess limited capabilities. They move in two- or three-dimensional space, sense their local environment, and communicate with only their nearest neighbors. These local interactions between hundreds or thousands of robots can potentially give rise to complex behaviors

# Main components

- Locomotion (Wheels, Propellers & Legs)
- Microcontroller
- Data Collection (Sensors)
- Data Transmission (Wifi & Bluetooth)
- Actuation Hardware (DC Motors & Servo Motors)
- Power Management ( Battery & Solar Panel)

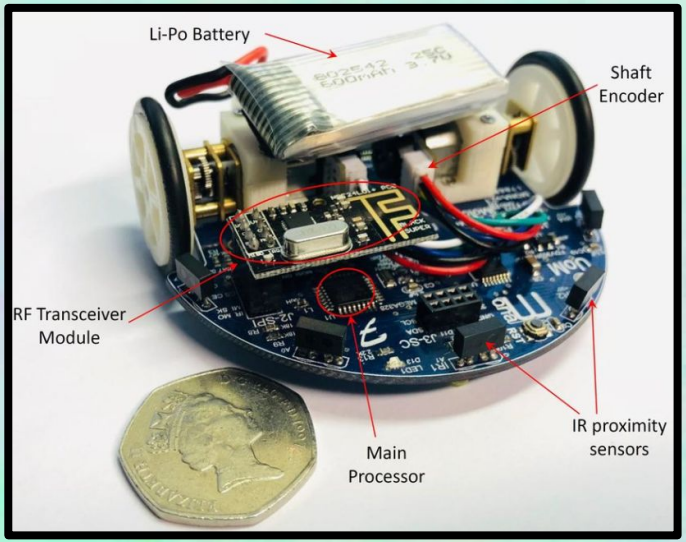
# LOCOMOTION

- The vast majority of swarm robotic systems use wheeled locomotion with DC motors and wheel encoders. There are a few exceptions which use tracks and wheels (treels) and accelerometers, gyroscopes, or stepper motors for odometry. Treels are considered as wheeled locomotion.
- a) Locomotion Wheels

  b) Locomotion Legs

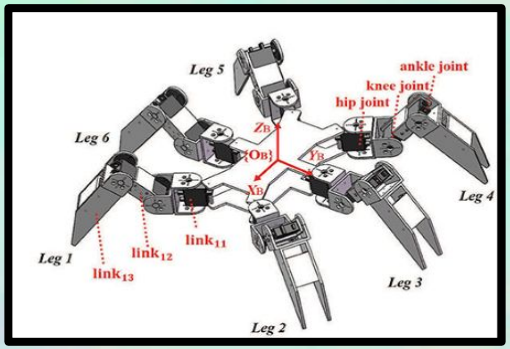
  c) Locomotion Propellers

# Locomotion (Wheels)

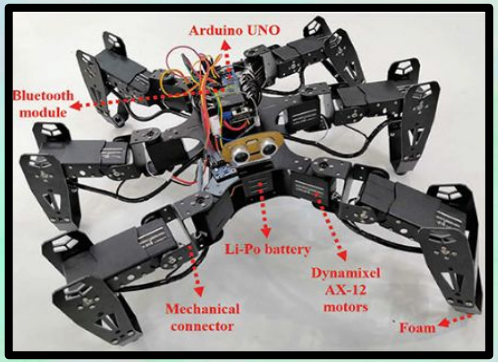



- In swarming robots, wheels are a typical locomotion component, especially for ground-based robots.
- Locomotion wheels are a simple way used to allow the robots to move fast

# Locomotion Legs




**The mechanical schematic of the hexapod robot.**




**The hexapod robot prototype**

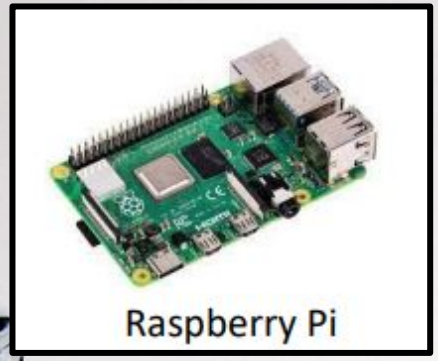
- Another form of mobility used by swarming robots is the usage of legs, particularly by those that must traverse difficult terrain or scale barriers.
- Legged robots have higher mobility since they can move in a number of ways, such as sprinting, jumping, and walking.

# Locomotion Propeller

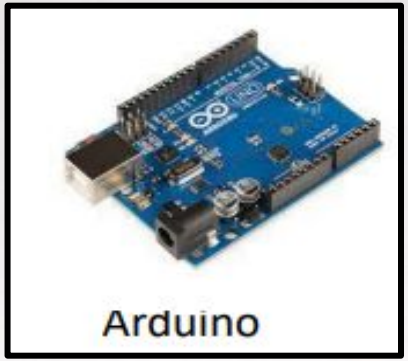
- Swarming robots that must fly, require propellers i.e: aerial drones,
- They give the robot lift and enable it to move  vertically and horizontally in the air
- For more control over the robot's movement, propellers might be fixed or adjustable .

