# ANTISWARM: A Swarm to Challenge the Task of the Swarms

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## ABSTRACT

In swarm robotics same task is assigned to all robots and there was no any central authority to monitor and control. We propose here a group of robots with a co-operative environment. These cooperative robots will be utilized to perform some pre defined task which is discussed in this paper.

While cooperating with other robots, the robot should have some kind of mechanism to analyze the work assigned to it. Robot will analyze its task and will also generate some kind of repository to forward same to the central unit and its communal robots. This idea is straightforward but what if we want to create cooperative robotic devices to kill the swarms or other co-operative robots. This is simply an ANTI-Swarming. A typical design methodology is adopted to implement the same.

This paper includes discussion about work done so far in swarm robotics. I propose here a practical approach to use swarms in decision making as well as strategic tool using artificial intelligence and robotics.

## Keywords:

Swarm, Anti-Swarm, Robot, Swarm Intelligence, Swarmanoid

## 1. INTRODUCTION

Robotics is a globally growing field of technology and there are many numbers of people working on innovative ideas in robotics. With the development of techniques, robots are getting smaller, and the number of robots needed for application is greater and greater. In swarm robot systems, each robot must behave according to the states and environments, and if necessary, must cooperate with other robots in order to carry out a given task. Therefore it is essential that each robot has both learning and evolution ability to adapt the dynamic environments.

There is a simple approach to design and implement co-operative robots to work in a special environment; each robot will act as an individual by coordinating its task with other robots. One approach is to have an individual robot communicating as peers via wireless link and server. Second approach discuss about having one master robot controlling/monitoring task of other robots and forwarding information by communicating with the master robot. In **Section 2** there is a discussion about the swarm intelligence and existing robotics environment. **Section 3** discusses the methodology for swarm robots and in **Section 4** we propose a methodology to use co-operative robots to kill or destroy the swarm challenging the on going task.

## 2. SWARM INTELLIGENCE AND SWARM ROBOTICS

Swarm intelligence is as we know is defined as "Any attempt to design algorithms or distributed problem-solving devices inspired by the collective behavior of social insect colonies and other animal societies". So every time something is inspired by swarms – it is swarm intelligence. Insect colonies for example seem to work in a coordinated manner – yet no single member of the swarm is in control. What is accomplished is an emergent phenomenon. Termites build giant structures, ants manage to find food sources quickly and efficiently and flocks of birds and schools of fish fend off predators and move as one body.

Swarm intelligence is the discipline that deals with natural and artificial systems composed of many individuals that coordinate using decentralized control and self-organization in particular; the discipline focuses on the collective behaviors that result from the local interactions of the individuals with each other and with their environment. Some human artifacts also fall into the domain of swarm intelligence, notably some multi-robot systems, and also certain computer programs that are written to tackle optimization and data analysis problems.

Swarm robotics is the study of robotic systems build by a swarm of robots interacting and cooperating to accomplish a set task. Self-organization and self assembly properties of social insects – are tried to be achieved for swarm robots. 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, spacecraft, inspection/maintenance, construction, agriculture, and medicine work. Many different swarm models have been proposed.

There are lot many algorithms presented by many scientists and number of swarm behaviors observed in natural systems that have inspired innovative ways of solving problems by using swarms of robots. This is what is called swarm robotics. In other words, swarm robotics is the application of principles to the control of swarms of robots. As with swarm intelligence systems in general, swarm robotics systems can have either a scientific or an engineering flavor. An example of artificial/engineering swarm intelligence system is the collective transport of an item which may be too heavy for a single robot, same behavior also often observed in ant colonies.

Following are the two figures that are relevant to each other to accomplish the task with cooperation.

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**Figure 1: Leaf Cutter Ants**

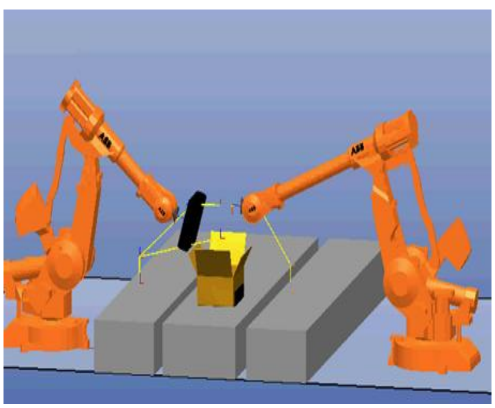

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**Figure2: Co-operative Robots**

## 2.1 Existing Applications: (Work done so far)

**Robot Soccer:** Problem solving in complex domains often involves multiple agents, dynamic environments, and the need for learning from feedback and previous experience. Robotic soccer is an example of such complex tasks for which multiple agents need to collaborate in an adversarial environment to achieve specific objectives. Robotic soccer offers a challenging research domain to investigate a large spectrum of issues of relevance to the development of complete autonomous agents.

