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Swarm robots in agriculture

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Abstract

Swarm robotics is a broad area of study that looks at the collective behavior of many autonomous robots to complete challenging tasks. Swarm robotics attempts to take advantage of the power of decentralization and self-organization to achieve adaptability, scalability, and robustness in robotic systems by taking inspiration from the collective behavior of natural swarms, such as ants, bees, and schools of fish.

Keywords: Swarm robotics; Autonomous Robots; Collective behavior; Power Decentralization; Agricultural Engineering.

1. Introduction

Robots are mechanical or electrical devices created to do specified tasks independently or with the guidance of a human controller. With the help of controlling arms and sensory tools to engage with the environment, they may consider information, come to conclusions, and make decisions according to their computing abilities. The hardware and the programming abilities are what make them so special, in addition to giving a peek into the extremely hard tasks that contemporary robots are capable of performing. They can be extremely complicated or extremely simple, depending on the nature of the job, and this has served as the starting point for interesting discussions regarding the practical applications of robot technology ever since.

Swarm robotics is an innovative approach for designing robotic systems that aims to benefit from the coordinated actions and interactions of numerous robots that are dispersed throughout a vast region. Such systems, in contrast to the conventional approach, can produce behavior patterns that beat the performance of any one robot by utilizing the talents and actions of individual robots [1-4].

2. Literature survey

Many researchers have studied the applications and advancements in swarm communication. Swarm robotics has achieved a lot of advancements that are intended to get around previous challenges and limitations of the field. Here are some recent tactics and applications that deal with these problems.

Improved Communication and Coordination, Decentralized Control and Self-Organization, Hybrid Approaches, Heterogeneous Swarms, Robustness and fault tolerance.

Şahin, E. et al. have described the desirable properties of swarm robotics systems as observed in the system-level functioning of social insects proposing a definition for the term swarm robotics, and putting forward a set of criteria that can be used to distinguish swarm robotics research from other multi-robot studies [1].

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3. System architecture

3.1. Arduino

Arduino is a platform for developing and prototyping interactive electronic objects that uses open source hardware and software. It comprises of an Arduino board—a physically programmable circuit board—and a programming environment that enables users to write and upload computer code that regulates the board's operation.

In our project we have used the Arduino to control the motor drivers and the receiver and transmitter to establish communication between the master and slave robots.

3.2. Motor Drivers

We have used L298N motor drivers. The L298N is a common double H-bridge motor driver integrated circuit (IC) that is often used in robotics and other projects to regulate and operate DC or stepper motors. It is capable of handling increased current and voltage demands, making it appropriate for driving medium-sized motors.

3.3. Transmitter and Receiver

We have used a 4 bit transmitter and receiver. A 4-bit transmitter is a digital circuit or device that can send a 4-bit binary signal via a radio frequency or communication channel. Microcontrollers, electronic devices, and communication protocols are all known to depend on it. In most cases, a 4-bit transmitter transforms parallel binary data into serial form before transmitting it.

A digital circuit or system that is designed to receive and handle 4-bit binary data is often referred to as a 4-bit receiver. It can be used in numerous computer architectures, data processing applications, and digital communication systems. The 4-bit binary input is received by the receiver, and particular actions are carried out using the received data.

3.4. Bluetooth Module

A well-known Bluetooth module called the HC-05 is frequently used for distant communication between electrical devices. It is typically used in a variety of jobs, such as advanced mechanics, home computerization, and Web of Things (IoT) projects, and the applications are endless from there. The fact that the HC-05 module is a Bluetooth Sequential-Port Module confirms its primary purpose is to set up a remote sequential correspondence interface.

3.5. Android RC App

A multifunctional program designed to remotely control electronic devices using an Android smartphone or tablet can be done using an Android RC app. This app provides a user-friendly interface that enables users to wirelessly connect to their devices, enhancing comfort and flexibility in a variety of activities.

3.6. Motor

An electromechanical tool that transforms electrical energy into mechanical energy is a motor. It is frequently employed to provide rotational or linear motion in a variety of applications, including robotics, cars, appliances, and industrial machines.

One particular sort of motor arrangement that is frequently offered on the market is a DC geared motor with a centered shaft, running at 12 volts, and turning at 150 RPM.

3.7. Pesticide Spraying System

A pump type designed to run on a 12-volt DC (coordinate current) control source could be referred to as a 12-volt water pump. These pumps are frequently used in a variety of settings where a low-voltage control source is available, including recreational vehicles (RVs), ships, tents, and off-grid systems.

3.8. 12V Battery-

A 12V battery is a rechargeable battery that operates at a standard 12V voltage. It is frequently utilized in a wide range of applications, including portable electronics, solar power systems, RVs, automotive, marine, and backup power systems.

