Swarm Robot

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ABSTRACT

Swarm robotics, an emerging field, draws inspiration from the collective behaviors observed in nature, like bird flocks and ant colonies. It centers on decentralized control and collaboration among simple robotic agents. Applications span environmental monitoring, search and rescue, and agriculture. Swarm systems excel in robustness, scalability, and adaptability, even in the face of agent loss. Challenges encompass communication constraints, collision avoidance, and task allocation. Researchers explore bio-inspired algorithms, machine learning, and heterogeneous robot integration. Swarm robotics has potential for addressing complex real-world problems and advancing autonomous multi-agent systems.

KEYWORDS *: Swarm robotic, Cooperative control, Modeling, Swarm intelligence.*

INTRODUCTION

Swarm robotics is an approach to the coordination of multiple robots as a system which consists of large numbers of mostly simple physical robots. It is supposed that a desired collective behavior emerges from the interactions between the robots and interactions of robots with the environment.

This approach developed in the field of artificial swarm intelligence, from the biological studies of insects, ants and other fields in nature where swarm behaviour occurs .

In this project, we will try to simulate the swarm behaviour in that our robots to coordinate with each other and try to form the shape that the user inputs while taking care that the distance covered and the time taken for the formation of the shape is optimal.

We will also take care that the robots do not collide while following their paths, using the Conflict Based Search (CBS) algorithm and infrared(IR) sensors.

LITERATURE REVIEW

Swarm algorithms are characterized by the individual entities adhering to localized rules, resulting in the emergence of collective behavior through interactions within the swarm. In the realm of swarm robotics, robots exhibit behaviors rooted in a spectrum of rules, ranging from rudimentary reactive mapping to complex local algorithms. These behaviors inherently involve interactions with the physical environment, including interactions with other robots and their surroundings. This interaction process entails retrieving environmental data and subsequently processing it to guide the actuators in accordance with a predefined set of instructions. This iterative process, often referred to as the fundamental activity, persists until the desired state is achieved. provides an overview of several naturally occurring behaviors, which we will delve into further in the subsequent subsection.

The design phase represents the crucial stage during which a system takes shape, evolving from its initial specifications and requirements. However, in the context of swarm robotics, the process of designing individual-level behaviors that yield the desired collective behavior lacks formal or precise methodologies. Regrettably, the primary driving force behind the development of swarm robotics systems remains the intuition of the human designer.

The categorization of design methods falls into two distinct categories: behavior-based design and automatic design.

Behavior-based design

Behavior-based swarm robots are characterized by individual robots exhibiting specific behaviors or rules that collectively result in the desired group behavior. Here are some examples of behavior-based swarm robots:

1. *Flocking Robots*: These robots exhibit behaviors inspired by the flocking of birds. Each robot follows simple rules, such as aligning with nearby robots, maintaining a certain distance, and moving towards the average heading of its neighbors. Together, these behaviors result in coordinated flock-like motion. Flocking robots have applications in surveillance, exploration, and environmental monitoring.
2. *Pattern Formation Robots*: These robots are programmed to form specific geometric patterns or shapes through local interactions. They may adjust their positions and orientations based on the positions of neighboring robots. Pattern formation robots are used in tasks like area coverage and formation control.
3. *Exploration and Coverage Robots*: In exploration tasks, robots follow behaviors that prioritize unexplored or unknown areas. They may use techniques like frontier-based exploration to identify and reach uncharted regions efficiently. Exploration and coverage robots are used in search and rescue, mapping, and environmental monitoring.
4. *Aggregation Robots*: Aggregation robots are programmed to come together and form a cohesive group. Each robot moves towards the center of mass of nearby robots. These behaviors can be used for tasks like gathering objects or aggregating data from various sources.
5. *Dispersion Robots*: Dispersion behaviors are the opposite of aggregation. Robots move away from each other to disperse within an area or environment. Dispersion robots can be applied in scenarios where maintaining a certain spacing is critical, such as in environmental sampling or maintaining separation between robots in a swarm.
6. *Cooperative Transport Robots*: These robots cooperate to transport heavy objects or payloads. They follow rules for coordinating their movements to ensure stable and efficient transport. Cooperative transport robots can be used in logistics, warehouse automation, and construction.
7. *Obstacle Avoidance Robots*: Behavior-based obstacle avoidance robots respond to environmental obstacles by adjusting their paths to navigate around them. They use sensors to detect obstacles and apply rules to ensure collision-free movement. Obstacle avoidance robots are crucial in environments with dynamic obstacles or unknown terrain.
8. *Herd Robots*: Inspired by the herding behavior of animals, herd robots exhibit behaviors that encourage the movement of a group in a specific direction. They use simple rules to control the direction and speed of movement. Herd robots have applications in livestock management and guiding groups of robots.
9. *Collective Decision-Making Robots*: In collective decision-making scenarios, robots use behaviors to reach a consensus or make group decisions. They may employ voting mechanisms or weighting strategies to collectively choose actions or paths.

