Algorithm for Movement of Swarm Robots

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ABSTRACT
Groups of robots can solve problems in fundamentally different ways than individuals while achieving higher levels of performance. This paper investigates the application of swarm intelligence principles for the co-operative behaviour of autonomous collective robots. Using swarm intelligence technique robots are able to get their optimized path during navigation. In the task of chain based path formation of swarm robots, a chain of multiple robots is formed between nest and prey for some specified work. Multiple robots randomly move to search the Nest and gather at Nest, after perceiving the Nest robots can self organizing into chain and again move randomly to search the Prey. In this paper I have proposed a method for the movement of swarm robots i.e. Spiral Move, which takes less time compare to random search.

General Terms
Artificial Intelligence, Swarm Intelligence, Swarm Robotics, Chain Formation.

Keywords
Swarm Robotics, Path Formation, Swarm Intelligence, Spiral Move, Nest, Prey.

1. INTRODUCTION
When creating artificial system, like robots, designers face problem of solving tasks which are beyond the capabilities of a single individuals. One possibility is to create multi-purpose, complex and monolithic robots that are able to tackle the desired tasks alone. Although this solution seems to be the simplest way, it is limited when it comes to robustness, flexibility and scalability. An alternative approach is the so called swarm intelligence: drawing inspiration from natural systems like social insects, it tries to overcome the problems outlined above by creating a flexible swarm of simple individuals. Using methods such as decentralization of control, limited communication abilities among individuals and the use of local information only, complex behavior emerges at colony level. Swarm intelligence systems exhibit the desired characteristics like flexibility and robustness, while remaining manageable on a local level [1],[2],[12]. Swarm robotics is the application of Swarm intelligence to robotics, using a swarm of relatively simple robots to tackle complex problems.
Swarm robotics is a novel approach to the coordination of large numbers of robots. It is inspired from the observation of social insects- ants, termites and bees-which stand as fascinating examples of how a large number of simple individuals can interact to create collectively intelligent systems that are beyond the capabilities of a single [3].
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.
Both miniaturization and cost are key-factors in swarm robotics. These are the constraints in building large groups of robotics; therefore the simplicity of the individual team member should be emphasized. This should motivate a swarm-intelligent approach to achieve meaningful behavior at swarm-level, instead of the individual level.
Potential applications for swarm robotics include tasks that demand for miniaturization (nanorobotics , macrobiotics), like distributed sensing tasks in micro machinery or the human body. On the other hand swarm robotics can be suited to tasks that demand cheap designs, for instance mining tasks or agricultural foraging tasks. Also some artists use swarm robotic techniques to realize new forms of interactive art. Swarm Robotics is also applicable in military operation, search operation, rescue operation, fire fighting, and space mission.
There are different types of tasks that can be performed by swarm robots like self assembly, coordinated motion, cooperative transport, goal search and path (or chain) formation, morphology formation, hole avoidance etc.

2. THE PROBLEM
By analyzing the previous work, in Chain Based Path Formation of Swarm Robots [5], which mentions that multiple robots randomly move to search the Nest, after perceiving the Nest robots can self organize in a chain and again randomly move to search the Prey. This task is used for exploration and navigation works by swarm robots. One of the challenging tasks in the task of chain formation is gathering at Nest by searching it. In previous work robots may take infinite time to search the Nest i.e. they move randomly to search the Nest. Since the communication range of the robots are very weak, if robots move randomly to search the Nest it will takes more or infinite time to search and gather at Nest. In this paper I have proposed a method i.e, spiral movement by swarm robot, which may take few time but at least they can find the Nest.

3. THE MODELS
Consequently, the models adopted in the studies [6],[7],[8],[9],[10] assume the robots to be relatively weak and simple. Specifically, these robots are generally assumed to be dimensionless, oblivious, anonymous and with no common coordinate system, orientation or scale, and no explicit communication. Each robot operates in simple “look-compute-move” cycles [10].
The basic model studied in e.g., [7],[8],[10] vary in two attributes . The first is Timing Models which have three types: 1) Fully-synchronous model,2) Semi-synchronous model, 3) Asynchronous model.
The second attribute is Orientation Models, referring to the local views of the robots in terms of their x-y coordinates. Elaborating on [3], the following five sub-models of common orientation levels are: 1) Full-compass, 2) Half-compass, 3) Direction-only, 4) Axes-only, 5) No-compass.

