© 2016 IJSRSET | Volume 2 | Issue 2 | Print ISSN : 2395-1990 | Online ISSN : 2394-4099
Themed Section: Engineering and Technology

A Review on Swarm Intelligence System

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ABSTRACT

The conventionally used robots are for real life work of large size and have complexity in construction and programming. Sometimes, the size of robots affects the external environmental conditions and the scenario around it. The construction cost of robot for a long duration and on a larger working area is much larger. The maintenance of robust robots is also a big problem due to complexity in the construction and materials used for construction.
This paper highlights and discusses the alternative and more economical and more efficient method can be used in real practice. The concept of natural Swarm Intelligence can be used artificially as "Artificial Swarm Intelligence". The task can be performed by number of small robots which will work collectively as per swarm intelligence seen in nature like ant colonies, flocks of birds, etc.
The efficiency of work and time taken for completion of task will be much less as it will be done by a group collectively.
Keywords: SI, AI, Ant Systems, ACO, PSO.

I. INTRODUCTION

An automatically operated machine that replaces the human effort was difficult to imagine; in the view of appearance or perform functions in a human like manner.

By extension, a robotic engineer deals with the design, construction and operation of robots. A robot is a mechanical or virtual artificial agent, which by its appearance or movements conveys a sense that it has intent or agency of its own. However, robots are used for various industrial, social and environment work.

While constructing a robot, it's a general practice to develop a single robot for particular work. But it leads some maintenance and construction problems. To solve these problems natural behaviours seen in animals, insects and other organisms can be efficiently utilized in practical robotics, such as swarm behaviour seen in insects.

II. METHODS AND MATERIALS

A. Literature Review

James Kennedy et al., (2001) [1],inspired by social behaviour of bird flocking or fish schooling. Particle swarm optimization (PSO) is a population based stochastic optimization technique developed by Dr. Eberhart and Dr. Kennedy in 1995. PSO shares many similarities with evolutionary computation techniques such as Genetic Algorithms.

Hussein Abbas et al., (2002) [2], Hussein's work integrates cognitive science, operations research and artificial intelligence. His dream is to design the next generation artificial intelligence system that he calls Cognitive-Cyber-Symbiosis (CoCyS, pronounced as Cookies), whereby human thinking is communicated and blended seamlessly in the Cyber space for improved decision making.

Macro Dorrigo et al., (2004) [3], Artificial Ants stand for multi-agent methods inspired by the behaviour of real ants. The pheromone-based communication of biological ants is often the predominant paradigm used. Combinations of Artificial Ants and local search algorithms have become a method of choice for numerous optimization tasks.

B. Swarm Intelligence

"It is an Artificial Intelligence (AI) technique based on the collective behaviour in decentralized, self-organized systems."

It is mostly made up of agents who interact with each other and the environment.

Swarm

It is a loosely structured collection of interacting agents.

Agents

Individuals that belong to a group (but are not necessarily identical).

They can recognize, communicate, and /or interact with each other. The instinctive perception of swarms is a group of agents in motion but that does not always have to be the case.

A swarm is better understood if thought of as agents exhibiting a collective behaviour.

Examples of swarm in nature

Classic example: Swarm of Bees
Can be extended to other similar systems:

TABLE I : EXAMPLES OF SWARM IN NATURE

SYSTEMS	AGENTS
ANT COLONY	ANTS
FLOCK OF BIRDS	BIRDS
TRAFFIC	CARS
CROWD	HUMANS
IMMUNE SYSTEM	CELLS AND MOLECULES

It was first introduced by Beni and Wang in 1989 with their study of cellular robotic systems. The concept of SI was expanded by Bonabeau and Dorrigo in 1999.

Using the expression "Swarm Intelligence" to describe this work only this work seems unnecessarily restrictive: that is why we extend its definition to include devices inspired by the collective behaviour of insect colonies and other animal societies.

Swarm Approach to Robotics:

It is the application of SI principles to collective robotics. A group of simple robots, that can only communicate locally and operate in a biologically inspired manner such as **insects**.

Insects have a few hundred brain cells. However, organized insects have been known for:

- Architectural marvels
- Complex communication systems
- Resistance to hazards in nature

In the 1950's E.O. Wilson observed: A Single ant acts (almost) randomly – often leading to its own demise and a colony of ants provides food and protection for the entire population.

Common SI Algorithms:

1. Ant Colony Optimization
2. Particle Swarm Optimization

1. Ant Colony Optimization (ACO):-

It is the studies of artificial systems modeled after the behavior of real ant colonies and are useful in solving discrete optimization problems.

It was originally called the Ant System (AS). It is the population based met heuristic used to find approximate solutions to difficult optimization problems.

ACO is decentralized; the individuals are simple and autonomous.
It has a local communication and control between the others bots.

Cooperative behaviors emerge through self-organization.

Applications of ACO:-

- The ACO can be used in heating oil distribution check.
- Swarms for cleaning up toxic waste where manual interference is possible.
- In space industries now a day it is being used to explore an unknown planet.
- Surveillance and other military applications.

2. Particle Swarm Optimization (PSO):-

It is a population based stochastic optimization technique. It searches for an optimal solution in the computable search space. It is developed in 1995 by Dr. Eberhart and Dr. Kennedy. The individuals in a population learn from previous experiences and the experiences of those around them.

The direction of movement is a function of:

a. Current position
b. Velocity
c. Location of individuals
d. Location of neighbors

Therefore, each individual in a population will gradually move towards the better areas of the problem space.

Applications of PSO:-

- Human tremor analysis
- Electric/hybrid vehicle battery pack state of change
- Human performance assessment
- Ingredient mix optimization
- Evolving neural networks to solve problems

III. USE OF ACO AND PSO

It can be applied to wide range of applications. It is easy to understand and easy to implement. Also the computationally is efficient.

Advantages of Swarm Intelligence:-

1. The systems are scalable, because the same control architecture can be applied to a couple of agents or thousands of agents.
2. The systems are flexible because agents can be easily added or removed without influencing the structure.
3. The systems are robust because the agents are simple in design; the reliance on individual agents is small.
4. Failure of single agents has a little impact on the system's performance.
5. The systems are able to adapt to new situations easily.

IV. CONCLUSION

With the advances in technologies, new approaches and techniques are required for solving various optimizations problem in areas like computer science, robotics, MANATs etc.

Nature inspired problem solving techniques have been found to be an intelligent and efficient way for this. Swarm intelligence is used in various other areas like in digital circuits, data mining and telecommunication. This paper presents an overview of swarm intelligence which can be applied in the society.

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