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Application of Swarm Intelligence in Disaster Management: A Review

Mohd. Daneel Khan
Student of MCA Dept., L.B.H.S.S.T's I.C.A. Bandra E,
Mumbai, India
e-mail: daneelkhan05@gmail.com

Krantee Jamdaade
Asst. Professor, MCA Dept., L.B.H.S.S. T's I.C.A. Bandra E
Mumbai, India
e-mail: krantee.jamdaade@gmail.com

Dilnawaz Ansari
Student of MCA Dept., L.B.H.S.S.T's I.C.A. Bandra E
Mumbai, India
e-mail: dilnawaz.ansari786@gmail.com

***Abstract*—**The efficient use of Swarm Intelligence in Disaster management is discussed in this paper. Many lives are lost in Disaster affected area, the rescue team cannot reach everyone to rescue them this where Swarm Intelligence can be used. The Swarm Intelligence is a collective behavior to perform multiple task. SI can be used in searching and rescue operation in the disaster affected area, the swarm of Drones and bots deployed to locate the lives and give their exact location so that they can be rescued. The drones can analyze the area a give instruction to the ground bots. Obstacle avoidance can be used for clearing path for the rescue team to reach the location of the stuck person. Bots can combine together and work as one which increases their strength and may clear path. Swarm Intelligence is effective in many areas in Disaster Management.

Keywords*-Swarm Intelligence(SI), Disaster Management, Obstacle Avoidance, Searching Safe Path and Location, Drones and Ground Bots.*

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I. INTRODUCTION

In Year 2015 in Nepal Earthquake nearly killed 9000 people and injured nearly 22000, In Year 2013 in Uttarakhand multi-day cloudburst centered the state causing multiple landslides and devastating floods (3). Due to these disasters many lives were lost and this happened because help could not reach their location. This is where Swam Intelligence (SI) can be used to rescue lives of people where help could not reach. The review is conducted to study the application of swarm intelligence in such disaster management that could help the community.

A. Swarm Intelligence (SI)

SI is used to work on Artificial Intelligence. It is a collective behavior of system to perform a certain task. It is basically using the natural phenomenon like swarm of birds flocking, bee colony, ant colony, firefly and even fish (1) (9) (11). These natural phenomenon shows that these natural creatures work together as a unified system to perform tasks and solve problems which outperforms the vast majority of individual member. We humans do not have the ability to form SI because we lack subtle connection that other species use like fish detect tremors in water, bees use high speed vibration a bird detect motion propagation through their flock. Now we have high speed network this is where the human can form swarm by sharing knowledge and wisdom and work collectively to perform a certain task. Swarm intelligence can also be implanted in robots, drones and mobile devices through this high-speed network.

B. Disaster Management.

Disaster when occurs it causes loss of private, community and public assets most of life is lost. This is where Disaster management people help the area affected disaster by providing shelter, food, saving lives of people stuck. Disaster management is important as it provides aid to the community. These management steps are taken by government, disaster are of two types one is man-made and other is natural disaster; the management team prepares for each type of phenomenon differently and strategic approach is taken. There are times when the disaster management team are not able to rescue lives or they are not aware of stranded people in disaster this is where the disaster management can take help of swarm intelligence (3). Swarm intelligence provides facility to work as a collective system in order to accomplish a certain task.

C. Application

Disaster management can be done using swarm intelligence with much efficiency and accuracy. Most of live are lost in disaster due to help couldn't reach them. There is multiple way of aiding people who are affected by disaster using swarm intelligence. The swarm of learning birds can be used in earthquake where multiple building are collapsed and people trapped inside building information and accurate data is required to make decision this is where the swarm of learning birds can be used to collect the information about the areas and provide accurate data to make proper decision (2) SI can also be use in in searching safe location and show the accurate path to that safe location using Ant algorithm on mobile devices (3) these are some of the few examples of use of Swarm Intelligence to help disaster affected people. Detailed information about the SI in Disaster management is explained below.