The key advantages of behavior-based swarm robotics is its ability to achieve complex and adaptive swarm behaviors through the interaction of relatively simple individual behaviors. Overall, behavior-based swarm robotics harnesses the power of simplicity, decentralization, and emergent behavior to create adaptive, scalable, and efficient robotic systems capable of addressing a variety of real-world challenges and tasks

Automatic-Biased Design

Automatic Biased Swarm Robots are a type of swarm robotics system where the individual robots within the swarm exhibit inherent biases or preferences in their behavior and interactions. Unlike traditional swarm robots that often follow purely decentralized and uniform rules, automatic biased swarm robots introduce individuality and preferences into the decision-making process of each robot. These biases can be based on various factors such as sensor data, historical experiences, or predefined rules.

1. Search and Rescue: In search and rescue missions, robots may have preferences for exploring specific areas based on available sensory information. Some robots may prefer to search for survivors while others focus on mapping the environment.
2. Precision Agriculture: In agriculture, robots can have biases related to soil quality or crop health. Some robots may prioritize tasks like soil sampling, while others may prefer to focus on planting or harvesting.
3. Environmental Monitoring: For environmental monitoring, robots may be biased towards certain types of data collection. Some may prefer water quality measurements, while others focus on air quality or wildlife tracking.
4. Delivery and Logistics: In delivery and logistics scenarios, robots with biases can be used to optimize package delivery routes. Some robots may prefer to handle fragile items, while others prioritize speed.
5. Traffic Management: In urban environments, automatic biased swarm robots can assist with traffic management. Some robots may have a preference for directing traffic at busy intersections, while others focus on pedestrian safety.
6. Exploration of Unknown Environments: In exploration tasks, robots may exhibit biases based on their historical exploration success. Robots that have previously discovered valuable information may be biased towards further exploration.
7. Multi-Objective Optimization: Automatic biased swarm robots can be applied in multi-objective optimization scenarios where robots balance conflicting objectives, such as energy efficiency and task completion.

The key advantage of automatic biased swarm robots is their ability to introduce diversity and adaptability into swarm behavior, which can lead to more effective and efficient task execution in complex and dynamic environments. However, designing and managing biases effectively is a challenge that requires careful consideration of the specific application and task requirements.

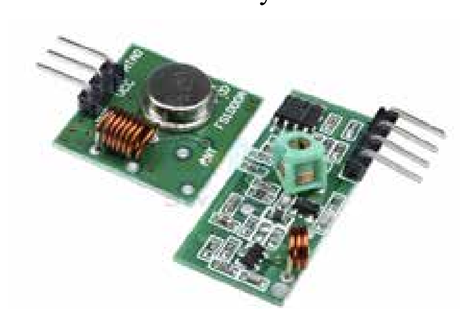
HARDWARE SPECIFICATION

Arduino Uno

The Arduino Uno is an ATmega328 microcontroller. It consists of two pins, i.e. digital and analog pins(I/O). It has a 6 number of analog input pins and 14 number of digital output pins, a USB type connector and a power jack. Programmed based on the Integrated Development Environment(IDE) and it can run on both platforms, like online and offline.

Rf Trasmitter and Encoder Module

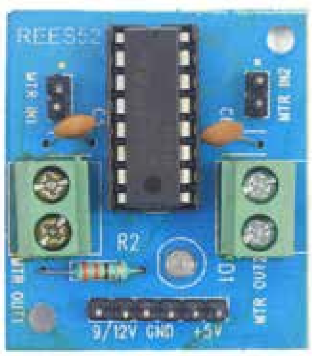
An RF module (short for radio-frequency module) is a (usually) small electronic device used to transmit and/ or receive radio signals between two devices. In an embedded system it is often desirable to communicate with another device wirelessly.



