Swarm Robotics

DOLOR SIT AMET

Introduction

Swarm Robotics

Swarm Robotics is an emerging field of adapting the phenomenon of natural swarms to robotics. It is a study of robots that are aimed to mimic natural swarms, like ants and birds, to form a system that is scalable, flexible, and robust.

Properties of Swarm Robotics

Flexibility

Swarm robotics aim to attain a verity of tasks. Here comes the feature of flexibility in focus. For the tasks, the system must be able to create various solutions by coordination and cooperation between robots. So, robots should find solutions by working together and be able to change their roles according to the given tasks. They should be capable of acting simultaneously according to the changes in their environment

Scalability

Scalability means that the systems must be able to work with different sizes of groups. There should not be a global number of robots present in a swarm, but the sizes may differ and accomplishing the task should still be possible and effective. The number of group members must not influence the performance of the system. So, swarm robotic systems should be able to operate with different number of members. The system should work effectively when the swarm size is small and it should support coordination and cooperation amongst the members, if the swarm size is large.

Robustness

A system is referred as robust, if it has the ability to continue operating even if there are environmental disturbances or system faults. Environmental disturbances may include the changing of the surroundings, addition in the number of obstacles in the environment, weather changes and so on. Some of the system members can have a malfunction or can fail to perform. A swarm robotic system must be able to cope with such circumstances. In swarm robotic systems, individual robots are mainly very simple. This means that they cannot perform any significant tasks alone. So, if a system loses some robots it should not affect the overall performance of the system. The loss of individuals can be compensated by another member and the tasks must go on with the same level of efficiency.

Autonomy

Acting randomly is known as autonomy. Robots that act and react on their own and make decisions by themselves are known as autonomous robots. They do not need a central entity to control their actions.

Self organised

Robots coping with the environment and reorganizing themselves are called self-organizing robots. Self organization is the most important aspect for swarm robotics. The main goal of most of the swarm robotic systems is to accomplish tasks in coordination and without a central entity.

Self-assembly

self-assembly is the autonomous organization of robots into patterns or structures without human intervention or another central entity

Decentralized

Swarm robotics aims to achieve tasks without any central leader, due to many reasons like, it is difficult to control large swarms, a central control is a single point of failure, it is difficult to attain flexibility, scalability and robustness in centralized systems and many other reasons.

Stigmergy

Stigmergy refers to the *indirect communication* among robots. This form of communication is inspired by the *pheromones*, that ants left on their way to the food sources, to signal other ants about some information, like the possible way to the food source.

Advantages & Disadvantages of Swarm Robotics

Advantages

- Robots are autonomous that can cope with their environmental changes.
- Robots can combine their powers and abilities to form complex structures and offer unlimited features.
- The systems are flexible. That means they can be applied in different fields and for a verity of tasks.
- The systems are scalable, that means all robots can manage to obtain its goals no matter how big or small the swarm is.
- *Parallelism* makes the systems work faster. Parallelism means tasks can be divided into sub tasks that can be allocated to different robots.
- Robots are designed very simply, that means they are also cost effective

Disadvantages

• The decentralized nature of swarm robotic systems make them a not so optimal choice for many applications.

• Due to their *autonomy* they will act to the changes in their surroundings individually and spontaneously.

Even if the goal is to obtain tasks in a collective manner, the decentralization can result in single robots acting differently than the rest of the group.

• The simple design and implementation of robots also makes it tough to design systems for real life applications in such a way that they achieve goals with a hundred percent guarantee.

• For many real-life applications, global knowledge must be provided to robots

Application Fields

Agriculture

In *agriculture area* swarm of robots are used to revolutionise farming and decreasing the workload of farmers. All farming tasks like harvest, sowing of seeds and so on can easily be done via robots.

Industrial

Industrial fields also make the use of swarm robotics in various activities, like the dealing with chemicals. Here robots can be used instead of human beings in order to reduce any damage or harm to human workers.

Military

Swarm robotic systems can be of great use in the military. For example, they can be used to detect and defuse bombs. This would exclude the need of human bomb diffusers. An army of robots can also be created to perform military tasks

Medical

The use of swarm robots in the medical field is becoming very interesting and attractive over the time. Nanorobots can move into the veins and arteries to detect and cure various diseases like cancer cells

Hazard Zones

Robots can be used to monitor dangerous areas to look for specific items like chemicals and toxins or survivors after a natural disaster. Dangerous goods can also be transported via robots and mining work can be accomplished without any human interference. Such tasks are ideal to obtain with robots in place of humans so that there is no danger for human workers.

Example of Swarm Robotics

Kilobots

Kilobot is a low-cost, easy-to-use robotic system for advancing development of “swarms” of robots that can be programmed to perform useful functions by coordinating interactions among many individuals. These swarms are inspired by social insects, such as ant colonies, that can efficiently search for and find food sources in large complex environments, collectively transport large objects, and coordinate the building of nests and bridges in such environments.

Hardware Configuration

ELEMENTS	TECHNICAL INFORMATIONS
Processor	ATmega 328P (8bit @ 8MHz)
Memory	32 KB Flash used for both user program and bootloader, 1KB EEPROM for storing calibration values and other non-volatile data and 2KB SRAM
Battery	Rechargeable Li-Ion 3.7V, for a 3 months autonomy in sleep mode. About 2.5 hours in standard use with motors.
Charging	Kilobot charger (optional). Time for charge is about 3 hours
Communication	Kilobots can communicate with neighbors up to 7 cm away by reflecting infrared (IR) light off the ground surface.
Sensing	When receiving a message, distance to the transmitting Kilobot can be determined using received signal strength. The brightness of the ambient light shining on a Kilobot can be detected.

Movement	Each Kilobot has 2 vibration motors, which are independently controllable, allowing for differential drive of the robot. Each motor can be set to 255 different power levels.
Light	Each Kilobot has a red/green/blue (RGB) LED pointed upward, and each color has 3 levels of brightness control.
Dimensions	The diameter is 33 mm and the height is 34mm (including the legs)
Software	The KiloGUI interface is available for controlling the controller board, sending program files to the robots and controlling them.
Programming	For programming, the open source development software WinAVR combinated with Eclipse gives a C programming enviromnent. An API with basic functions such as motor speed, led control, distance measurement,… is available and some examples are provided. An online compiler is also available directly on the Kilobotics website