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Exertion of Swarm Robotics of Factual Life

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Abstract— This paper describes the swarm robotics and factual life. Swarm robotics is a new approach to the coordination of multi-robot system consists of large number of relatively simple robot it's inspiration from social insects. It is supposed that a desired collective behavior emerges from the interaction between the robots and the interaction of robots with the environment. Swarm robotics plays an important role in the development of collective artificial intelligence. It is based on the use of local rules, and simple robots compared to the complexity of the task to achieve, and inspired by social insects in a more efficient way than a single robot, giving robustness and flexibility to the group. A review of different research works and experimental results, together with a discussion of the world application completes this work.

Keywords— Mobile robot, Cooperative control, modeling simulation, Swarm intelligence.

1 INTRODUCTION

Swarm robotics is an approach to the of multi robot systems which consist 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 emerged on the field of artificial swarm intelligence, as well as the biological studies of insects, ants and other fields in nature, where swarm behavior occurs. Swarm robotics research project, involving a physical multi-age system, is initiated; one problem is to have a mobile robot platform that has the required capabilities like the right sensor set, a flexible power system communication link, and enough computing power for example. Swarm robotics is to study the design of robots, their physical body and their controlling behaviors. It is inspired but not limited by the emergent behavior observed in social insects, called swarm intelligence. Relatively simple individual rules can produce a large set of complex swarm behaviors. A key-component is the communication between the members of the group that build a system of constant feedback. The swarm behavior involves constant change of individuals in cooperation with others, as well as the behavior of the whole

Unlike distributed robotic systems in general, swarm

Robotics emphasizes a large number of robots, and promotes scalability, for instance by using only local communication. That local communication for example can be achieved by wireless transmission systems, like radio frequency or infrared.

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Fig: 1 swarm robotics

2 MOTIVATIONS FOR SWARM ROBOTICS

Motivation can be defined as the action of orienting ones behavior to a specific goal. One of the most important uses of motivation is in a company. Organizations employ workers to perform certain tasks; these workers need to be motivation in order to perform their tasks with maximum productivity. To keep employees in the organization for a long period of time, the process of motivation is once again responsible. The traditional motivation for a worker is his salary, but in many cases that isn't enough. Companies use a lot innovating tactics to keep their productivity at a maximum level.

2.1 Robustness

Requires that the swarm robotic system should be able to continue to operate, although at a lower performance, despite failures in the individuals, or disturbances in the environment .This robustness can be attributed to several factors .First, redundancy in the system; that is ,any loss or malfunction of an individual can be compensated by another one ,second ,decentralized coordination ;that is destroying a certain part of the system ,Third ,simplicity of the individuals ;that is ,comparison to a single complex system, Fourth, multiplicity of sensing; that is distributed sensing by large number of increase the total signal-to-noise ratio of the system.

2.2 Flexibility

Flexibility requires the swarm robotic system to have the ability to generate modularized solutions to different tasks. As nicely demonstrated by ants, in ant colonies individuals can take part in tasks of very different nature such as foraging, prey retrieval and chain formation. During the foraging task, ants act independently searching for food in the environment; their search is partially coordinated by the pheromones laid in the environment.

2.3 Scalability

Scalability requires that a swarm robotic system should be able to operate under a wide range of group sizes. That is, the coordination mechanisms that ensure the operation of the swarm should be relatively undisturbed by changes in the group sizes. Although we have presented the inspiration behind the swarm robotics approach, and described its envisioned properties as observed from natural systems, these by themselves are not sufficient to define the approach. In the next section, we propose a definition of the term, followed by a set of criteria to support the definition given. Scalability requires that a swarm robotics system should be able to operate under a range of group sizes. That is, the coordination mechanisms

