JCSE International Journal of Computer Sciences and Engineering Open Access
Research Paper Volume-3, Special Issue-1 E-ISSN: 2347-2693

A SWARM Based Approach in Saving Flood Survivors

Dr. Dilip Roy Chowdhury
Dept. of Computer Science & Application
University of North Bengal
Siliguri, West Bengal, India
diliproychowdhury@gmail.com

Subhajit Bose*
Delhi Public School, Siliguri
BidyaBharati Foundation
Siliguri, West Bengal, India
bosesubhajit87@gmail.com

***Abstract* - Swarm intelligence (SI) is a branch of artificial intelligence that has evolved based on the collective behavior of social insect colonies and other animal societies that have decentralized mode of work control. It is the collective behaviour (intelligence) exhibited by many individual elements for carrying out a common work that coordinate among them using a decentralized control and self-organization both in natural and artificial system. This paper proposes an optimized algorithm based on swarm intelligence algorithms to save people who are stuck in flood in the minimum time when the number of motorized inflatable rescue boats available is comparatively less to the number of people stuck in flood.**

Keywords– Artificial Intelligence; Ant Colony Optimization (ACO); boids; foraging; motorized inflatable rescue boats; Swarm Intelligence; stigmery; component; formatting; style; styling; insert

I. INTRODUCTION

Human beings are the most intelligent creature on the planet. As a result they prefer to do almost all of their own work by themselves. They don't mind working with others together but that has to be in a centralized work environment. Consequently, they are accustomed to work only in two modes – self and in a centralized group. This has led their brain to be trained in such a manner that they don't know how to respond in a chaotic situation created due to natural disasters like earthquake, flood etc. or due to a fire breakout. Their normal senses stop functioning though they find themselves among other people who too are trying to act in the best possible way to come out of the situation which should have given them confidence, but as because most of them do not know each other they feel as if they are lonely. In such situations, the best way to respond is to do what insect colonies such as that of ants and bees do – a collective behaviour to achieve a common goal. This is where swarm intelligence comes into play.

Swarm Intelligent system consists of a number of simple agents, also called boids that interact locally with one another and in turn with their environment. The agents follow very simple rules in doing their tasks, and though there is no centralized control structure to tell them how to coordinate and carry out their task, interactions between individual agents leads to the emergence of an "intelligent" global behaviour, which is unknown to the individual agents [1, 2].

Swarm Intelligence exhibited in natural biological systems include that of ant colonies, honey bees, termite colonies, bird flocking, animal herding etc [3].

II. RELATED STUDIES

Very few works have been done in this domain and whatever has been done focuses mainly on the water channels and not on the people who actually get affected due to flooding in their areas.

Wang Jian – qun *et al.* [4] proposed a combination of particle swarm optimization with reservoir cycling method to solve the flood optimal control model, that was established to optimize flood control of the reservoir group (Luhun reservoir, Guxian reservoir and Xiaolangdi reservoir, in addition to Huanyuankou hydrological station as the common flood control point, with each reservoir having its own flood control objective, respectively) along the middle and lower reaches of Yellow River, based on the maximum flood peak clipping criterion whose effectiveness is validated through an expirical study.

M. Janga Reddy *et al.* [5], in their paper, proposed swarm intelligence based methodology for optimal and reliable design of irrigation channels because the input parameters (lining material, longitudinal slope etc.) involved in the channel design are prone to uncertainty and the solution of deterministic model may result in risk of flood and affect the stability of the channel. In order to provide reliability in the design, they presented an overtopping probability constrained design in their study. They also proposed a modified cost function in order to account for the uncertainty of design parameters (bed width, side slopes, and flow depth of the channel) in the objective function. Hence, they propounded a swarm based methodology to solve the problem in a meta-heuristic environment and solved it using elitist-mutated particle swarm optimization (EMPSO) method.