II. LITERATURE REVIEW

In this study researcher referred twelve research papers, journals and some articles, based on this review performed.

A. Swarm Robots: From Self-assembly to Locomotionby Hongxing W. et. al.

The collective behavior of robots is known as swarm robots. These collective behaviors can be seen in the insect where swarm of ants work together to form a structure to overcome obstacle. This behavior of insect has inspired

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researchers to form self-assembly swarm robots. The number swarm robots which has similar behavior can be connect together to form a robotic structure with stronger locomotion, sharper perception and stronger working ability. This type of robot behavior can be very useful in disaster affected areas.
Swarm robotic has a collective behavior and similar functions. In the previous research the number of robots were considered to work together and research on self- assembly of robot been done but does not have locomotion ability. The Sambot has the ability to move autonomously And it can assemble itself, the bot is divided into parts, one is active docking interface and other is main body. The active docking interface contains pair of hooks which can dock with four docking grooves on other Sambot.The Sambothas a docking interface with infrared sensor and mechanical designwhich guides and judges weather the bots are in docking state or not which gives the information to docking hooks to lock tightly on the grooves of the other bot. The main body has two pair of infrared sensors which detects the obstacle. Two pairs of infrared sensors which is on all four side of the main body reacts to the approaching infrared sensor for docking on other bot, the bots navigate to the accurate position and adjust itself according to the other bot's position.

The docking is synchronized so there is no interference between the bots. The docking grooves has asymmetric mechanism which helps in synchronized docking. The Sambots selects the worm-driven mechanism for hooks. Sambots can form different structure by docking multiple bots using Self-assembly configuration, the bots can disconnect and re-dock again and through this they can form a certain structure and Self-reconfigure itself without human interaction and adapt in various environment and surroundings; for easy movement of Sambot it contains spring flakes in both the wheel. The active docking interface keeps moving until it detects the signal, when the signal is detected the sambot starts moving in that direction the bot starts moving anticlockwise until it finds the direction for docking on other bot. The bot's locomotion in excellent as multiple Sambots can dock on each other and form a chain-type structure and self-reconfigure itself in such a way that whole multiple bots works together as one. Multiple several successful experiments are conducted on these bots.

This type of robotics can prove to be very useful in disaster affected environment which will help in aiding community(1).

B. Scanning Environmentwith Swarm of Learning Birds: A Computational Intelligence Approach for Managing Disasterby Mehmet E. Aydin. et. al.

This Research considers the scenario of a major earthquake and its aftershock in urban area which is highly populated and upgrades the previously developed low level model architecture. When the earthquake occursin densely populated area with multiple building collapsed and people trapped inside, Information and accurate data is required to make decision that is where Learning birds comes in to collect the data of the area and provide the series of practical decision that can be made by the rescue team by analyzing the environment and structural integrity of build and condition of victims.