A British inventor has created a ‘super drone’ with 54 propellers, which is enough to keep a human airborne (pictured). ‘The swarm’ can only remain in the air for 10 minutes on a single battery charge and seems to climb to a height of around 15 feet (seven metres) but it is impressive non-the less

# Microcontroller



Raspberry Pi



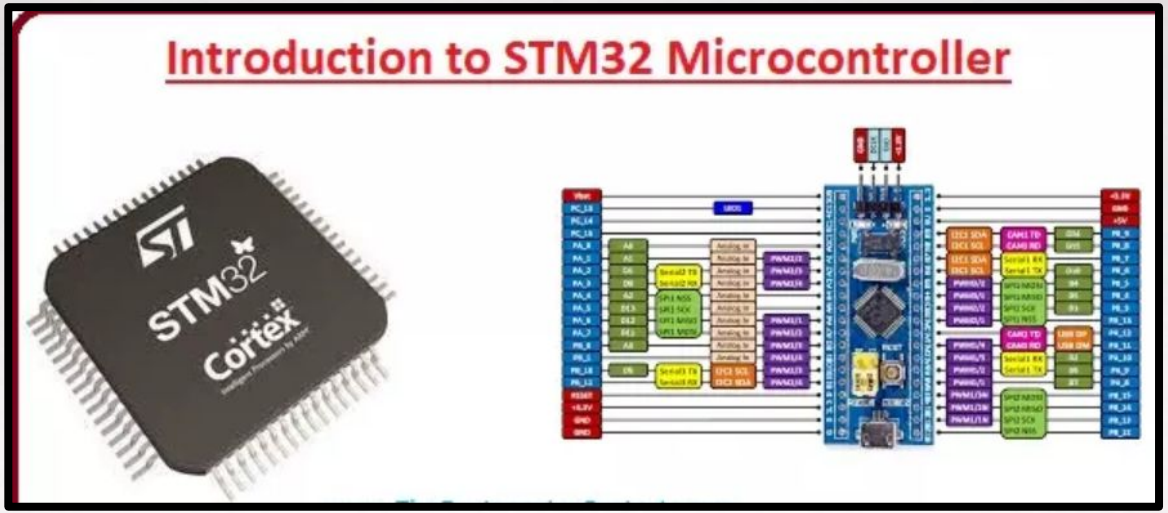
Arduino

**Beaglebone**

- A microcontroller is the brain of a robot that controls all the robot's functions, such as processing sensor data, communicating with other robots, and performing actions

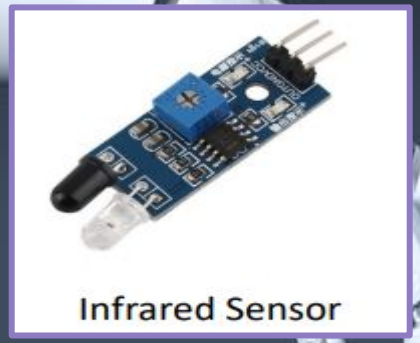
It is similar to the Raspberry Pi but has more input/output (I/O) pins and is designed for more advanced projects.

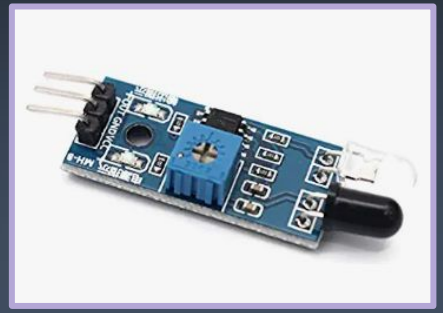
# Microcontroller



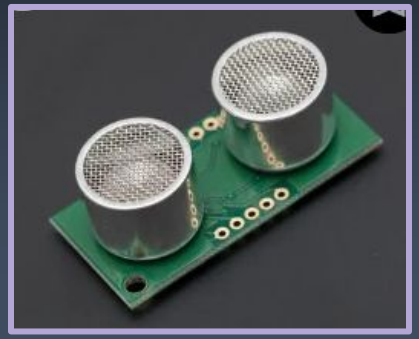

- They are powerful, efficient, and have a large community of developers who contribute to their development.

# Data collection ( sensors )



Proximity sensor



Srfo5 ultrasonic sensor

➔ The purpose of sensors in swarm robots is to enable the robots to sense their environment and gather information that is necessary for them to achieve their goals. Sensors allow swarm robots to perceive their surroundings, detect obstacles and other robots, and navigate through their environment. They also enable swarm robots to interact with each other and coordinate their behavior.

