Seminar report

on

"Swarm Robotics"

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SUBMITTED TO: **SUBMITTED BY:**

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ABSTRACT

Swarm robotics is currently one of the most important application areas for swarm intelligence. Swarms provide the possibility of enhanced task performance, high reliability(fault tolerance), low unit complexity and decreased cost over traditional robotic systems. They can accomplish some tasks that would be impossible for a single robot to achieve. Swarm robots can be applied to many fields, such as flexible manufacturing systems, space crafts, inspection/maintenance, construction, agriculture and medicine work.

Swarm-bots are a collection of mobile robots able to self assemble and to self organise in order to solve problems that cannot be solved by a single robot. These robots combine the power of swarm intelligence with the flexibility of self reconfiguration as aggregate swarm-bots can dynamically change their structure to match environmental variations.

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INTRODUCTION

Swarm robotics is the study of how large number of relatively simple physically embodied agents can be designed such that a desired collective behavior emerges from the local interactions among agents and between the agents and the environment. It is a novel approach to the coordination of large numbers of robots. It is inspired from the observation of social insects ---ants, termites, wasps and bees--- which stand as fascinating examples of how a large number of simple individuals can interact to create collectively intelligent systems.

Social insects are known to coordinate their actions to accomplish tasks that are beyond the capabilities of a single individual: termites build large and complex mounds, army ants organize impressive foraging raids, ants can collectively carry large preys. Such coordination capabilities are still beyond the reach of current multi-robot systems.

As robots become more and more useful, multiple robots working together on a single task will become common place. Many of the most useful applications of robots are particularly well suited to this "swarm" approach. Groups of robots can perform these tasks more efficiently, and can perform them in fundamentally difficult to program and co-ordinate.

Swarm robots are more than just networks of independent agents, they are potentially reconfigurable networks of communicating agents capable of coordinated sensing and interaction with the environment.

1. Evolution of swarm (Biological Basis and Artificial Life)

Researchers try to examine how collections of animals, such as flocks, herds and schools, move in a way that appears to be orchestrated. A flock of birds moves like a well choreographed dance troupe. They veer to the left in unison, then suddenly they may all dart to the right and swoop down towards the ground. How can they coordinate their actions so well? In 1987, Reynolds created a "boid" model, which is a distributed behavioral model, to simulate on a computer the motion of a flock of birds. Each boid is implemented as an independent actor that navigates according to its own perception of the dynamic environment.

A boid must observe the following rules. First, the "avoidance rule" says that a boid must move away from boids that are too close so as to reduce the chance of in-air collisions. Second, the "copy rule" says a boid must fly in the general direction that the flock is moving by averaging the other boids' velocities and directions. Third, "the center rule" says that a boid should minimize exposure flock's exterior by moving toward the perceived center of the flock. Flake added a fourth rule, "view" that indicates that a boid should move laterally away from any boid that blocks its view.

This boid model seems reasonable if we consider it from another point of view, that of it acting according to attraction and repulsion between neighbors in a flock. The repulsion relationship results in the avoidance of collisions and attraction makes the flock keep shape, i.e., copying movements of neighbors can be seen as a kind of attraction. The centre rule plays a role in both attraction and repulsion. The swarm behavior of the simulated flock is the result of the dense interaction of the relatively simple behaviors of the individual boids.

3.WORKING OF SWARM :

3.1Swarm Intelligence:

Swarm intelligence describes the way that complex behaviors can arise from large numbers of individual agents each following very simple rules. For example, ants use the approach to find the most efficient route to the food source.Individual ants do nothing more than follow the strongest pheromone trail left by other ants. But, by repeated process of trial and error by many ants, the best route to the food is quickly revealed.

3.2.Software from insects

Local interactions between nearby robots are being used to produce large scale group behaviors from the entire swarm. Ants , bees and termites are beautifully engineered examples of this kind of software in use. These insects do not use centralized communication; there is no strict hierarchy, and no one in charge.

However, developing swarm software from the "top down", i.e., by starting with the group application and trying to determine the individual behaviors that it arises from, is very difficult. Instead a "group behavior building blocks" that can be combined to form larger, more complex applications are being developed. The robots use these behaviors to communicate, cooperate, and move relative to each other. Some behaviors are simple, like following, dispersing, and counting. Some are more complex, like dynamic task assignment, temporal synchronization, and gradient tree navigation. There are currently about forty of these behaviors. They are designed to produce predictable outcomes when used individually, are when combined with other library behaviors, allowing group applications to be constructed much more easily.