4. Methodology

Swarm robotics is an approach that involves designing, implementing, and controlling a number of very simple robots that cooperate in order to accomplish a common objective.

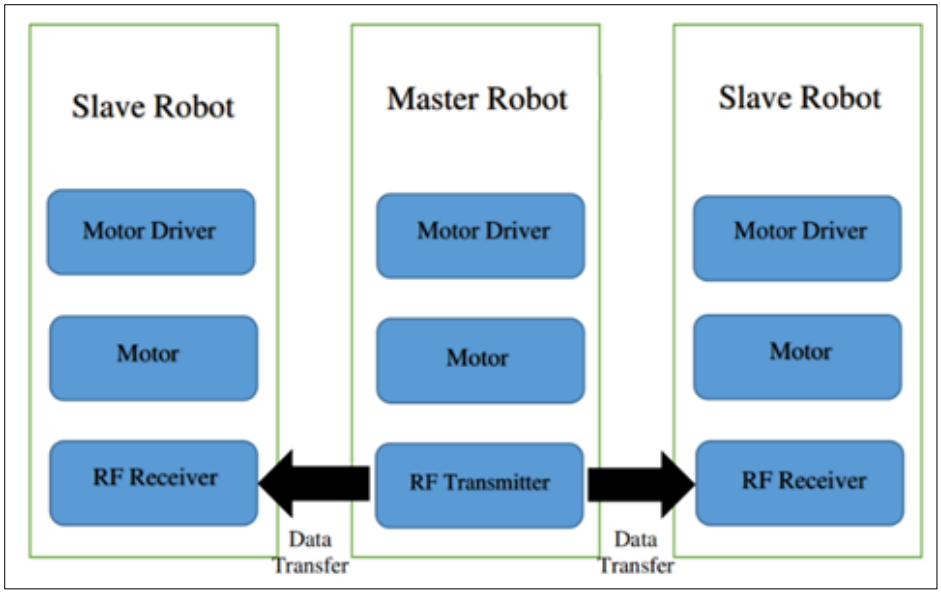

Figure 1 Block diagram

Swarm robotics block diagrams frequently include a number of connected elements that work together to encourage collective behavior and cooperation among the robots.

Arduino Programming- The swarm robot's Arduinos are configured to connect via Bluetooth to the main Arduino and process commands sent to it.

Table1. System Specifications

Materials	Specifications
L298n Motor Driver	Model of Driver: L298N 2A Double H Bridge L298N driver chip Maximum Motor Supply Voltage: 46V Maximum Motor Supply Current: 2A Driver Voltage: 5-35V Logic Voltage: 5V Vehicle Current: 2A Current Logic: 0-36mA The maximum power is 25W. Heat sink for improved efficiency LED power-on indicator
	For use with Arduino and other microcontrollers, a serial Bluetooth module Operating Voltage: 4 to 6 volts (usually +5 volts). 30 mA operating current. 100 meter range. Compatible with serial transmission (USART) and TTL Adheres to the IEEE 802.15.1 standard protocol.

HC05 Bluetooth Module	Frequency-hopping spread spectrum (FHSS) is utilized. Able to function in Master, Slave, or Master/Slave mode. Easily connects through Bluetooth to laptops or mobile devices. 9600, 19200, 38400, 57600, 115200, 230400, and 460800 baud rates are supported.
4-Bit Transmitter & Receiver	Pinouts 1, 2, 3, and 4; all receive four independent pieces of data by simply connecting their corresponding pins to ground with the use of a push button switch. When linked to ground through another push button, Pin 14 certifies switching of the transmitter signals. The 4-bit data is processed and is sent to the TWS-434 IC for transmission of the signal data to the 4-bit transmitter. Similarly, these bits will be received by the receiver to the pin no.1, 2, 3 & 4.
JQC-3FF-S-Z Relay Switch	Operating voltage: 10A 250VAC Pin 1-5V, Pin 2- Ground, Pin 3- Vcc COM1- Battery NC1- Pump
Arduino Pins	Pin 3, 4, 12 & 13, - 4-Bit Transmitter Pin 5, 6, 9 & 10 – Motor driver ln1, ln2, ln3 & ln4. Pin Arduino Tx & Rx will be connected to Bluetooth Tx & Rx. Pin 5V – Motor driver, Vin of Transmitter, HC05 & Arduino. Pin Gnd - Motor driver, Vin of Transmitter, HC05 & Arduino. Pin 3- Spray Pump data pin.

Bluetooth Pairing- Every robot in the swarm is separately paired with the central Arduino to start a connection. Each robot in the system is uniquely identified due to this pairing process.

Command Transmission- The individual swarm robots are communicated with wirelessly using Bluetooth orders or instructions from the central Arduino. These orders could call for data collecting, specific tasks to be carried out, or instructions on how to move.

