DOI: 10.21917/ijsc.2019.0261

A CONCISE CHRONOLOGICAL REASSESS OF DIFFERENT SWARM INTELLIGENCE METHODS WITH MULTI ROBOTICS APPROACH

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Abstract

Swarm insight is the discipline that arrangements with normal and fake frameworks made out of numerous people that facilitate utilizing decentralized control and self-association. Specifically, the order focuses on the collective behaviours that outcome from the nearby cooperation's of the people with one another and with their environment. We can discover swarm in provinces of ants, school of fishes, herds of feathered creatures and so on. The different Swarm Intelligence models, for example, the Ant Colony Optimization where it depicts about the development of ants, their conduct, and how do it conquer the impediments, in fowls we see about the Particle swarm advancement it depends on the swarm knowledge and how the positions must be put in view of the standards. Next is the Bee state streamlining that arrangements with the conduct of the honey bees, their associations, likewise portrays about the Movement and how they function as developing aggregate knowledge of gatherings of basic self-governing operators. As a new research territory by which swarm knowledge is connected to multi-robot frameworks; swarm mechanical technology thinks about how to facilitate extensive gatherings of generally straightforward robots using neighbourhood rules. It centers on concentrate the plan of huge measure of generally basic robots, their physical bodies and their controlling practices. Since its presentation in 2000, a few fruitful experimentations had been acknowledged, and till now more tasks are under examinations. This paper tries to give a review of this space look into for the aim to orientate the readers, particularly the individuals who are recently coming to this research field.

Keywords

Pheromone, Stigmergy, Particle Swarm Optimization, Ant Colony Optimization, Bee Colony Optimization

1. INTRODUCTION

A swarm is large number of homogenous, basic operators interfacing locally among themselves, and their condition, with no focal control to enable a worldwide fascinating conduct to rise. Swarm-based calculations have recently emerged as a group of nature-inspired, population-based algorithms that are equipped for delivering minimal effort, quick, and vigorous answers for a few complex issues. Swarm Intelligence (SI) [5] can in this way be characterized as a generally new part of Artificial Intelligence that is utilized to demonstrate the aggregate conduct of social swarms like it can be the colonies of ant, honey bees, and bird flocks [14] [23]. In spite of the fact that these specialists (bugs or swarm people) are generally unsophisticated with restricted abilities all alone, they are collaborating together with certain personal conduct standards to helpfully accomplish errands essential for their survival [19]. The social associations among swarm people can be either direct or indirect.

Precedents of direct connection are through visual or sound contact, for example, the waggle move of honey bees. Indirect interaction occurs when one individual changes the environment and the other individuals respond to the new environment, for example, the pheromone trails of ants that they store on their approach to scan for food sources [9]. This circuitous sort of association is alluded to as stigmergy, means communication through the environment [10] [22]. The zone of research displayed in this paper centers around Swarm Intelligence.

In particular, this paper examines two of the most mainstream models of swarm knowledge roused by ants' stigmergic behaviour and birds' flocking behaviour. In the previous decades, researcher and regular researchers have been considering the behaviours of social insects because of the amazing efficiency of these natural swarm systems [13]. In the late-80s, researchers proposed the logical bits of knowledge of these common swarm frame works to the field of Artificial Intelligence. In 1989, the articulation Swarm Intelligence was first presented in the worldwide streamlining system as an arrangement of calculations for controlling automated swarm. In 1991, Ant Colony Optimization (ACO) [2] [17] was presented as a novel nature-enlivened metaheuristic for the arrangement of hard combinatorial optimization (CO) issues. Natural swarm based speculations have been connected to tackle closely resembling designing issues in a few areas building from combinatorial streamlining to establishing correspondence arrange and also mechanical technology applications, and so on [18] [21].