3.3.Particle swarm Optimization:

Particle swarm optimization or PSO is a global optimization algorithm for dealing with problems in which a best solution can be represented as a point or surface in an n-dimensional space. Hypotheses are plotted in this space and seeded with an initial velocity, as well as a communication channel between the particles. Particles then move through the solution space, and are evaluated according to some fitness criterion after each time step. Over time, particles are accelerated towards those particles within their communication grouping which have better fitness values. The main advantage of such an approach over other global minimization strategies such as simulated annealing is that the large numbers of members that make up the particle swarm make the technique impressively resilient to the problem of local minima.

In near future, it may be possible to produce and deploy large numbers of inexpensive, disposable, meso-scale robots. Although limited in individual capability, such robots deployed in large numbers can represent a strong cumulative force similar to a colony of ants or swarm of bees.

4.TYPES OF SWARM:

  4.1.Modular Robots:

A module is essentially a small, relatively simple robot or piece of a robot. Modular robots are made of lots of these small, identical modules. A modular robot can consist of a few modules or many, depending on the robot's design and the task it needs to perform. Some modular robots currently exist only as computer simulations; others are still in the early stages of development. But they all operate on the same basic principle- lots of little robots can combine to create one big one.

Modules can't do much by themselves. A reconfiguring system also has to have:

➢ Connections between the modules
➢ Systems that govern how the modules move in relation to one another.

Most modular, reconfiguring robots fit into one of the three categories: chain, lattice and modular configuration.

4.2. Chain robots :

Chain robots are long chains that can connect to one another at specific points. Depending on the number of chains and where they connect, these robots can resemble snakes or spiders. They can also become rolling loops or bipedal, walking robots. A set of modular chains could navigate an obstacle course by crawling through a tunnel as a snake, crossing rocky terrain as a spider and riding a tricycle across a bridge as a biped. Examples of chain robots are Palo Alto Research Center's (PARC) Polybot and Polypod and NASA's snakebot. Most need a human or, in theory, another robot, to manually secure the connections with screws.
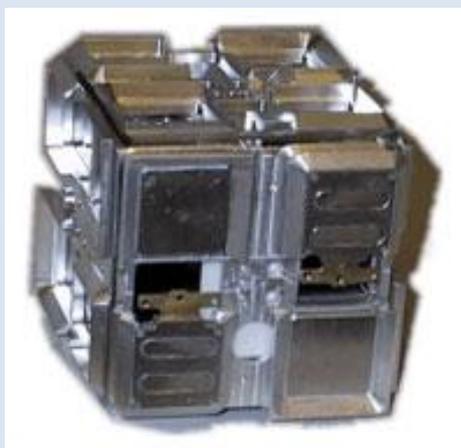
A Telecube G2 module fully contracted.

NASA's Snakebot

The basic idea of a lattice robot is that swarms of small, identical modules tat can combine to form a larger robot. Several prototype lattice robots already exist, but some models exist only as computer simulations. Lattice robots move by crawling over one another, attaching to and detaching from connection points on neighboring robots. Its like the way the tiles move in a sliding tile puzzle. This method of movement is called substrate reconfiguration – the robots can move only along points within the lattice of robots. Lattice modules can either have self-contained power sources, or they can share power sources through their connections to other modules.

Lattice robots can move over difficult terrain by climbing over one another, following the shape of the terrain, or they can form a solid, stable surface to support other structures. Enough lattice robots can create just about any shape. The modules can combine to make flat surfaces, ladders, movable appendages and virtually any other imaginable shape. So a lattice robot is more like a Terminator T-1000 than a Transformer.

Swarm-bots can maneuver independently, or they can combine to complete tasks they could not perform alone.

Like lattice robots mobile reconfiguration robots are small, identical modules that can combine to form bigger robots. However, they don't need their neighbors' help to get from place to place- they can move around on their own. Mobile configuration robots are a lot like cartoon depictions of schools of fish or flocks of birds that combine to create a tool or structure. They move independently until they need to come together to accomplish a specific task. Even though these swarm-bots look very different from one another, they have many similarities in how they move and operate.

4.3. Asteroid eaters: Robots to hunt space rocks, protect Earth.

The best way to stop an asteroid from wiping out earth is to lob a few nuclear missiles at the rocky beast or blow it apart from the inside with megaton bombs. But the more efficient weapon can be a swarm of nuclear powered robots that could drill into asteroid and hurl chunks of it into space with enough force to gradually push it into non-Earth impacting course.

