BIO-INSPIRATIC
CONFIGURATIONS OF SWARM-BOT

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ABSTRACT

Scientists and engineers in the whole time history have turned to nature for encouragement and dreams for trouble solving for the real time environments. By observing the performance of groups of bees and ants are working together has given to a rise to the 'swarm intelligence concepts'. One of the most interesting and new explore area of recent decades towards the impressive challenge of robotics is the design of swarm robots that are self-independent and self intelligence one. This concept can be essential for robots exposed to environment that are shapeless or not easily available for an individual operator, such as a distorted construction, the deep sea, or the surface of another planet. In this paper, we present a study on the basic bio-inspirations of swarm and its physical configurations, such as reconfigurability, replication and self-assembly. By introducing the swarm concepts through swarm-bot, which offers mainly miniaturization with robustness, flexibility and scalability. This paper discusses about the various swarm-bot intelligence, self-assembly and self-reconfigurability among the most important and capabilities as well as functionality to swarm robots.

KEYWORDS

Bio-Inspiration, Environments, Flexibility, Physical configurations, Swarm-bot,

1. INTRODUCTION

Swarm-bot is an innovative intelligence design and which combines several very small mobile robots to the desired functionality and can be autonomously self re-assembled into large individual identity. A swarm-bot entity [13] is self-possessed of many (2 to 35 swarm- bots) single robots physically organized. Each swarm-bot is a fully autonomous [2] mobile robot accomplished to perform basic responsibilities such as autonomous direction-finding and perception to grasp the surroundings objects. The special feature of the swarm-bot is which can develop high rich link mechanism devices to patch up into various positions depends upon the environment applications.

The swarms bots are exploited by several bio-insects [1] which provide a collective robots inter-action with all are often that implicit world. Insect means any small creative with six legs and a body divided like ants, bees and flies [19].

1.1 SOURCES OF INSPIRATION

Many research fields are going in the robotics, where self-organizing system [3] becomes the source of inspiration for swarm. First and primary function of the swarm is learning of self-organization, which is defined as "a process in which pattern at the worldwide level of an organization emerges solely from numerous links among the lower-level system of the organization." In this sense, swarm-bots can be considered as the development and functionality of self-organization in actually material form. Studies of self-organization in biological system

[1], [3] demonstrate that interplay of positive and negative feedback of connections among the individuals are essential for such phenomenon. Some social insects [19], such as ants and bees, spend their most of time in foraging for food. Honey bee colonies have a decentralized system to collect the food and it can adjust the searching methods precisely in order to enhance the collection of system. Bees estimate the distance from the hive to food sources by measuring the amount of energy consumed when they fly, besides the direction and the quality of the food source as shown in figure 1. The above such phenomenon like decentralization, searching and arriving into the optimized path make inspiration to the formation of swarm bots [13].

1.2 Motivations For Swarm Inspirations

a) *Robustness* requires that the swarm robotic organization [1] should be able to keep on, to operate, although at a lower arrangement, despite failures in the individuals, or problem in the environment.

b) *Flexibility* requires the swarm robot organization to have the ability to generate modularized solution to dissimilar tasks. As satisfactorily recognized by ants, take part in responsibilities of very different nature such as foraging, prey retrieval and chain configuration [6]

c) *Scalability* requires that a swarm robotic organization should be able to operate below a wide variety of group sizes.

d) *Low cost* requires this type robots can potentially lower overall cost by making many copies of one type modulus. So in this economic of scale, one set of module, saving cost through reuse and generate of the system. The source of figures is from swarmbot.org.

Figure 1 . Foraging Swarm

Figure 2. Flocking Fish

Figure 3. Foraging behaviour of ants *[Source: swarmbot.org]*

Swarm robot features:

- Collected many individuals
- Individuals are maximum homogeneous structure
- Individuals are relatively incapable

- The interactions among the individuals are based on the behavior rules that exploit only local in sequence (communication)
- The overall behavior from self-inspiration process coordinated exploration

1.3 Environmental Monitoring

- Swarm of mobile robots for localizing an odor source
- Simple behaviors based on odor and wind detection
- Communication can help to increase the efficiency

1.4 Pheromone Robotics

- Robot dispersion
- Shortest path
- Pheromone diffusion

1.5 Chaining

- Limited sensing range
- Signaling of colors (directional chains)