3 SWARM ROBOTICS

Swarm robotics is the study of distributed systems which usually perform tasks that can be easily parallelized. This system involves simple tasks and orders combined to produce large and sometimes complex results. The key aspect of a swarm is the persistent communication between individuals in a constantly changing state. In contrast to traditional robotic systems, swarm robotics puts emphasis on having many robots working together, and scalability. A key aspect of many individual swarm robots is the unit cost. This is important because keeping costs low allows for the construction of more robots and therefore a more powerful swarm. With these constraints, efforts are focused on individual simplicity contributing to an overall complexity at a higher level. Here simplicity is an entirely relative measure based on the overall complexity of a given task. Simplicity could also be defined compared to a hypothetical single robot solution which accomplishes the same task equally well. These include tasks such as agricultural crop collection, mass area mapping, and mining. On the smaller scale, swarm robotics could be used on a microscopic level to enter the human body and achieve any number of results.

3.1 Autonomous robots

As much as it seems obvious, we believe that the requirement that the individuals that make up the swarm robotic system be autonomous robots needs to be explicitly stated. That is, the individuals should have a physical embodiment in the world, be situated, can physically interact with the world and be autonomous. Sensor networks that consist of distributed sensing elements, but with no physical actuation abilities, should not be considered as swarm robotic systems. Yet we believe that the studies on sensor networks are highly relevant for swarm robotics.

3.2 Large number of robots

The study should be relevant for the coordination of a “swarm of robots". Therefore, studies are applicable to the control of only a small number of robots and do not aim for scalability, fall outside swarm robotics. Although putting a number as a lower bound of group size is difficult to justify, and most would accept group sizes of 10-20 as “swarms". Despite the lowering cost of robots, maintenance and experimentation with large groups of robots will remain as a main obstacle.

3.3 Few homogenous groups of robots

The robotic system being studied should consist of relatively few homogeneous groups of robots, and the number of robots in each group should be large. That is, studies that are concerned with highly heterogeneous robot groups, no matter how large the group is, are considered to be less “swarm robotic". For instance, studies on rob soccer teams mostly fall outside of swarm robotics since these teams typically consist of individuals whose deferent “roles" are assigned to them by an external agent prior to the operation of the team and hence they are highly heterogeneous.

4 SWARM INTELLIGENCE

Swarm intelligence can be described as the collective behavior emerged from social insects working under very few rules. Self-organization is the main theme with limited restrictions from interactions among agents. Many famous examples of swarm intelligence come from the world of animals, such as birds flock, fish school and bugs swarm. The social interactions among individual the concept of intelligence suggests that the problem-solving method is somehow successful The information-processing units that compose a swarm can be animate Mechanical, computational, or mathematical; they can be insects, birds, or human beings; they can be array elements, robots, or standalone workstations; they can be real or imaginary. Their coupling can have a wide range of characteristics, but there must be interaction among the units. Given the diversity of paradigms that call themselves swarm intelligence, this chapter will focus on the particular approach known as particle swarm optimization.

Fig 2: Swarm Intelligence

5 Particle Swarm Optimization

Particle swarm optimization (PSO) is a population-based stochastic approach for solving continuous and discrete optimization problems. In particle swarm optimization, simple software agents are called particles; move in the search space of an optimization problem. The position of a particle represents a candidate solution to the optimization problem at hand. Each particle searches for better positions in the search space by changing its velocity according to rules originally inspired by behavioral models of bird flocking.

Although putting a number as a lower bound of robots and do not aim for scalability, fall outside swarm robots and group size is difficult to justify, and most would accept group sizes of 20-30 as "swarm". Deposit the lowering cost of robots, maintenance and experimentation with large group of robots will remain as a main obstacle. Therefore

the system model the social interaction and seemingly intelligent behavior of naturally occurring colonies of ants. Observing the ant colonies we can notice that, although the behavior of a single ant doesn't seem logical, the resulting behavior of the colony solves the problem of great importance for the survival. The ants use the trail-laying trail-following behavior to communicate via environment. The lay pheromone can attract other ants.

- ➢ Positive feedback (amplification) example is recruitment and reinforcement.
- ➢ Negative feedback counterbalance positive feedback and helps to stabilize the collective pattern in the form of saturation, exhaustion or competition.
- ➢ Amplification of fluctuations randomness is often crucial since it discovery of new solution.