# Data Transmission



- Communication devices allow robots to communicate with each other and share information. Some examples of communication devices used in swarming robots are:

1. Wi-Fi: Wi-Fi is a wireless communication technology commonly used in swarming robots to transmit data between robots. It provides high bandwidth and long- range communication capabilities.
2. Bluetooth: Bluetooth is a wireless communication technology commonly used in swarming robots to transmit data between robots. It provides low-power and short-range communication capabilities.

# Actuator

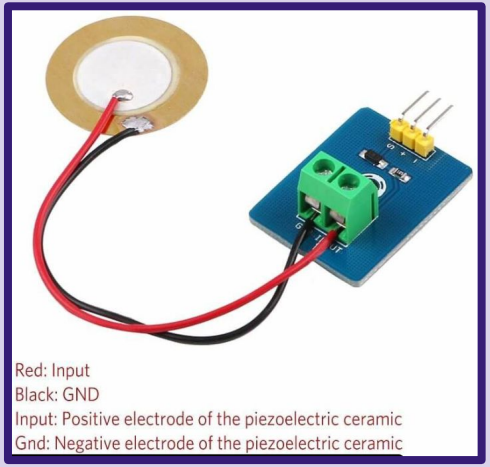
Actuators are components that provide motion to the robot. They are responsible for controlling the robot's movement and performing tasks] Some examples of actuators used in swarming robots are:

1. DC motors: DC motors are commonly used in swarming robots for their simplicity and low cost. They are used to control the robot's speed and direction of movement.

2. Servo motors: Servo motors are used in swarming robots for their precision and ability to control the robot's movement accurately. They are commonly used in robotic arms to perform tasks that require fine control

# Actuator

12V 430RPM 1kgfcm 32mm Planetary DC Geared Motor with encoder




Analog Piezoelectric Ceramic Vibration Module

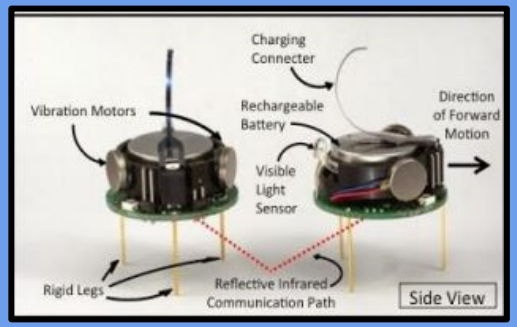

Standard 10kg.cm Metal Gears Analog Servo

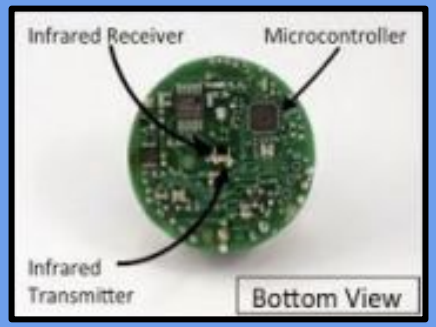
# Power management (Batteries and charger)

- Batteries: Batteries are a popular source of power in swarming robots. They provide a portable and dependable source of power that is easily rechargeable. Depending on their power requirements and operational conditions, swarming robots may employ a number of battery types, such as lithium ion or nickel-metal hydride batteries. The Kilobot swarm robot, for example, is powered by a lithium-polymer battery that can run continuously for up to 9 hours.

- Solar Panels: Another sort of power source utilised in swarming robots is solar panels, which are particularly useful for robots that work in outdoor locations with plenty of sunlight. Solar panels provide a sustainable energy source that can be utilised to recharge batteries or directly power the robot. The RoboBees are an example of swarming robots that employ solar panels for power management.

# Power management (Batteries and charger)




**Lithium-polymer battery in Kilobot**

# Summary

Swarm robots are a group of autonomous robots that work together to achieve a common goal. They use a variety of locomotion mechanisms such as wheels, legs, and propellers to move and navigate through their environment. To control their behavior, swarm robots rely on microcontrollers that receive and process data from a range of sensors, such as cameras, lidar, and proximity sensors. These sensors allow the robots to sense their surroundings, communicate with each other, and respond to changes in the environment. Actuators, such as DC motors, servo motors, and piezoelectric actuators, convert electrical signals into physical motion or force, allowing swarm robots to move and interact with their environment. Power management techniques, such as battery management, energy harvesting, and sleep mode, are used to optimize power consumption and extend the robot's operating time. Overall, swarm robots offer a flexible and adaptive approach to achieving complex tasks, with the potential to revolutionize industries such as manufacturing, logistics, and environmental monitoring.