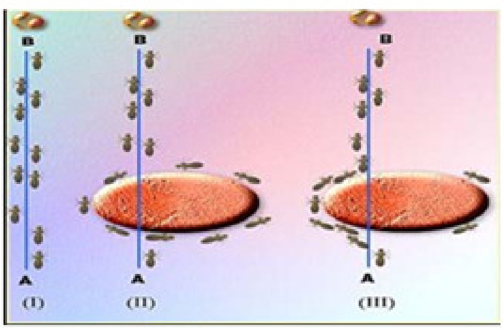

Figure 4 Ant pheromone shortest path route

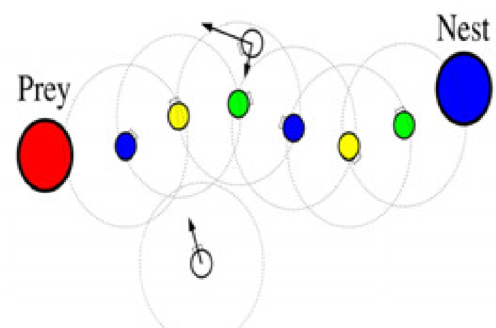

Figure 5. Pheromone Shortest path route

Figure 6. Chaining

2. Problem Identification

The problem of inter connection between the existing modules robots, which has already developed by many researchers in the field of self-reconfigurable robots. Some module robots like MTRAN, Polybot [4],[5],[6],[15],[16] display some user efficient connection in MTRAN design [2] based on the permanent magnet method with non-linear springs for dis-assembly. Polybot connection between the plates with four groove pins that match four holes or opposite plates and gripped by the latching mechanism. Both are under working mechanical latching mechanism. CONRO modules [10],[16] have pin based connection between the two modules, but this module is not neutralas shown in figure 7. I-cubes and molecule module robot, having two types of a module inbuilt the system. One module is based on the structure and another one is connectivity (connecting complex shapes only possible).

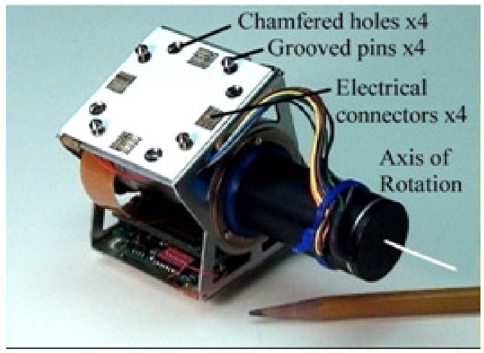

Figure 7. Polybot module[5]

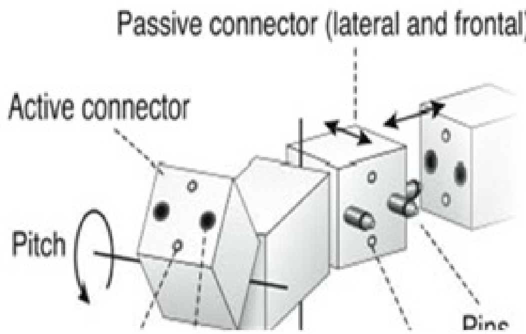

Figure 8. Polybot module linking mechanism [5]

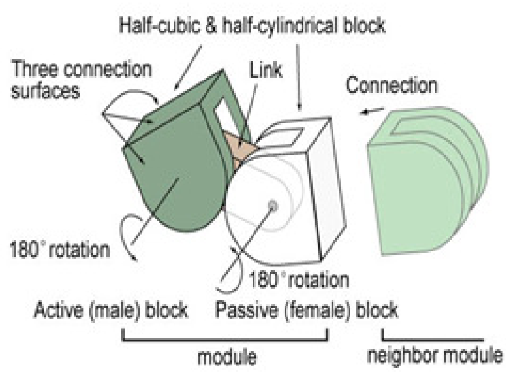

Figure 9. MTRAN Module [2]

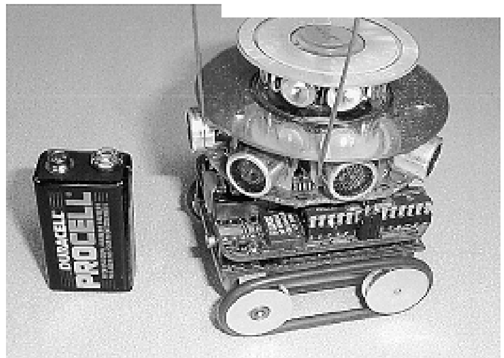

Figure 10. Millibot model [9]

MTRAN modules [6] are having only flat contact surfaces for better tolerance to misalignment as shown in figure 9. It does not withstand any lateral forces, by mechanical parts using friction. Millibots are any two modules inter connect [6], [8],[10] with each other where the structure does not exist. They are more complex design. Millibot design [9] is very simple base pin-hole concept for strong mechanical stability, but it makes very tough to perform the task and also more sensors used in the joints as shown in figure 10.

When given the task of building a robotic system, the main decisions to be taken by the researchers concern the architecture of the hardware and of the control system. In this discussion, we have presented the results of the swarm-bots project. The swarm bots project [13] fundamentally focused on the evaluation of two particular choices in robotic system design. For the hardware, we chose to implement a system comprised of many autonomous robots [2] with a unique ability to attach to (and detach from) one another. So as to form bigger, physically connected structures[11] and to control this system from the available information. These choices were motivated by the desire to make our robotic system the swarm-bot robust and versatile (By saying that a robot is versatile we mean to say that it is capable of dynamically changing shape and control functionality depending on the situation it faces], as well as allowing it to navigate on rough terrain.