Meraji S.H. *et al.* [6], in their paper, developed an optimization model for the optimal design of flood control systems which contains both detention dam and bottom outlet. Their proposed model uses the particle swarm optimization (PSO) algorithm as the search engine and the "Transport Module" of "SWMM" as the hydraulic analyzer of the system.

Wei Huang *et al.* [7], in their paper, proposed a flood disaster classification assessment method based on multi-swarm cooperative particle swarm optimization, which adopts a tri-parameter Logistic curve to construct the flood disaster projection pursuit model, and uses multi-swarm system particle swarm optimization method to optimize the parameters of the projection index functions.

All the above mentioned researches are concerned only with one end, i.e. the source of water, but none of them has laid emphasis on what would happen if excess water flows into domestic area thereby flooding the area and putting people's life in danger. This paper proposes an algorithm that can be used by the rescue team to save people who are stuck in flood in a very effective manner and in the minimum time.

III. PROPOSED METHODOLOGY

The proposed method can be divided into two phases namely, Phase I and Phase II. Phase I deals with collection of information about people stuck in flood while Phase II deals with the procedure used by the rescue team to rescue people.

A. *Phase I*

In situations like flood, it is essential to get an overview of the flood affected area from top by using a helicopter to scout the area in order to find out how many people are stuck in flood. If it is a matter of only one or two person being stuck in flood (*Ideal Case Scenario*) then, in that case, the helicopter itself can pick them up with the help of a helicopter rescuer harness (such as LSC Tri-SAR [8]) by sending the harness down with a rescuer who will grab the person, tie the harness around that person and then inform the other rescuers in the helicopter via an *airband portable radio* or *portable programmable radio* [8] to pull them up. This process will get repeated for the remaining few persons and the rescue operation will get over in Phase I itself. There will be no need to move to Phase II, but when there are lot many people stuck in flood and each of them needs help, (*Average Case Scenario*), pulling everyone up in the helicopter will not be feasible. In such a case, the best thing for the rescuers in the helicopter to do is to make a good estimate on how many people are stuck in flood and pass this information on to Phase II. Another situation (*Worst Case Scenario*) may come up where even the helicopter will not be functional, that is, a situation where the flood is accompanied by heavy rainfall or thunder storm. It will be a risky affair to scout the flood affected area with a helicopter. Hence, the only option left will be to carry out Phase II.

The above three case scenarios put light on the fact that Phase II is very important in a flood rescue operation, which is explained below.

B. *Phase II*

In this phase, based on the information passed from Phase I, some *motorized inflatable rescue boats* [8] will be placed on water having rescuers in them who will go to each of the locations where people are stuck to pick them up. For instance, if 100 people are stuck in flood and each *motorized inflatable rescue boat* has a capacity of 10 people, out of which 2 seats are already occupied by the rescuers who will pick up people from water on to the boats, then, in an *ideal situation*, 13 *motorized inflatable rescue boats* should be available to rescue all the people at the same time.

Based on the above understanding, two constraints may arise. First, Phase I only gives an estimate of the number of people stuck in flood, it does not give the exact value. Secondly, sufficient number of *motorized inflatable rescue boats* may not be available to rescue all the people at the same time.

Consequently, rescuers on boats will either face the *Average Case* or the *Worst Case Scenario* of Phase I followed by the second constraint of Phase II in the absence of the *ideal situation*. That is, rescuers on boats, will either receive a rough estimate of the number of people stuck in flood from Phase I (*Average Case Scenario*) or receive none (*Worst CaseScenario*) and may have sufficient number of *motorized inflatable rescue boats* (ideal situation of Phase II) to rescue all the people together at the same time or may have comparatively less number of *motorized inflatable rescue boats* (second constraint of Phase II) where they have to use the same boats again and again to rescue all the people.