The models considered in this project are: *Asynchronous Timing Model***:** Robots operate on independent cycles of variable lengths. They do not share any common clock. *No-compass Orientation Model***:** There are no common axes, direction or orientation. Robots have their own coordinate system.

4. PROPOSED WORK

As highlighted in [4] swarm robots chain formation, robots behavior can be detailed as Search, Explore, Chain, and Finished. The author summarized that a robot swarm can form a chain in following manner:

1) Initial position: In this position all the robots are positioned at different places, and start moving randomly to search the nest,
(2) Gathering at the Nest: After perceive the Nest robots can start self organizing chain,
(3) Formed chain: After perceives the Prey chain (path) is formed.

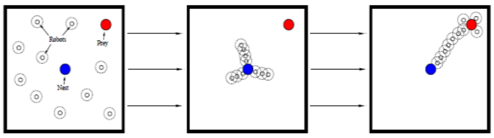

Fig.1:(a) Initial Position, (b) Gathering at the Nest,

(c) Formed Chain

In the previous work of chain formation by swarm robots [5] there are many loop holes. At the start the robots are moving randomly in the arena which seems to be time consuming and it may happens that robots may take huge amount of time in searching the nest if it goes on searching around the sides of the arena and may required to be direction the robot manually in the desired direction which is the NEST. To optimize the searching time for gathering at the Nest I have proposed a method.

1) Searching the Nest: - In the first step all the robots are in active position, to optimize the searching time for gathering at the Nest (where as in previous work robots may take infinite time to search the Nest) I have proposed two methods:

Proposed method: Spiral move

In this spiral move method robot may take few time but at least they can find the Nest. In this method robot can move spirally from their origin point (initial position) towards the searching of the NEST.

Algorithm for this spiral movement:

Step 1: All the robots have their fixed ‘X’ and ‘Y’ coordinates.

Step 2: Initially robots can measure an angle “θ” with their X axis and move some steps towards the appropriate direction of angle “θ” for finding the best position (optimum solution) from their initial position.

Step 3: If nest is perceived then robot gather at the Nest, else continue step 2 until all the robots gathered at the Nest.