4.4. A MADMEN swarm:

Since each MADMEN robot could only give a small push to an asteroid over time, SEI reseachers envision sending an entire fleet of them to a potential Earth impactor. The key, is said to have a lander on each face of an asteroid working together autonomously to push the space rock in one direction as it tumbles through space, each lander "firing" as it comes into position.

4.5.Nubot:

Nubot is an abbreviation for "Nucleic Acid Robots." Nubots are synthetic robotics devices at the nanoscale. Representative nubots include several DNA walkers.

The water skater:

A bug like robot inspired by insects that skate across water has been engineered. The machine provides deeper insight into hoe these long legged bugs known as water striders or pond skaters move.

The machine is over 7 centimeters long, and looks and moves very like a real insect. It has six legs: two front, two back and two out to the side, which row back and forth to propel it forward. Made of a light weight metal, the robot weighs only 0.6 grams. But the lightness alone is not what keeps it walking on water.

Tiny hairs on the ends of its legs that repel water keep the actual insect afloat. These machines are made bouyant by dipping the legs in a water resistant Teflon solution.

**Fig: 7.This robot has water-resistant legs to make
sure it floats in water**

Three flexible joint-like connections called actuators, one on the body and one where each side leg attaches to the body, give the robot the flexibility it needs to move.
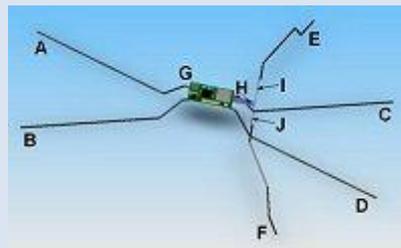
A, B, C and D are the supporting legs; E and F are the actuating legs; G is the body with sensors, power sources and a wireless communication module; H is the middle actuator; and I and J are the right/left actuators (Image: Carnegie Mellon University)

The actuators, made from a ceramic metallic composite layered on top of a stainless steel plate, shrink or expand when voltage is applied. Varying the frequency of the electric current going to each leg allows the robotic insect steers left, right, forward or backward. In the natural world, the water strider moves at the lighting sped of 1 to 2 meters per second. For now, the bugs move at 5 centimeters per second.

5.APPLICATION OF ROBOT SWARMS:

There are many applications for swarms of robots. Multiple vacuum cleaner robots might need to share maps of areas where they have previously cleaned. A swarm of mars rovers might need to disperse throughout the environment to locate promising areas, while maintaining communications with each other. Robots used for earthquake rescue might come in three flavors: thousands for cockroach sized scouts to infiltrate the debris and locate survivors, a few dozen rat-sized structural engineers to get near the scene and solve the "pick-up-sticks" problem of getting the rubble off, and a few brontosaurus-sized heavy lifters to carry out the rescue plan.

In all these applications, individual robots must work independently, only communicating with other nearby robots. It is either too expensive (robot vacuums need to be very cheap, too far (it takes 15 minutes for messages to get to Mars), or impossible (radio control signals cannot penetrate into earthquake rubble) to control all of the robots from a centralized location. However, a distributed control system can let robots from a centralized location. However, a distributed control system can let robots interact with other nearby robots, cooperating amongst themselves to accomplish their mission.

5.1.Journey into small spaces:

The mini-machines could travel in swarms like insects and go into locations too small for their bulkier cousins, communicating all the while with each other and human operators in a remote location.

Eventually fleets of robots could scamper through pipes looking for chemical releases of patrol buildings in search of prowlers. Taking the smaller robots in large numbers have the better chances of finding what we are looking for.

Currently these robots can navigate a field of coins, puttering along at 20 inches (50 cm) a minute on track wheels similar to those on tanks. The treads give added mobility over

predecessors with conventional wheels, allowing it to travel over thick carpet. Though they can't zip along as fast as a spider or ant yet, with modifications it could go up to five times faster.

5.2.Covert uses possible:

The size of the robot is limited by the size of its power source. The frame must be large enough to hold three watch batteries, which drive its motors and instruments. The robot could play a major role in intelligence gathering. Over the next several years these mini robot can be fitted with impressive options, including video cameras and infrared or radio wireless two-way communications.