In case of the scenario where the second constraint of Phase II is in place, that is, compared to the number of people in water less number of motorized inflatable rescue boats is available to save them, swarm intelligence will play an important role and is the topic of discussion of this paper. Prior to the release of the *motorized inflatable rescue boats* on water, the process will be carried out through a centralised mode of control but once the *motorized inflatable rescue boats* are released on water there will be no centralised control rather the rescuers on boats will have to do their work in a decentralised manner.

The following swarm intelligence algorithms when used in conjunction with each other will suit best in the above mentioned situation. They are defined and explained in the sections given below and how they will be used together by the *motorized inflatable rescue boats* to pick up people from water is explained in a later section of this paper.

i. Ant Colony Optimization (ACO)

Ant Colony Optimization (ACO) algorithm is one of the most popular swarm intelligence algorithms due to its optimization technique. It uses a probabilistic technique for solving computational problems which can be reduced to finding good paths through graphs. It was initially proposed by Marco Dorigo in 1992 in his PhD thesis [9].

This algorithm has been derived based on the foraging behavior of ants. Ants find the shortest path from their nest to the food source. They lay down pheromone trails on the path travelled by them which other ants use to follow for food source. This type of indirect communication via the local environment is known as stigmergy. Figures 1 through 6 illustrate the above mentioned fact.

Foraging behavior of Ants

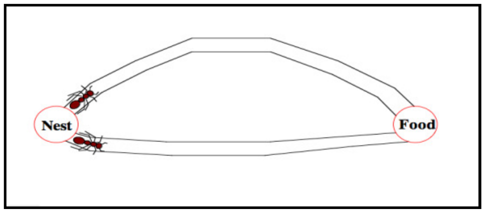

Fig. 1. Ants moving out in different directions

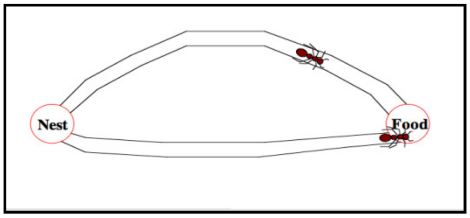

Fig. 2. The shorter path

In fig. 1, two ants start from their nest but on different paths to reach the same food source and as they travel, they deposit pheromone along their path.

In fig. 2, one can see that the ant on the shorter path has reached the food source, so, it will have a shorter to-and-fro time from its nest to the food source while the other ant is still on its path to reach the same food source, so, it will take more time to reach the food source and hence greater to-and-fro time from its nest to the food source.

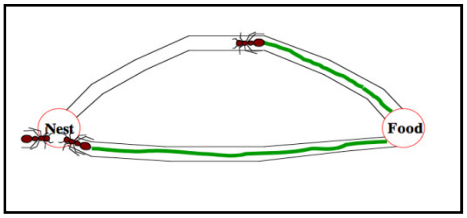

Fig. 3. Pheromone deposit density

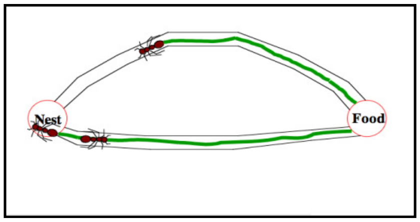

Fig. 4. Path taken by a new ant

Fig. 3 illustrates that the amount of pheromone deposited on the shorter path is more because 2 passes have already been covered by the ant on the shorter path.

In fig. 4, the next ant takes the shorter path from the nest because of more pheromone deposit on the shorter path.

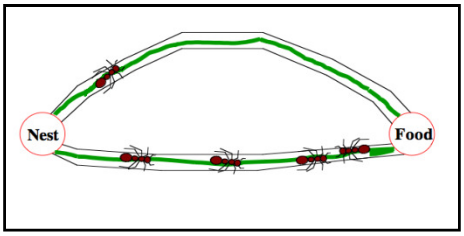

Fig. 5. Path taken by more ants

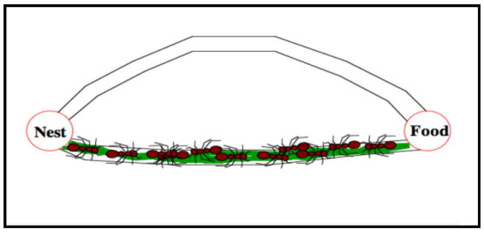

Fig. 6. Optimal path for ants to the food source

In fig. 5, it can be noticed that as more and more ants take the shorter path, higher becomes the pheromone deposit on the path, thereby strengthening the shorter path.