Particle swarm optimization belongs to the class of swarm intelligence techniques that are used to solve optimization problems. The term swarm intelligence was first coined by Gerardo Benin [1] as a "buzz word" to denote a class of cellular robotic systems However; the term was embraced more by the social insect studies and by the optimization studies that used the social insect metaphor, losing much of its original robotics context [2]. During recent years, the term swarm robotics emerged as the application of swarm intelligence to multi-robot systems, with emphases on physical. Embodiment of the entities and realistic interactions are among the entities, between the entities and the environment. In a sense, the term swarm robotics took the heir of swarm intelligence which moved on to cover a broader meaning. Although, like every other newly coined term, swarm robotics will have a life of its own to claim its meaning, our observations indicate that such new terms run the risk of turning into buzz words that tend t Be attached to existing approaches with little thought over whether it really fits or not. Such misuses, in time, can drift the term in every direction blurring the very point that made it novel. In an attempt to prevent this, we will propose a definition and a set of distinguishing criteria for the swarm robotics approach. As our starting point, we propose the following definition for the term swarm robotics: Swarm robotics is the study of how large number of relatively simple physically embodied agents can be designed such that desired collective behavior emerges from the local interactions among agents and between the agents and the environment. This definition by itself, however, is not sufficient to properly describe this newly emerging term. Within the multi-robot research only (see for two rather out-dated surveys of the field), there already is a plethora of terms labeling different flavors of multi-robot research such as "collective robotics" "distributed robotics" [3], "robot colonies"[4], with often vague and overlapping meanings. Therefore, we would like to put forward a set of experimentation with large groups of robots will remain as a main obstacle. Therefore the issue of relevancy is mentioned to express that the field should be open to 2 studies that are carried out with smaller group sizes, but with the vision/promise of scalability in sight. 3.3 Few homogenous groups of robots .The robotic system being studied should consist of relatively few homogeneous groups of robots, and the number of robots in each group should be large. That is, studies that are concerned with highly heterogeneous robot groups, no matter how large the group is, are considered to be less "swarm robotic". For instance, studies on rob soccer teams mostly fall outside of swarm robotics since these teams typically consist of individuals whose different "roles" are assigned to them by an external agent prior to the operation of the team and hence they are highly heterogeneous. We agree that, the issue of homogeneity in a group of robots is not a trivial one. In [5] Balch proposed a metric, called the hierarchical social entropy, which can be used for this purpose. Yet, it is difficult to determine whether two individuals belong to the same group or not using a simple evaluation run in the evaluation chamber as proposed in[5].

This is due to two reasons: 1) the nonlinear inter-robot interactions will have a large affect on the behavior of the robots, and 2) probabilistic behaviors can make it impossible to obtain exact similar evaluation runs under exactly the same conditions. 3.4 Relatively incapable or inefficient robots. The robots being used in the study should be relatively incapable or inefficient on their own with respect to the task at hand. That is, either 1) the robots should have difficulties in carrying out the task on their own, and the cooperation of a group of robots should be essential, or 2) the deployment of a group of robots should improve the performance/robustness of the handling of the task. Collective retrieval of a large prey by ants is a good example to the first case where retrieval by a single ant would be impossible.