The most notable swarm based calculations are: Ant Colony Optimization Algorithms (ACO) [7], Particle Swarm Optimization Algorithms (PSO), and Bee based Algorithms. The ACO calculation [3] is enlivened from the scavenging conduct of subterranean insect states in finding most limited ways from their homes to nourishment sources. The wellspring of motivation of PSO based calculations comes particularly from the conduct saw in winged creature rushing or fish tutoring when they are moving together for long separations to scan for sustenance sources, Bee based calculations can be arranged into three diverse fundamental gatherings: (1) the bumble bee' scavenging conduct based calculations, (2) the ones dependent on mating conduct in bumble bee, and (3) the ruler honey bee development process based calculations [4].

Swarm Intelligence calculations in a few advancement undertakings and research issues. Swarm Intelligence standards have been effectively connected in an assortment of issue spaces including function optimization problems, finding optimal routes, scheduling, structural optimization, and image and data analysis Computational modelling of swarms has been additionally connected to an extensive variety of different areas, including machine learning, bioinformatics and restorative informatics, dynamical frameworks, operations research, they have been even applied in finance and business [24].

2. ANT COLONY OPTIMIZATION

Ant colony optimization (ACO) was proposed the main calculation is to look for ideal way in light of the conduct of ants finding the most limited way looking for sustenance source ACO calculation is utilized to tackle complex issues like optimization problems, sequential ordering problems, scheduling problems, graph colouring, assembly line balancing, vehicle routing problems and Multi goals zones utilized are information mining, media transmission and bioinformatics [25] [27]. ACO will be frequently used by swarm intelligence it is a class of algorithms which inspires the foraging behaviour of ants. A key point in the advancement of any ACO calculation is to choose the wellness work in light of which the parts of an issue's development diagram will be compensated with an abnormal state pheromone trail and to decide how ants will misuse these promising segments while building new arrangements [26]. The wellness capacity of ACO is frequently and certainly planned as cost minimization of arrangement segments, i.e., the objective of fake ants is to stroll on the development chart and select the hubs that limit the general expense of the arrangement way. Since it has been exhibited, there are a couple of unmistakable variations to the principal improvement estimations [28]. So we compel our fixation to Ant Systems (AS) where the primary ACO estimations were displayed. The major characteristic is that the pheromone levels are revived by each one of the ants which gather a response for the cycle. Scavenging behavior of ants is the best case for clearing up the limit of creepy crawly settlements [29].

2.1 ANTS NATURE

Ants are thought to be the best normal case for swarm. Ants follow indirect connections. Ants live in colonies and are "relatively visually impaired" people, as they lay pheromone (i.e., volatile chemical substance) in transit from settle when they go looking for food source. The expression "pheromone" was presented in view of Greek word Pherin which implies transport and hormone implies stimulate. There are diverse sorts of pheromones utilized by social creepy crawlies, as they alarm pheromone and nourishment trail pheromone.

2.2 ANTS BEHAVIOUR

Alarm pheromone is utilized to create an alarm to adjacent ants to escape from hazardous predators to ensure their colonies. The power of pheromone in transit is higher the likelihood in the hunt of nourishment [30]. Food trail pheromone is wherever the ants goes looking for the nourishment it leaves the compound pheromone on its way, in its condition. Ants are little minor animal which has restricted scholarly capacities which are sufficiently brilliant to play out their day by day assignments to locate the shortest path for sustenance source. Ants isolate their works inside themselves [31]. These undertakings can be performed by subterranean insect provinces in a proficient way. Singular ants are basic and minor animals in a productive fit for performing errands rapidly and more proficient to change the environment.

2.3 STIGMERGIC NATURE

Ants, in the same way as other social creepy crawlies, speak with one another utilizing unpredictable compound substances known as pheromones, whose heading and power can be seen with their long, portable antennae. The expression "pheromone" was first presented in view of the Greek word Pherein (intends to transport) and hormone (means to stimulate). There are diverse sorts of pheromones utilized by social bugs. One case of pheromone composes is caution pheromone that squashed ants deliver as an alarm to adjacent ants to battle or break perilous predators and to ensure their settlement. Another imperative kind of pheromone is food trail pheromone.