In our project, we have used the Android RC App through which we will control the master robot and the commands will be followed by the slave robot. The operation of the water spray pump will also be done through the app. The communication between robots is done through receivers and transmitters.

4.1. Software Tool

Open-source programming (OSS) is computer programming whose source code has been publicly available and authorized with a permit, granting the right to study, modify, and distribute the work to anyone and for any purpose to the copyright holder. Programming that is open-source is constantly developed in a shared, collaborative manner. The most prominent example of open-source development is open-source programming, which is sometimes compared to (legally characterized) open content innovations or (actually characterized) user-generated content.

Arduino is a tool for creating computers with greater sensing and control capabilities than a desktop computer. It is an open-source physical computing platform built on a basic microcontroller board that includes a software development environment. Arduino may be used to build interactive objects using switches or sensors as inputs and a variety of lights, motors, and other physical outputs as controls. Arduino projects can function independently or in conjunction with computer software.

The Arduino programming environment consists of a text editor for writing code, a message area, a text console, a toolbar with buttons for fundamental operations, and a number of menus. It links to the AtMega 328P hardware on the Arduino platform to upload programmes and interact with them.

5. Experiments and results

The goal and purpose of a swarm robot in agriculture is often to enhance agricultural processes and address issues facing the sector.

A swarm robot project aims to research and create a system of many robots that can cooperate and display collective behavior to carry out complicated tasks more effectively and efficiently than individual robots or a single robot [5].

We assembled the hardware components and tested the basic movements of both the robots.

We started with the software and robot programming for swarm communication.

Basic Robot Movements- Investigating how basic movements are completed by a swarm of robots is the goal of this project. The goal of the experiment is to determine how a swarm of small robots may use swarm robotics to accomplish common tasks like moving forward, turning, and avoiding obstacles.

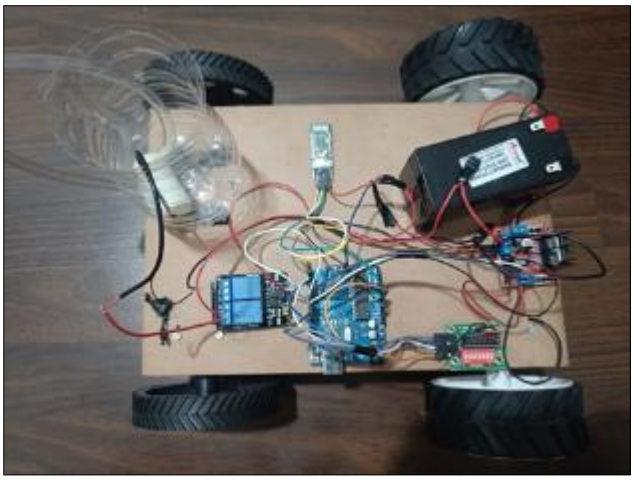

Figure 2 Master Robot

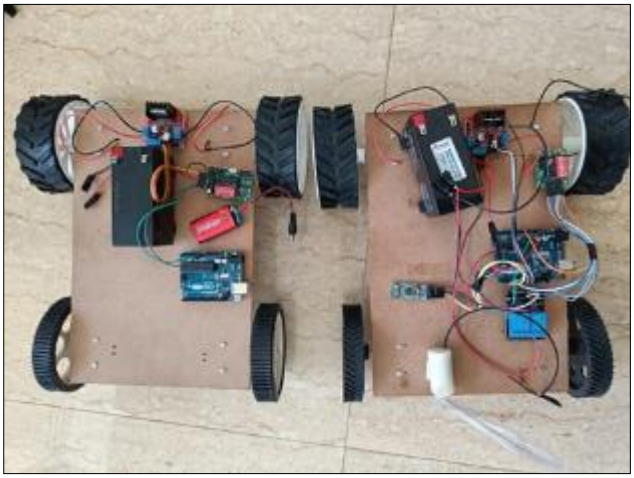

Figure 3 Master and Slave Robot

6. Conclusion

We discovered that our project's Swarm robots has numerous advantages over the other traditional robotics systems after examining many research papers and academic periodicals.

First off, the end-user's robot's compact size enables us to transport the robots easily to any given area for work. Second, the built-in Android application makes it simple for the user to delegate tasks to the robots.

Numerous large sectors, including the automotive industry and warehousing, can use this principle. Currently, when doing a certain activity, while one robot is working on it, the other robots are waiting for it to be finished, which slows down how quickly the assigned task is processed.

With the help of the "swarm robotics" concept, fewer robots can work together to perform a task in a shorter amount of time, increasing efficiency and output while simultaneously cutting costs.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare no conflicts of interest regarding the publication of this manuscript.

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