**NASA:**

NASA foresees a future for space flight where interstellar missions are undertaken by teams of smaller, cheaper spacecrafts, instead of one giant shuttle. A recent patent application shows exactly how the agency plans to deal with failing spaceships that could put its team members at risk, or jeopardize the entire operation: This is referred as a *self destruction*. In no uncertain words, the United States Patent Application reveals that “spacecraft in the system can sacrifice themselves for the greater good of the entire [group]”, while the remaining ships exhibit self-adapting behavior to compensate for the loss.

New Scientist describes some of the proposed self-sacrificing procedures. Highly prescient failures can be solved by the damaged ship setting itself a new course that would either take it away from the swarm before exploding or, as the patent describes, “Steering into an asteroid, planet, or sun.”

## 2.2 Robotic Cleaning Devices:

The robotic cleaning devices are designed to move space junk from around the International Space Station, by grabbing debris and then rocketing off into the Earth’s atmosphere where the trash, and the satellite, would be destroyed.

## 2.3 Swarmanoid:

We know that a swarm robotic system consisting of two different types of robots can solve a foraging task. In a swarmanoid scientists have created types of robots that are small wheeled robots, called foot-bots, and the second types are flying robots that can attach to the ceiling, called eye-bots. While the foot-bots perform the actual foraging, i.e. they move back and forth between a source and a target location, the eye-bots are deployed in stationary positions against the ceiling, with the goal of guiding the foot-bots. The key component of our approach is a process of mutual adaptation, in which foot-bots execute instructions given by eye-bots, and eye-bots observe the behavior of foot-bots to adapt the instructions they give. Through a simulation study, we show that this process allows the system to find a path for foraging in a cluttered environment. Moreover, it is able to converge onto the shorter of two paths, and spread over different paths in case of congestion.

## 2.4 Motivation for the Proposed System:

Military is going to need more ship defense weapon systems to prevent swarm attacks of missiles, UAVs, or a barrage of enemy fire. When it comes to smart munitions, they are the most dangerous in defending a carrier group or an individual ship. Therefore, the US military will need a way to take out large swarms of incoming rockets, smart munitions, missiles, or UAVs.

What they will need is a way to shoot a rocket into the geographical center of the swarm, rather than try to hit each unit with a ship laser weapon, or put up a wall of lead using Aegis type system. It's very hard to hit a missile with another missile, or to put up enough projectiles where a missile can't get through, especially if there are 1000 units in a major swarm coming at you.

## 3. PROPOSED SYSTEM

There are many interesting efforts taken by space scientists to know more about the space. Lot many electromechanical, digital, and automated devices are designed to accomplish the various tasks. Let us have now looked for a system to capture environmental conditions in the space with the help of swarm agents.

The proposed system consists of a Network of Robots. Each robot will have specific identification parameter say its IP Address or a very small device ID. The Identification parameter is used to monitor or control the activity performed by each swarm element(Robot) please see figure Below.

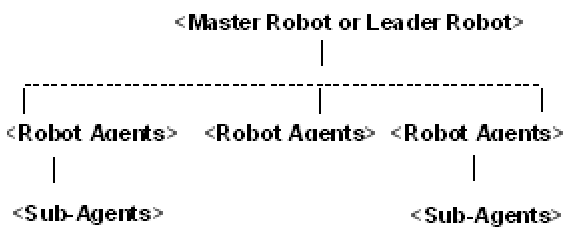


**Figure 3: Swarm Robots with a Master**

Here we propose the concept of cellular robotics systems, which consists of collections of autonomous, non-synchronized, non-intelligent robots co-operating in a cellular space under distributed control. These robots operate autonomously and cooperate with others to accomplish predefined global tasks. Co-operative robots are particularly simple but act under the influence of their "communal robots". The behavior-based control strategy is quite well known and it has been applied to collections of simple independent robots, usually for simple tasks. Other authors have also considered how a collection of simple robots can be used to solve complex problems. Robots can be organized in tree-like hierarchies with communication between robots limited to the structure of the hierarchy. The robots act in ignorance of one another, are informed by one another, or intelligently cooperate with one another. As inter-robot communication improves, more and more complex behaviors are possible.

As seen in **section I** above swarms are decentralised but we propose them to be built for a central control. As shown in the figure above there is a master robot will act as a central server for agents in the next level they can be made to communicate with each other to share the processes or tasks they are involved in. They directly transfer their information to the master. Above diagram can be modified to have a robot that will function as a on field controller and will further send the information collected by its team members (sub-ordinates) to the Base station or central information system. We can predefine the tasks of each swarm members and we also can change their task by selecting the task control mechanisms.