Dissimilar to flies, most ants live on the ground and make utilization of the dirt surface to leave pheromone trails, which can be trailed by different ants on their approach to look for nourishment sources. Ants that happened to pick the shortest route to nourishment will be the quickest to come back to the home, and will strengthen this briefest course by storing food trail pheromone on their way back to the home. This course will step by step draw in different ants to take after, and as more ants take after the course, it turns out to be more attractive to different ants as demonstrated. This autocatalytic or positive feedback process is an example of a self-organizing behaviour of ants in which the probability of an ant's choosing a route increases as the count of ants that already passed by that route increases.

At the point when the sustenance source is depleted, no new nourishment pheromone trails are set apart by returning ants and the unstable pheromone fragrance gradually vanishes. This negative input conduct enables ants to manage changes in their condition. For example, when an officially settled way to a sustenance source is hindered by an impediment, the ants leave the way to investigate new courses. Such trail-laying, trail-following conduct is called stigmergy (connection through nature), and can be considered as a circuitous sort of correspondence in which ants change the earth (soil surface) and alternate ants identify and react to the new condition. Stigmergy gives a general mechanism that is related to the local or individual and colony-level (global) behaviours: individual behaviour modifies the environment (trail-laying), which in turn modifies the behaviour of other individuals.

2.3.1 Double Bridge Experiment:

The pheromone trail-laying and trail-following conduct of ants has been contemplated in controlled tests by a few specialists. One simple, yet brilliant experiment is referred to as the double bridge experiment, which was designed and run by Goss, Deneubourg and colleagues in the late 1980s. The trial was just made of a double bridge connecting a nest of ants and a food source as shown in Figure Goss et al. considered diverse variants of the trial setup over different analysis runs. In one form, the more extended part of the twofold scaffold was twice the length of the short one and the two branches are introduced from the earliest starting point of the investigation as appeared in Figure

At first, ants left the home to investigate the earth; once they touched base at a choice point, they need to pick one of the two branches. Since the two plain branches at first seemed to be indistinguishable to the ants (on singular level conduct), they were chosen randomly. In any case, very astounding at first, the ants (on province level conduct) seemed sufficiently shrewd to inevitably pick the shorter branch. This is on the grounds that the fortunate ants that happened to pick the short branch are the first to achieve the food and to begin their arrival to the home. On their arrival path to the home, these ants will be one-sided to pick the short branch over once more (now probabilistically and not arbitrarily), in view of the larger amount of pheromone they officially left on the short branch.

2.3.2 Ant Net Algorithm:

In the Ant Net calculation, directing is controlled by methods for extremely complex collaborations of forward and in reverse system exploration agents ("ants"). The thought behind this sub-division of operators is to enable the regressive ants to use the valuable data assembled by the forward ants on their trip from source to goal. In view of this guideline, no hub directing updates are performed by the forward ants. Their solitary reason in life is to report organize delay conditions to the backward ants, as raw data and use it to update the routing table of the nodes between each network node. The backward ants inherit this and the algorithm is given below:

Step 1: Represent to the solution space by a development chart.

Step 2: Set ACO parameters and introduce pheromone trails.

Step 3: Create ant solutions from every ant's walk on the development diagram intervened by pheromone trails.

Step 4: Refresh pheromone intensities.

Step 5: Go to stage 3, and re-hash until the point that assembly or end conditions are met.