6 SOURCES OF INSPIRATION

There are many research fields that can act as sources of inspiration for swarm robotics. First and foremost among them is the study of self-organization, which is defined as "a process in which pattern at the global level of a system emerges solely from numerous interactions among the lower-level components of the system". In this sense, swarm robotics can be considered as the engineering and utilization of self-organization in physically embodied mobile swarms. Studies of self-organization in biological systems show that interplay of positive and negative feedback of interactions among the individuals is essential for such phenomena. In these systems, the positive feedback is typically generated through autocatalytic behaviors. The snowballing effect triggered by the positive feedback cycle is counterbalanced by a negative feedback mechanism, which typically stems from a depletion of physical resources in the system or the environment. Studies that attempt to uncover the principles behind the emergence of self-organization in biological systems often develop models that are built with simplified interactions in the world and abstract behavioral mechanisms in individuals. Self-organization models of social insects and animals have already been used as inspiration sources for many swarm robotics studies. Below, we would like to draw attention to three other lines of research, which we believe, contain ideas that can act as inspiration sources. In our reviews, we tried to emphasize the ideas that, we consider, most relevant and inspiring for swarm robotics research. Unicellular organisms some species of unicellular organisms, such as bacteria, mycobacterium, amoeba, are observed to display interesting examples of coordination. These organisms, which act independent of each other under favorable conditions (plenty of food, no antibiotics, etc.), are observed to display coordinated behaviors when times get hard. 4.1.1 Aggregation of amoeba into slime mold Aggregation is a highly observed phenomenon in various life forms since it constitutes a pre-condition of most collective behaviors. One well known example of aggregation is observed during the formation of the slime mold by the D. disodium from cellular dictyostelium amoeba [12]. When the food is abundant in the environment, these amoebas feed and multiply with no signs of coordination among different individuals. When the food supply is depleted, however, the amoeba begins to aggregate forming complex spatial patterns. The aggregation process creates a slug, a multi cellular organism which can move on a surface for some time, and then speculate. Studies have shown that the aggregation is governed by CAMP, a chemo attractant that is produced and released into the extracellular environment by the starving amoeba. It is shown that amoeba have two modes of CAMP secretion: oscillatory and relay. In the oscillatory mode, starving amoeba releases CAMP with a period of 5-10 minutes. In the relay mode, that is when the amoeba is hit by a CAMP pulse, the amoeba responds by a producing a larger CAMP pulse. The positive feedback of CAMP production cycle is bounded by the desensitization of CAMP receptors in high CAMP concentrations. This mechanism is shown to generate spiral CAMP waves that propagate in one direction. The CAMP waves guide the cells towards the center of the spiral, which once begin to adhere to each other, create clumps that are difficult to disperse. The amazing aspect of this aggregation process is its size; typically 10,000-100,000 cells aggregate to form the slime mold. Experiments on developing controllers for aggregation of mobile robots, which use sound or light for long range signaling, indicate that even aggregation of individuals on the order of 10's is very difficult [17]. The gap between the scales of aggregation suggests that stigmergic communication (which occurs through CAMP concentration in the extracellular environment of amoeba) is very important. Long range signaling modalities, such as sound and light that are typical on mobile robots are not persistent in the environment as chemicals making them unusable for such stigmergic coordination. Two possible strategies to use stigmergy in swarm robotic systems exist. First, one can use embedded intelligent markers in the environment which can store stigmergy information and interact with each other to simulate physical diffusion like signal spreading. Gnats [6] or smart materials like those envisioned by the amorphous computing paradigm [7] can use for this purpose. Second, in a large swarm, some of the individuals can make 4 them immobile and act as a stigmergic medium to guide the rest of the swarm. Although similar ideas were used in for route discovery and following, their uses are rather limited and the idea needs to be exploited for other tasks as well

7 CONCLUSION

This work has given the detailed overview of current swarm intelligence research and its applications in swarm robotics. Swarm robotics is an interesting alternative to classical approaches to robotics because of some properties of problem solving by social insects, which is flexible, robust, decentralized and self6th WSEAS Int. Conference on Computational Intelligence, Man-Machine Systems and Cybernetics, Tenerife, Spain, December 14-16, 2007 44 organized. Advantages of swarm-based robotics are numerous. Some tasks may be too complex for a single robot to perform. The speed is increased when using several robots and it is easier to design a robot due to its simplicity. Rapid progress of hardware brings innovations in robot design allowing further minimization. The communication between robots is reduced, because of the interactions through the environment. We are reaching a stage in technology where it is no longer possible to use traditional, centralized, hierarchical command and control techniques to deal with systems that have thousands or even millions of dynamically changing, communicating, and heterogeneous entities. The type of solution swarm robotics offers, and swarm intelligence in general, is the only way of moving forward when it comes to control of complex distributed systems.

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