2.1 MECHANICAL CONCEPT AND IMPLEMENTATION

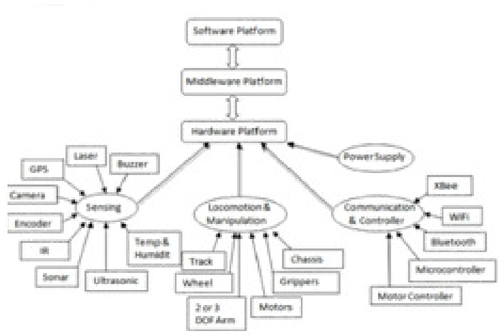

Figure 11. Hardware architecture of Swarm- Bot

In swarm-bots configuration, the connection between the bots is based on the above two dimensional shape matching without penetration. The link mechanism is a gripper that matches the shape of a ring present on the main body of the robot. Two connected swarm-bots with the detail of shape matching between gripper and ring. This concept allows a robot to grasp another robot all around its body.

3. Robot Design

3.1. Swarm-Bot Size

The swarm-bot is generally having a size 19cm x 12cm height and diameter respectively and also weighs approximately 700g-800g, looks like a size of a small ball. [1]. They are having main components which are all direction mobility treels drive mechanism (2DOF), rotation of the main body with respect to motion base (1DOF), rigid arm with gripper (2DOF), flexible arm with gripper (4DOF), sensors, panoramic camera and microphones etc. and also transparent ring with colour LEDs Loudspeakers. Each Swarm -bot is equipped with two grippers.

3.1.1 Rigid Gripper

One is supported by a rigid structure with one degree of freedom (DOF) .The rigid gripper allows creating very stable multi-robot structures with one active degree of freedom on each inter-robot link.

3.1.2 Flexible Gripper

The second one is placed at the end of a flexible arm with three DOF. The flexible gripper allows the creation of flexible swam configurations with the surface of the terrain. The flexible gripper can extend all the way to the ground and therefore can also be used to grasp objects. The two grippers play very different roles in swarm-bot configurations [12], [18]. Swarm-bot in our review considered the mechanical robustness in autonomous operations [2]. It has simple and less number of mechanical connections, with positions look like a gripper as shown in figure12. In this robot systems are based on two dimensional shapes harmonizing without dispersion. In this type module, mechanisms used by animals for this type of task, like mandibles. [Simply as jaws]

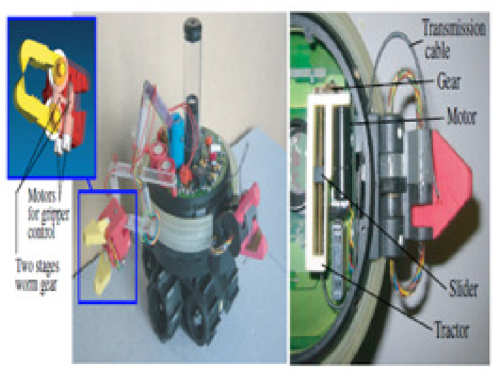

Figure 12. Gripper model[11]

Figure 13. Swarm collaborate to pass an obstacle[14]

3.2. MECHANICAL REPRESENTATION

A *Swam-bot* [13] entity is the collection of many (2 to 35swarm-bots) single robots physically organized. In the *Swarm-bot* connection between the *Swarm -bots* are having 2D shape matching without dispersion. The mechanism is a gripper that matches the position of a ring present on the main body of the robot. The figure13 shows two connected Swarm-*bots* with a detail of location corresponding between the gripper and ring. The solution allows a *Swarm-bot* to snatch another *Swarm-bot* all around its body.

3.3. MOBILITY

The mobility of the system is ensured by a combination of tracks and wheels. We call this type of structure as differential treels drive. Each side of the treels (one track and one wheel) is controlled by a motor so that the Swarm-bot can freely move in the environment and easily rotate on the spot. This structure enables a very good mobility, thanks to the position of the wheel and their diameter larger than the tracks height. The resource of motivation for a robot design is taken from nature and is formed by ecological necessities [19]. It gives various understanding of the wide-ranging applications considerations needed to build a robot for robotic swarm applications [12]. The concept of a swarm robot design plan is that it should be very simple and relatively cheap to produce. For example, if one robot would get misplaced or broken beyond repair during an assignment it would not matter much. Measure is the key to success in a robotic swarm to successfully utilize Swarm intelligence (SI) algorithms. A robot should be fairly strong, easy and valuable [3]. There are more than a few designs in robotic swarm applications that satisfy these terms. One case of such like a robot is the swarm-bot, [7],[13],[15],[19]. The Swarm-bot as the name illustrate is designed for swarm applications and it's suitable for swarm functions.