3. PARTICLE SWARM OPTIMIZATION

Particle Swarm Optimization (PSO) was initially used to take care of non-direct, non-stop improvement issues, yet more as of late it has been utilized in numerous pragmatic, genuine application issues. For instance, PSO has been effectively connected to track dynamic frameworks, advance weights and structure of neural systems, investigate human tremor, enlist 3D-to-3D biomedical picture, control responsive power and voltage, notwithstanding figuring out how to play amusements and music organization. PSO draws motivation from the sociological conduct related to fledgling rushing. It is a characteristic perception that winged creatures can fly in huge gatherings with no impact on expanded separations, trying to keep up an ideal separation among themselves and their neighbors. This area displays a few insights about flying creatures in nature and reviews their abilities, also their sociological rushing conduct.

3.1 NATURE

Vision is considered as the most critical sense for flock organization [8] [6]. The eyes of most winged animals are on the two sides of their heads, enabling them to see on each side at a time. The bigger size of winged creatures' eyes with respect to other creature bunches is one motivation behind why flying creatures have a standout amongst the most profoundly created faculties of vision in the set of all animals. Because of such vast sizes of winged animals' eyes, and additionally the manner in which their heads and eyes are orchestrated, most types of feathered creatures have a wide field of view. For instance, Pigeons can see 300 degrees without turning their head. Flying creatures are for the most part pulled in by nourishment; they have great capacities in running synchronously looking for food and long-distance migration. Winged animals likewise have productive social connection that empower them to be able to:

- Fly without crashing even while frequently altering course abruptly,
- Disperse and rapidly regroup while responding to outside dangers, and
- Maintain a strategic distance from predators.

3.2 APPLICATION OF SWARM ROBOTICS

Since the evolving of swarm robotics study field, several installations have been issued to explain how we can promote from the properties of swarm robotics systems that make them engaging in several possible submission domains. Swarm robotics have been involved in many tasks [1] such as the ones demanding miniaturization, like distributed sensing tasks in micro-machinery or the human body; those demanding cheap designs, such as mining task or agricultural foraging task; those requiring large space and time cost, and are dangerous to the human being or the robots themselves, such as post-disaster relief, target searching, military applications, etc [20].

3.2.1 Tasks Covering Large Area:

Swarm robotics can be useful in tasks that require a large province of space. The robots are expert for large exposure tasks (e.g. surveillance, demining, and search and rescue) and they are circulated in an unstructured or large environment (e.g. underwater or extraterrestrial planetary exploration) in which no available communications can be used to control the robots. In such tasks, robot swarms are well-matched because they are able to: act originally without the need of any form of external coordination, detect and monitor the dynamic change of the entire area, locate the source, move towards the area and take quick actions.

3.2.2 Tasks Dangerous to Robot:

In several unsafe tasks such as mine rescue and improvement, robots may be irreversible after the task is accomplished; thus, it's good to use swarm robotics with simple and cheap individuals rather than using complex and expensive robots. Additionally it's practically reasonable to apply swarm robots that provide laying-off for dealing with such dangerous tasks.

3.2.3 Tasks need Scaling Inhabitants and Redundancy:

Swarm apply autonomy can be additionally connected in circumstances in which it is troublesome or even difficult to evaluate ahead of time the assets expected to achieve errands, for example, hunt and save, following, and cleaning. A case for this circumstance is: clearing oil spillage after tank mishaps; beneficiary toward the start of the undertaking the number of inhabitants in swarm is profoundly kept up when the oil releases quick and it's step by step decreased when the break source is stopped and the spilling territory is nearly cleared. The arrangement required in these cases ought to be versatile and adaptable; in this manner a robot swarm could be an engaging arrangement: robots can be included or evacuated in time with no huge effect on the execution to give the fitting measure of assets and meet the prerequisites of the explicit errand. This can be regarded by the vigor highlight of swarm mechanical autonomy that is the principle profits by excess of the swarm.