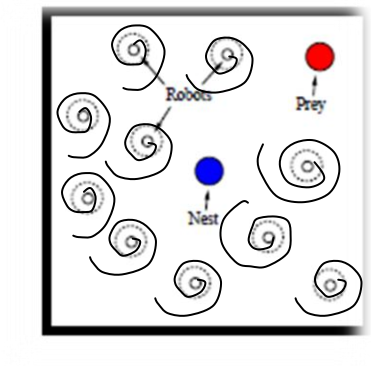

Fig.2: Robots moving spirally towards the nest

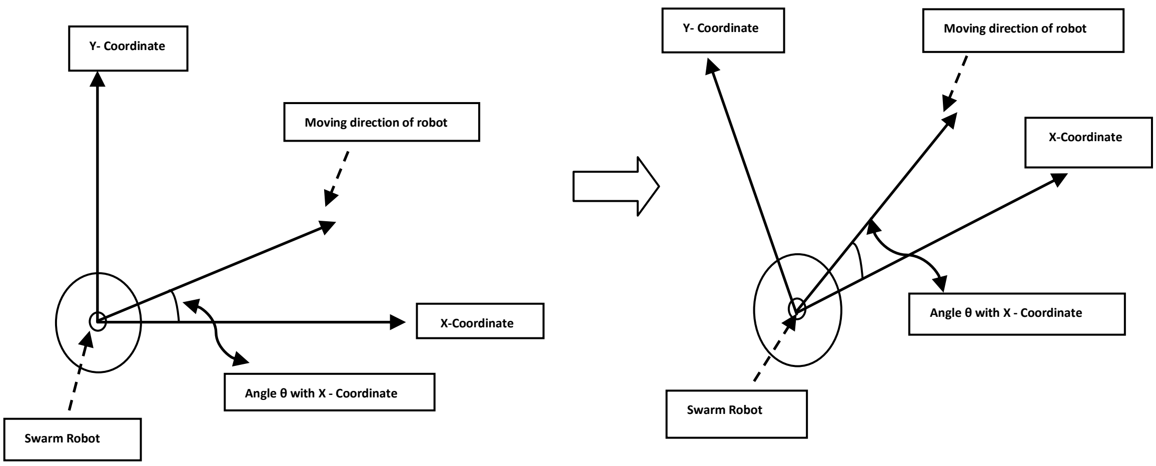

Fig 3: (a) Spiral move first step **(b) Spiral move second step and so on**

2) Gathering at the Nest: - After spirally move towards the nest, all the robots gathered at nest. We assume that the nest have a prior knowledge about the direction of Prey. Because in previous paper not mention about position and direction of Prey, so robots could make chain but move like blind o n the field and there is no time limit to find the Prey, so it may be time consuming also.

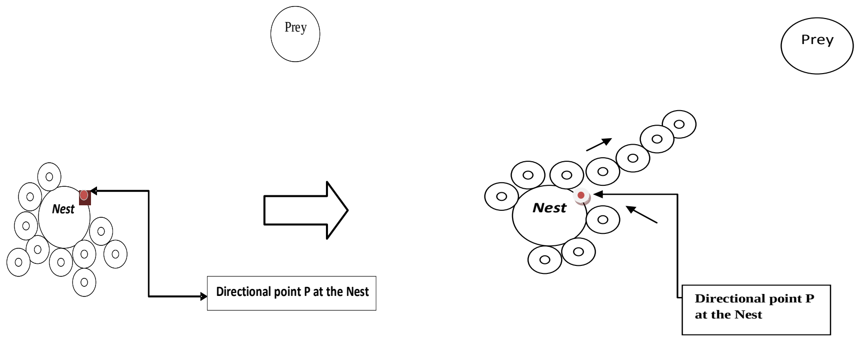

Fig 4: (a) all the robots gathered at Nest **(b) robots aligning in chain according to P**

We introduce a point "*P"* at the 'Nest' towards the direction of 'Prey'. After gathering at the Nest the nearest robot from P can align first towards the direction of Prey, and this process continues until the chain can formed.

3) Chain Formation: - After gathered at the Nest robots can aligned one by one according to point "P". Nest can relay a message to all robots about the direction towards the Prey. And finally all robots can make a chain from the Nest to the Prey.

Robots sensing range can be increased or decreased according to need of work. In previous work the sensing range of robots covered their two neighbor robots, and I am following that point.

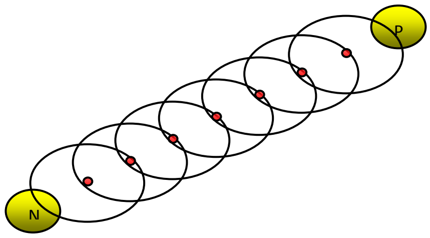

Fig 5: Chain formation between Nest and Prey

5. EXPECTED RESULT

To optimize the searching time, for gathering at the Nest, the proposed algorithm for spiral move of swarm robots can be used. As an expected result the algorithm for spiral move will be better than the existing method i.e. random move because spiral move of swarm robot will take less time than random move. Existing random movement method, in previous paper [5] has some loop holes. Because at the start the robots move randomly in the arena which seems to be time consuming and it may happens that robots may take huge amount of time in searching the nest if it goes on searching around the sides of the arena and may required to be direction the robot manually in the desired direction which is the NEST.

6. CONCLUSIONS

In this paper, I have proposed a method for movement of swarm robots for gathering. The proposed method is an efficient *Spiral Move*. This method can be used to optimize the searching time for gathering at the Nest (where as in previous work robots may take infinite time to search the Nest).

The region is obstacle less, we have used concept of Swarm Robots where the robots are very simple, weak, identical, autonomous, memoryless and performs similar algorithm. Each robot operates in simple "look-compute-move" cycles. I have assumed that each robot follows Asynchronous Timing Model and No Compass Orientation Model. The robots can have two states: active and sleep.

Future directions of this work will include investigation on how the population density in the arena affects the performance. Several types of obstacles will also be modelled in order to understand the emergent behaviours that obstructions may produce.

7. ACKNOWLEDGEMENT

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