5.3.Terminators, Transformers and Other Self-Reconfiguring Robots:

The coolest thing about Transformers, of course, is that they can take two completely different shapes. Most can be bipedal robots or working vehicles. Some can instead transform into weapons or electronic devices. A Transformer's two forms have vast different strengths and capabilities.

This is completely different from most real robots, which are usually only good at performing one task or a few related tasks. The Mars Exploration Rovers, for example, can do the following:

➢ Generate power with solar calls and store it in batteries.
➢ Drive across the landscape.
➢ Take pictures.
➢ Drill into rocks.
➢ Use spectrometers to record temperatures, chemical compositions, X-rays and alpha particles
➢ Send the recorded data back to Earth using radio waves.
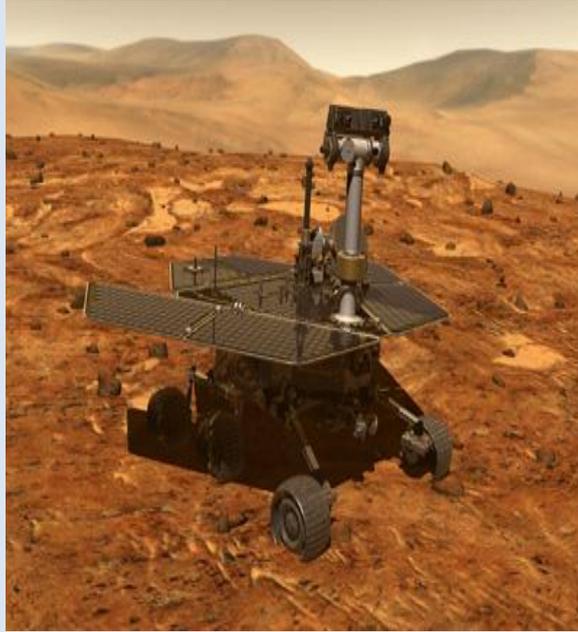
An artist's rendering of a Mars Exploration Rover on the surface of Mars

An exploration rover wouldn't be very good at tasks that don't fit into categories. It can't, for example assemble a bridge, fit into very small spaces or build other robots. In other words, it would make a lousy search-and-rescue robot, and it wouldn't fit in at all in an automated factory.

That is why engineers are developing reconfiguring robots. Like Transformers, these robots can change their shape to fit the task at hand. But instead of changing from one shape to one other shape, like a bipedal robot to a tractor trailer, reconfiguring robots can take many shapes. They are much smaller than real Transformers; some reconfiguring robot modules are small enough to fit in a person's hand.

A Glance at the other applications:

Fig:8 Self-Assembly with Swarm-bot

The given figure shows a group of s-bots trying to locate, approach and connect with an object (e.g. a teammate). Connections can be either direct or indirect, that is, via a chain of connected robots.

Group transport by pre-attached robots

This figure is about the transport of heavy object towards a common target by a group of pre-attached s-bots. Their performance is affected by the characteristics of the terrain (flat terrains of different friction, different types of rough terrain).

Adaptive all-terrain navigation

This figure shows a group of robots navigating over an area of unknown terrain over a target light source. If possible, the robots should navigate to the target independently. If,

however, the terrain proves too difficult for a single robot, the group should self-assemble into a larger entity and collectively navigate to the target.

Self-assembly with a Super-mechano Colony

A control algorithm for autonomous self-assembly can be ported from a source multi-robot platform (i.e. the swarm-robot system) to a different target multi-robot platform (i.e. a super-mechano colony system). Although there are substantial differences between the two robotic platforms, it is possible to qualitatively reproduce the functionality of the source platform on the target platform. Therefore, the transfer does neither require modifications in the hardware nor an extensive redesign of the control. The results of a set of experiments demonstrate that a controller that was developed for the source platform lets robots of the target platform self-assemble.

Self-assembly and group transport

This is an experimental study about the integration of self assembly and group transport. Here the ability of a group of six independent s-bots to localize, approach and transport an object (called the prey) from its initial position to a home zone.

Transport of objects of different shapes and sizes

This is about the problem to transport prey of different shapes and dimensions towards a target location. The evolved. controllers perform robust with respect to different prey, and allow the group to transport the prey towards a moving target.

CONCLUSION:

Robots are going to be an important part of the future. Once robots are useful, groups of robots are the next step, and will have tremendous potential to benefit mankind. Software designed to run on large groups of robots is the key needed to unlock this potential.

CONCLUSION:

REFERENCES:

- **Google.com**
- **Wikipedia**
- **Studymafia**