Finally, as illustrated in fig. 6, the shorter path becomes the final path for all the ants of the nest [10].

The idea of the ant colony algorithm is to mimic the above behaviour of real ants with "simulated ants" walking around a graph to solve a problem. The following mathematical interpretations explain the concept.

Let us assume that there are some simulated ants in a graph *G(V,E) where V is the set of vertices and E is the set of edges.* Now, finding the shortest path in this graph to solve a problem using *Ant Colony Optimisation* algorithm works as follows:

Simulated ants move from vertex to vertex to solve a problem, in turn, making a route. When an ant finds a route *s* from its point of origin v_o to the destination v_d, the ant releases pheromones $\tau_{i,j}$ corresponding to all edges $e_{i,j} \in s$. The pheromones deposited by *m* ants is given as

$$\tau_{i,j} \leftarrow (1-p)\tau_{i,j} + \sum_{k=1}^{m} \Delta\tau_{i,j}^{k}$$

where, $\tau_{i,j}$ is the amount of pheromone deposited on the edge $e_{i,j}$ on the path s, *p* is the pheromone evaporation coefficient, and $\Delta\tau_{i,j}^{k}$ is the amount of pheromone deposited by k^{th} ant and is given by,

$$\Delta\tau_{i,j}^{k} = \begin{cases} Q/|s| if\, e_{i,j} \in s \\ 0 otherwise \end{cases}$$

where Q is a constant.

The remaining simulated ants objective is to follow the same route *s* from vertex v_o to v_d. They do so by the following rule:

The probability of an ant *k* who is at vertex *i* to go to vertex *j* is defined as follows:-

$$p_{i,j}^{k} = \begin{cases} \dfrac{\tau_{i,j}^{\alpha}\eta_{i,j}^{\beta}}{\sum_{e_{i,j}} \tau_{i,k}^{\alpha}\eta_{i,k}^{\beta}} & if\, e_{i,j} \in N(s^{p}) \\ 0 \; otherwise \end{cases}$$

where, s^p is the partial solution of s, $N(s^p)$ is the set of vertices that must be passed through to visit s^p, $\eta_{i,j}$ is the inverse heuristic estimate of the distance between vertex i and j, α is a parameter to control the influence of $\tau_{i,j}$, and β is a parameter to control the influence of $\eta_{i,j}$.[11]

ii. Artificial Bee Colony algorithm

It is a population based optimization algorithm based on the intelligent foraging behaviour of honey bee swarm. It was proposed by Karaboga in 2005. As per this algorithm, the bee colony consists of three groups - employed bees, onlookers and scouts. Employed bees are the ones who are responsible for bringing food for the entire colony. For each food source, one bee is employed. They go to the food source that is there in their memory and compares it with a neighbouring food source on the basis of the nectar amount it contains. If the nectar amount of the new one, i.e. the neighbouring food source, is higher than that of the previous source, the bees memorize their new source position and forget the old one. Otherwise they keep the position of the one in their memory. They come back to the hive and go to an area in the hive called the "dance floor", and perform a ritual known as the waggle dance. Through the waggle dance, the employed bees communicate the location of their discovery to the idle onlookers. Onlookers are the ones who watch the dance of each of the employed bees and choose food sources depending on their dances.

The length of the dance is proportional to the bee's rating of the food source. The employed bee whose food source has been abandoned becomes a scout and starts searching for a new food source.