4. BEE COLONY OPTIMIZATION

The BCO is composed in light of the conduct of honey bees. In the BCO, there are numerous operators which work on the whole to take care of the issue in the improvement method. BCO is somewhat unique in relation to the genuine honey bee settlement. At first, before BCO, there were two calculations that were environmental and honey bee framework calculation which depended on the aggregate knowledge of honey bees conduct and the last is of the hereditary algorithm. BCO can be identified with the travelling salesperson problem. BCO can likewise be called as the population calculation since it finds the optimal solution. One of its applications is ride coordinating issue can be settled utilizing BCO. It is met heuristic and it is persuaded by the scrounging conduct of honey bees. The algorithm is stated below:

The foraging behaviour of the bees will be considered for the bee colony algorithm. This finds the optimal solution.

Step 1: Population of the honey bees are to be introduced.

Step 2: Population wellness must be computed.

Step 3: While (condition (halting criteria) not met)

Step 4: Select certain spots to seek.

Step 5: Select more honey bees for the new spot and figure the wellness.

Step 6: Decide the fittest honey bees.

Step 7: Different honey bees must be allotted haphazardly for the hunt.

Step 8: End While.

Each cycle of inquiry comprises of three stages: moving the utilized and spectator honey bees onto the food sources and ascertaining their nectar sums; and deciding the scout honey bees and guiding them onto possible food source. A sustenance source position speaks to a conceivable answer for the issue to be enhanced. The amount of nectar of a food source corresponds to the quality of the solution Onlookers are placed on the food sources by using a probability based selection process. As the nectar measure of a sustenance source expands, the likelihood esteem with which the nourishment source is favoured by spectators builds too. The scouts are described by low pursuit costs and a low normal in nourishment source quality. The choice is controlled by a control parameter called “limit”. If a solution representing a food source is not improved by a predetermined number of trials, then that food source is abandoned.

5. APPLICATIONS OF PSO

The main use of PSO was in the field of neural systems, when PSO could prepare and change the weights of a feed-forward multilayer perceptron neural system as adequately as effectively as the conventional error back-propagation approach. From that point forward, an about exponential developing number of PSO applications have been investigated in a few areas because of their effortlessness, productivity and quick assembly nature. A thorough specialized report in has made a broad audit of more than 1,100 PSO distributions. Among those more than one thousand PSO productions, the audit report considered around 350 papers as proposition for enhancements and expansions to the first -1995-version of PSO. Such substantial proposed number of PSO varieties and expansions has made PSO fit for taking care of a few streamlining issues extending from unconstrained, single-goal or static issues to obliged, multi-target or dynamic issues. The report additionally considered the rest of the ~700 papers as PSO applications, although many of them also introduced different customizations and extensions to PSO method to fit their particular application. Of those ~700 papers, PSO applications have been ordered into 26 distinct classes. The enormous number and extent of fruitful PSO applications fall under a wide space of research regions, extending from combinatorial streamlining issues to computational knowledge applications, from electrical and electromagnetic applications to signal processing and graphics, from image analysis and robotics to bioinformatics and medical applications.

5.1 PSO RELEVANCE WITH BIOINFORMATICS

The key test of bioinformatics issues lies in the enormous measure of their information, and in this manner their computational multifaceted nature. Thus, numerous bioinformatics issues don’t generally require the correct ideal arrangement; an estimation to the arrangement is regularly utilized. Bioinformatics issues, subsequently, require ideal or even close ideal arrangements that are computationally modest, and can be delivered in a quick and strong means, which PSO calculations are really recognized by. That is the reason PSO calculations have been proficiently connected in numerous bioinformatics issues. Moreover, the lab activities on DNA, for example, characteristically include blunders and vulnerability, which are more mediocre in PSO calculations contrasted with deterministic calculations. As a matter of fact, these blunders might be viewed as useful in PSO to some degree, as they may acquaint helpful haphazardness and contribute with populace decent variety – an attractive property for PSO union. The PSO-based methodologies are proposed to handle the shading picture quantization. Visual information mining through the development of virtual reality spaces for the portrayal of information and learning, includes Particle swarm improvement (PSO) joined with traditional advancement techniques. This methodology is connected to high dimensional information from microarray quality articulation analyzes with a specific end goal to comprehend the structure of both raw and processed data