4. SWARM APPLICATIONS

4.1 TASKS THAT ARE TOO DANGEROUS COVER AN AREA

In several hazardous tasks such as mine rescue and recovery, robots may be permanent after the task is accomplished as shown in figure 14; thus, it's economically acceptable to use swarm robotics with simple and low-priced individuals rather than using difficult and expensive robots

Figure 14. Rescue operation carried out by a group of swarm-bots. [14]

4.2 TASKS THAT REQUIRE IDLENESS

Swarm robotics can be also apply in situations in which it is hard or even not possible to estimate in advance the funds needed to achieve tasks such as search and rescue, tracking, and cleaning. The solution wanted in these cases should be scalable and flexible; therefore a robot swarm could be an appealing solution: robots can be added or removed in time without any significant impact on the performance to provide the appropriate amount of resources and meet the requirements of the specific task. Looking at a swarm, it works as a collective, by a common behaviour to complete a task rather than a robot performing the task. A swarm could be seen as one large entity. The design of a robotic swarm or multi-robot system consists of different highly integrated parts. Looking not at the physical design [11-12] of the swarm robot, the swarm design is more the method a swarm functions within. Physical parameters are a condition of the swarm design, though it does not play a vital role in its construction. Prominence is put on communication due to the fact that it is the main advantage of the swarm concept [10]. A swarm uses communication to share information among its members. New robotic system based on swarm techniques (S-bot) is a growing field of cooperative robots, these collective swarms of robots with lighting through interacting and cooperating to reach their goals.

The physical links are used to assemble into Swarm-bot form, able to solve problem that cannot be solved by a single robot. Swarm-bot is capable of autonomously carrying out individual and collective behaviour [11-12] by exploiting load interacting among the Swarm-bots. This bots are always searching for a goal location or tracing a path to goal as shown in figure 15

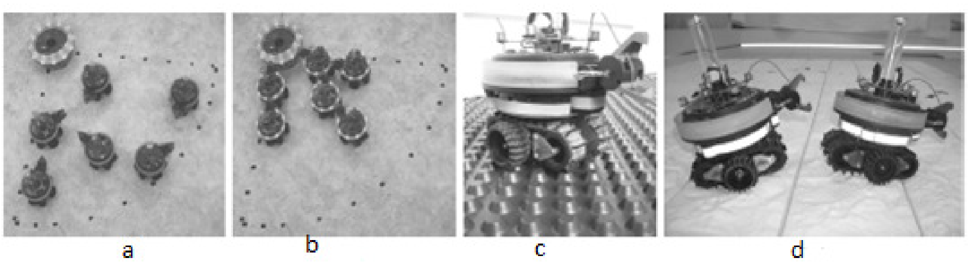

Figure 15.Initial (a) and final (b) configuration of six s-bots self-assembling with the prey on flat terrain. Types of rough terrain: the moderately rough terrain (c), and the very rough terrain (d).[2]

5. COMPARISON OF SWARM BOT AND MRS ROBOTICS

Table 1. Comparison of Swarm Bot and MRS robotics

Characteristics	**Swarm robots**	**MRS**
Population Size	Variation in great range	Small
Control	Decentralized and autonomous	Centralized / remote
Homogeneity	Homogeneous	Heterogeneous
Flexibility	High	Low
Scalability	High	Low
Environment	Unknown	Known/Unknown
Motion	Yes	Yes

Our discussion falls between the domains of collective robotics (MRS) and self-reconfigurable robotics [3-6],[8],[10]. It is closely bio-inspired, in the sense that many of our choices and techniques have inspiration of some natural process or biological observations. However, we do not try to replicate faithfully any natural system; we rather take inspiration from natural processes and let these principles guide our engineering choices. Our work differs from collective robotics, however, in that we are interested in the study of self-assembling structures and in their exploitation for the solution of problems for which cooperation through physical connection is a necessity.

As in self-reconfigurable robotics, we study robotic structures as swarm-bots that can change their shape as a function of the task they are performing, however, in that the units composing our self-reconfigurable robot are autonomous units that can perform tasks independently of each other or in co-operation, as required by the particular task considered.

6. CONCLUSION

In this paper, we have discussed about the study of the problem of self-assembly in autonomous mobile robots. Real life applications for robotic swarms using present technology are limited, where supervision, interactions with a swarm and energy accumulators are of large concerns. This concept brings some innovative elements through bio-inspired and collective robotics, which opens new research directions in swarm robotics and distributed intelligence. In spite of the similarity with self-reconfigurable robotics due to the physical connection between Swarm-bots, several key aspects of the swarm-bot approach have shown to be complementary to self-reconfigurable robots.

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