The step wise representation of the algorithm is as given below.

- Initialize food sources for all employed bees

- REPEAT
  - Each employed bee goes to a food source in its memory and compares it with a neighbouring food source, on the basis of its nectar amount.
  - If (nectar amount of the new source > nectar amount of the old source), then, the bee memorizes the new source position and forgets the old one else she keeps the position of the one in her memory.
  - They come back to the hive and go to an area in the hive called the "dance floor", and perform a ritual known as the waggle dance to communicate the location of their discovery to the idle onlookers.
  - Each onlooker watches the dance of all the employed bees and chooses one of their sources depending on the dances.
  - Abandoned food sources are determined and are replaced with the new food sources discovered by scouts.
  - The best food source found so far is registered.
- UNTIL (requirements are met) [12]

iii. Proposed People Extraction Algorithm

Let us assume that a large area has been flooded with water and lot many people are stuck in it. Also, the flood is accompanied by heavy rainfall and thunder storm. (*Worst Case Scenario* of Phase I). Now, going by the guidelines laid out in the beginning of the proposed method, Phase I, cannot be carried out by the rescuers. Hence, they have to move to Phase II. Here, again, let us assume, that, they have comparatively less number of *motorized inflatable rescue boats* (second constraint of Phase II), say 3 for instance, which they have to use again and again until all the people are rescued or some more *motorized inflatable rescue boats* come to their help to rescue all the people quickly. Let us designate these boats as A, B and C for convenience of understanding this algorithm.

In this case, following Ant Colony Optimization (ACO), the three boats can move out in different directions but unlike ants they cannot lay down pheromone trails on their path, as a result, prior to moving out in different directions on water, they need to appoint someone who will do the job of an onlooker like the ones in case of Artificial Bee Colony algorithm. This onlooker cannot be a rescuer as because all the rescuers are needed to save people. Rather, a rescue trainee, who is in the process of becoming a rescuer, can be allotted the job of an onlooker.

Here, the onlooker's job will be to wait for information from the rescuers in boat A, boat B and boat C once they come back with flood survivors and take decisions based on the information received. For example, the rescuers on boat A come back with flood survivors, drop them safely on land and inform the onlooker that they need to go back again in water as because they had found more people stuck in flood whom they could not accommodate owing to unavailability of space in the boat, in the vicinity of the area (*target location*) from where they had picked up other flood survivors. The onlooker will take a rough estimate of the number of people still in water in A's area and let boat A move out again. The rescuers in Boat A move out by memorising the target location so that, when they are in water they must know exactly where to go and pick up survivors. This process will be repeated by rescuers of boat A as long as there are people to be picked up from the vicinity of the area from where they had picked up people last. In the meantime, let say, boat B arrives with flood survivors, drops them safely and informs the onlooker that it does not have any more survivors left in its area. Then, in that case, the onlooker can guide boat B to move in the direction of boat A, otherwise boat B can wait for boat A to arrive and then both can move out together. Let say, boat B waits for boat A to arrive. When boat A arrives again, both boat A and boat B will move out in water because boat A had found some more people in its area or in its vicinity whom it could not pick up. This time, after their departure, boat C arrives with flood survivors, drops them safely and informs the onlooker that it had no more survivors left in its area. Then the onlooker can ask boat C to become a scout and move out in a new direction in search of more flood survivors. Now, if more *motorized inflatable rescue boats* (designated by D, E, F etc.), which were not there earlier, arrive later in the situation, they can also be guided by the onlooker in the same way as it did to boat B and boat C so that the area which has more survivors still in water can be cleared up quickly.

In general, we can state from the above mentioned scenario that each of the boats will retrace back to its target location as long as there are survivors to be picked up and they will be accompanied by those boats who have cleared up their areas and had no more survivors left to be picked from their areas or their vicinities under the guidance of the onlooker who tells the free or available boats in which direction to move next and follow which boat or wait for a particular boat to arrive and then follow that boat or else become a scout to look for flood survivors in some new directions.