5.1.1 Applications:

- *Multi-Robot Systems (MRS):* Multi-robot frameworks (MRS) are destined to conquer the need in data handling ability and numerous different parts of single robots that are not proficient to dial with uncommon undertakings; which, so as to be productively finished, require participation and joint effort between gatherings of robots [11]. Since its presentation in the late 1980s, different works, such as: (cellular robotics, collective robotics, and distributed robotics) have been issued to portray gathering of straightforward physical robots teaming up to perform explicit undertakings. MRS have additionally make an extraordinary progress and gained an incredible ground in numerous regions, for example, cooperative transportation and aggregation, environmental monitoring, search-and-rescue missions, foraging, and space exploration [12]. In such assignment, even the straightforwardness in plan and the minimal effort in profitability, and the expansion in abilities, adaptability, and adaptation to internal failure points of interest picked up when utilizing multi-robots rather than a solitary one; anyway with the new emerging difficulties, for example, decentralization in charge and self-association, analysts in multi mechanical field started to gain regard for the expansion ground known in swarm insight frameworks bringing forth the new sub-area look into "swarm robotics".

- *Swarm Robotics (SR):* Swarm robotics can be characterized as the investigation of how all things considered can emerge from local interactions of a large number of relatively simple physically embodied agents. The principle thought of the methodology behind this space look into is to fabricate moderately numerous little and minimal effort robots that should achieve indistinguishable errand from a solitary complex robot or a little gathering of complex robots [15]. The approach also takes into account studying the design of robots (both their physical body and their controlling behaviors) in a way that a desired collective behavior emerges from the inter-robot interactions and the interactions of the robots with the environment [16].

Table.1. Comparison of SR and MRS Swarm robotics

Parameters	Swarm Robotics	Multi-robot systems
Population Size	Variation in great range	Small
Control	Decentralized and autonomous	Centralized or remote
Homogeneity	Homogeneous	heterogeneous
Flexibility	High	Low
Scalability	High	Low
Environment	Unknown	Known/unknown
Motion	Yes	Yes

6. CONCLUSION AND FUTURE WORK

Swarm apply autonomy is a generally new research zone that takes its motivation from swarm knowledge and mechanical autonomy. It is the consequence of applying swarm insight methods into multi-mechanical technology. In spite of the fact that various inquires about have been proposed, it's still very far for viable application. In the present paper, a review of swarm mechanical technology has been given for better comprehension of this multi-robot area look into and for elucidating the excellent lines being centered on this space. Interests that are recently resulting in these present circumstances point research can be effectively guided toss the diverse areas exhibited in this paper.

Honey bee states is that they are exceptionally productive in abusing the best sustenance sources in view of a gathering of forager honey bees. At the point when a forager honey bee chooses to pull in more honey bee mates to a newfound decent nourishment source, it comes back to the hive and begins performing what is known as the waggle move to convey spatial and benefit data about the found sustenance source, and enlist more bumble bees (dancer followers) to abuse it. The waggle move comprises of a progression of waggle stages. A waggle stage begins when the selection representative honey bee energetically shakes its body from side to side. The time interim between each waggle stage is known as an arrival stage, in which the selection representative honey bee makes an unexpected swing to one side or just before beginning another waggle stage. The complexity of an ant colony or the beautiful sight of a large swarm of birds surprises with the simplicity of the underlying rules. With ant colony optimization and particle swarm optimization two algorithms have been created which can solve difficult computational problems efficiently, while still being easy to understand. As there is a wide variety of swarm behaviour in nature, there is a great chance we will see more algorithms and systems modelled after social insects and other social animals. As the algorithms are parallel in nature, they are well adapted for the use on parallel hardware. On coming processor generations, which will feature a growing number of parallel processing units this may lead to very efficient implementations of these algorithms.

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