L239D Motors Driver

The L293D is a popular motor driver IC (Integrated Circuit) commonly used in electronics and robotics projects to control the direction and speed of DC motors. It provides an easy and efficient way to interface microcontrollers or other digital control circuits with motors, allowing for precise motor control.

Its is widely used in hobbyist and educational projects, as well as in small-scale robotics applications. It simplifies the task of controlling DC motors and is compatible with various microcontrollers like Arduino, Raspberry Pi, and others. Its dual H-bridge configuration and direction/speed control capabilities make it a versatile choice for motor control tasks.



B01 Motors

BO1 Dual Shaft Motor gives good torque and RPM at lower operating voltage, which is the biggest advantage of these motors. Small shaft with matching wheels give optimized design for your application or robot. Mounting holes on the body & light weight makes it suitable for in-circuit placement.

In This Project we need 2 Motor for each robots.

KEY FEATURES

Swarm robotics is a field of robotics that focuses on the coordination and collaboration of a large number of relatively simple robots, known as a swarm, to achieve collective tasks. Key features and characteristics of swarm robotics include:

- Decentralization: Swarm robots operate with limited or no centralized control. Instead, they rely on local interactions with neighboring robots and the environment to make decisions collectively.
- Emergent Behavior: Complex and adaptive swarm behaviors emerge from the interactions of individual robots following simple rules. These behaviors are not explicitly programmed but rather self-organize based on the local interactions.
- Scalability: Swarm robotics can scale to large numbers of robots, making it suitable for tasks that require extensive coverage, exploration, or distributed sensing. The addition of more robots can often improve system performance
- Flexibility: Swarm robots can adapt to changing environmental conditions and mission objectives. They can exhibit different behaviors or reconfigure themselves to achieve different tasks.
- Diversity: Swarms can consist of heterogeneous robots with different capabilities or sensors. This diversity can enhance the swarm's ability to perform a wide range of tasks.
- Communication: While swarm robots primarily rely on local interactions, some swarm robotics systems may incorporate limited communication between robots. Communication can be used for sharing information, coordination, or synchronization

METHODOLOGY

Swarm Robotics is based on master and slave algorithm in this one robot is going to be main robot which give command to all the other robots. In our case Master robot will give command the other robots to copy its movement. the instructions give to them by the master robots.

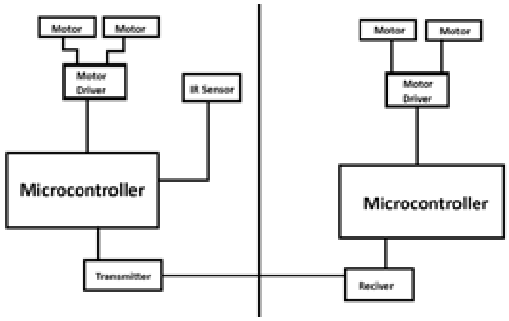


Fig : Block Diagram of Swarm Robotics

The working of this project is quit simple. In this project we have two robots one is master robot and other one is slave robot. The master robots is where all command will be give and it will execute the commands, and forward those command to the slave robot which will do as its given the command, this will copy the movement of the master robots and do what is master robot doing the slave robot will only follow the commands.

Now movement of the robots the main movement commands of the robots are going to be (“Forward”, “Backward”, “Left”, “Right”, “Stop”) , Both the robots are going to have to Motors which will help the Robots to Move. Each Movement are going to given separately, For Example : If Robot have to move forward both Motor will execute forward command, and to Move Back word It will Execute Backward command, as For Moving Side to Side, One motor will execute either forward or backward command, and other motor will opposite of the command like backward or farword.

For the Our Project We are using IR Sensor, to Give input to master robot, In this the 2 IR Sensor will given input and based on the input robot move, for example : let say both IR sensor give input of 500 or above then its command to move forward, and if its given input of 100 or less then its commands to stop, if only one get the reading of 500 and other get 100 it will go left or right based on with side of motor get 100 or less reading. And all the cammond will follow by the slave as well

CONCLUSION

In conclusion, swarm robotics represents a fascinating and promising field at the intersection of robotics, biology, and artificial intelligence. By drawing inspiration from the collective behaviors observed in natural swarms, researchers and engineers have developed innovative approaches to solving complex problems and performing tasks that are challenging for individual robots or centralized systems.

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