The stepwise representation of the people extraction algorithm is as follows:-

Input: *The number of motorized inflatable rescue boats.*

Output: *The number of people saved in time t.*

Algorithm:

```
Step 1: START
Step 2: Make a rescue trainee as an onlooker.
Step 3: DO
        Step 3(a): All the available boats with rescuers in them will move out in different directions in search of people stuck in flood.
        Step 3(b): Rescuers in the  boats will pick up people as they comes across in water on their path and will go on doing so as long as they have space in their boats to accommodate people.
        Step 3(c): When the boats gets filled up they will come back on land, drop them safely.
        Step 3(d): If the rescuers found some more people stuck in flood who they could not accommodate owing to unavailability of space in the boat, in the area or its vicinity from where they had picked up other survivors then
```

```
            they will give an estimate of the number of people still out there in water to the onlooker
        before returning to the target location
        else
            they will stay back and wait for the onlooker's decision.
        Step 3(e): Based on Step 3(d), the onlooker can decide as to how to utilise the boats that have come back
        with flood survivors and are not returning as they did not find any more flood survivors. That is, the
        onlooker will put aside some available boats to accompany those boats which are repeating the to-and-fro
        process of picking and dropping people due to high flood survivor density in their areas on their return to
        speed up the people extraction process and the rest of the available boats will be made as scouts to explore
        some other areas in search of people.
        Step 3(f): If some extra boats arrive later in the situation, which were not there earlier then
            they also can be guided by the onlooker in the same way as it did in Step 3(e)
        WHILE (all the flood survivors are not extracted)
Step 4: STOP
```

IV. CONCLUSION

This work proposes a novel approach by using the idea of swarm intelligence in saving people but situations like flood cannot be mapped onto paper with one or two case scenarios and requires many more case scenarios to be considered to generate an optimal swarm based algorithm in tuning the performance of the rescue personnel. The future work will focus on this aspect.

REFERENCES

[1] http://en.wikipedia.org/wiki/Swarm_intelligence

[2] http://staff.washington.edu/paymana/swarm/ krin k_01.pdf

[3] http://www.scholarpedia.org/article/Swarm_intell igence

[4] Wang Jian – qun, Guoxu-yang, "Application of particle swarm optimization in flood optimal control of reservoir group", 2010 IEEE Fifth International Conference on Bio-Inspired Computing: Theories and Applications (BIC-TA), pp. 856 – 859, 23-26 Sept. 2010

[5] M.Janga Reddy and S.Adarsh, "Overtopping Probability Constrained Optimal Design of Composite Channels Using Swarm Intelligence Technique", http://www.academia.edu

[6] Meraji S.H., Afshar M.H., Afshar A., "Optimal design of flood control systems using particle swarm optimisationalgorithm",International J. Industrial Eng. And Production Management(IJIE), Vol. 19 , No. 8-1, pp. 41 To 53, 2008.

[7] Wei Huang and XingNan Zhang, "Projection Pursuit Flood DisasterClassification Assessment Method Based on Multi-Swarm Cooperative Particle Swarm Optimization", Journal of Water Resource and Protection, Vol. 3 No. 6, pp. 415-420. , 2011.

[8] https://www.ncdps.gov/Index2.cfm?a=000003, 0 00010, 000023, 000487, 000597, 001741, 001751

[9] http://en.wikipedia.org/wiki/Ant_colony_optimization_algorithms

[10] www2.fiit.stuba.sk/~pospichal/prednaskaEA_STU…/antcolonyA1.ppt

[11] Morten Goodwin, Ole ChristofferGranmo and JaziarRadianti, "Escape planning in realistic fire scenarios with Ant Colony Optimisation", Springer Science.

[12] http://en.wikipedia.org/wiki/Artificial_bee_colony_ algorithm