## 4. MULTI AGENT ROBOTS

Collection of two or more mobile robots working together are often called as team members or "Society of multiple robots" or simply Multi agents. They can be utilized to lot many tasks as planetary explorations, removing land mines. The more Number of robots will cover a larger area.

We can use the concept of multi agents to utilize the robotic resources to attack the flocks of Robots. We propose this as multi agents are co-operate with each other and react also as an individuals. Some level of distributed artificial intelligence is required to be implemented.

Let us now discuss a problem we want to solve with multi-agents and then have further focus on the methodology to be adopted.

As already discussed in motivation part of section II we need to design a system comprising the robot agents to challenge the attack of swarm of missiles; here is the task:

**"There is a military base of our country and enemy has designed a swarm robot team to attack the military base. Our country is intelligent enough to identify the enemy robots and fail their intention much before the attacking robots reach the target."**

There are lot many questions while implementing this security system. Major questions are How to identify the robots? How to avoid the attack? How to save our robot Forces?
Following are the challenging parameters in designing such a system:

- Designing the Team is a Hard. There may be a impairments in Communication among the robots.
- It is not hard to recognize the enemy Robots but it is difficult to kill them or make them non-functional.

To avoid the above mentioned difficulties we need to propose two types of control mechanisms as centralized control and distributed control.
**Centralized Control:** Robots communicate with the central Computer; Central computer will act as tele-operator.

**Distributed System:** In this robot will make its own decision and act independently.

We need to decide whether it is fully centralized, Partially Centralized or Fully Distributed or/and partially Distributed system environment.

**Sensing and attacking Mechanism**: Here we focus on the sensing and attacking mechanism need to be implemented.

We human beings can immediately recognize each other easily. We have to have a mechanism to track the societal robots and also recognize intruders or attacking robots.

We have to identify the attacking end-effectors used by attacking robots and their modus operandi.

We also need to design the mechanism to destroy the Robots and their end effectors so that we minimize the causalities even for our soilder robots.

**Proposed Algorithm for Anti Swarms**

As we have already discussed about the challenges in making an Anti Swarming Mechanism following is the very First algorithm to start up deciding Anti Swarming policy

**Centralised ANTI SWARM control**
Step 1: Initialize all swarms.
Step 2: Set the Task
Step3: Activate Sensing Mechanism.
Identify any Stranger Robot
Step 4: If Stranger
Step5: Identify the end effectors
Step 6: Activate Protective Mechanism and kill the stranger
Step 7: Kill or Destroy all Attacking Robots.
Step 8: Update and Go to Step 3.

**Algorithm 1 : Centralised Control**

**Distributed ANTI SWARM Operation**
Step 1 : Map the addresses properly over chosen communication protocol.
Step 2: Initialize all swarms, set for Action.
Step 3: Set the monitoring Mechanism
Step 4: Generate the reports from the results given by Swarms.
Step 5: This algorithm will end automatically when there are no Attackers left or all Team members declare the victory.

**Algorithm 2: Distributed Control**

**Future Work**

We have only developed centralized Robots that can be set for the tasks to be accomplished where human interaction is not possible. This is just a proposed architecture where we need to develop generations of multiple swarms. These swarms will be used as anti swarms to kill the attacking swarms or flocks.

Following are the two Robots we have created in 2010.

**Figure 4: Pick and Place Robot**

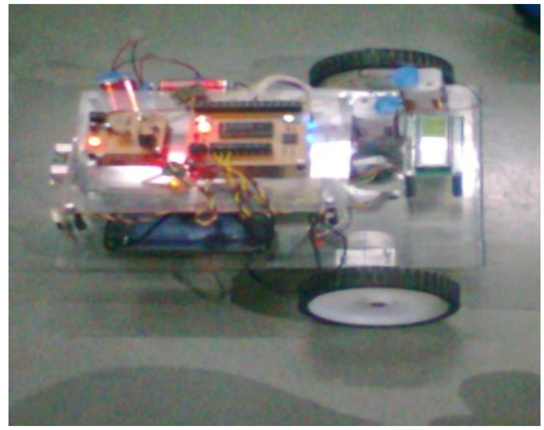

**Figure 5: Sensing Robot**

## 5. CONCLUSION

We can monitor the task of all Robot agents and their Leader by Central Server. Central Server can only communicate with the master robot which is at a very long distance monitoring its agents. Another innovative idea is to use our co operative robots to kill the flocks of the other swarm robots. This anti swarming can be achieved for defense purpose to kill swarm of missiles attacking on a military Base (AIR, NAVAL or ARMY).

Distributed approach can be help full to build the community of robots and existing wireless technology or mobile telephone network can be utilized to achieve the tasks from communal robots.

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[8] http://bexar-tx.tamu.edu Figure 1 Leaf Cutter Ants

[9] http://www.emeraldinsight.com Figure 2 Co-operative robots