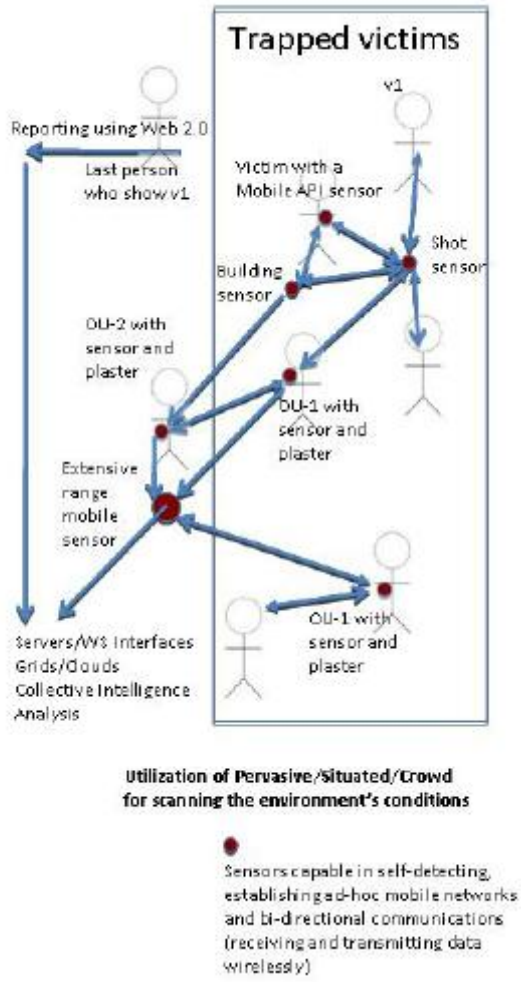

Figure 1. A Low-level Interaction Flow (Source adapted from (2))

In the previous model it is assumed that OU-1 (operational unit 1) has entered the collapsed building in order to rescue to trapped victims an aftershock occurs, and the OU-1 team is trapped along with originally trapped victims, and every member of rescue team is wearing a plaster which records the individual health condition and scans the environment by collecting the data. The rescue team members who are in good condition collect the data at range and buildings also have installed sensors with victims having sensors API installed on their mobile devices. The trapped OU-1 member will detect the sensor nearby and establish limited ad hoc network for communication outside the building for rescue which uses the Grids and Cloud for data transferring. There is a great difficulty in this model, so the model is redeveloped.

Leaning birds are a direct reference to the flock of birds who has collective intelligence. Once the aftershock occurs and rescue team is trapped under the building wreckage there will not be accurate information to act on. The swarm of Learning birds will be used to collect the information which will be a team of small moving robots interconnected with SENSORNET and each robot will have experience of similar environment and will gain more experience to keep itself updated. The swarm of birds will suggest the solution in collective manner so appropriate decision can be made. SENSORSNET is used to monitor physical and environmental condition and stay

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interconnected with radio access. Swarm of learning birds uses Q learning algorithm, PSO Particle swarm optimization, Reinforcement Learning (2).

C. *Finding Safe Path and Locations in Disaster Affected Area using Swarm Intelligenceby Anshul Karasi. et. al.*

In this paper the author emphasized on disaster affected area and how to keep the affected people away from the disaster to a safe location until the help arrives to them. The Author has done research considering the large-scale disaster recently occurred in Uttarakhand where more than 100,000 were stranded.

This research considers the behavior of ants where ant is an agent i.e., person having smartphone who is not able to perform complex task alone but can do it with swarm intelligence. There are multiple agents scattered in disaster affected area, some agents might be stranded while others might be on the safe location. The data is collected from the agent's smartphone from disaster management server which runs heuristic algorithm using behavior of ants to find safer area which then can be shared to other stranded agents it uses stigmergic communication the system uses GPS tracking for paths which can be viewed on Google maps using agent's mobile network.

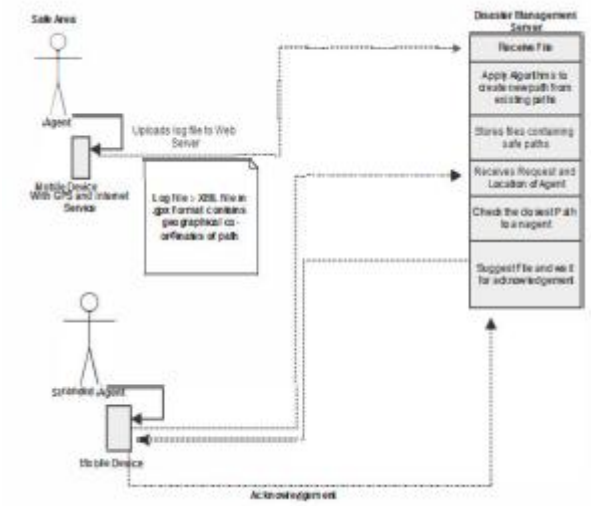

Figure 2. System Architecture (Source adapted from (3))

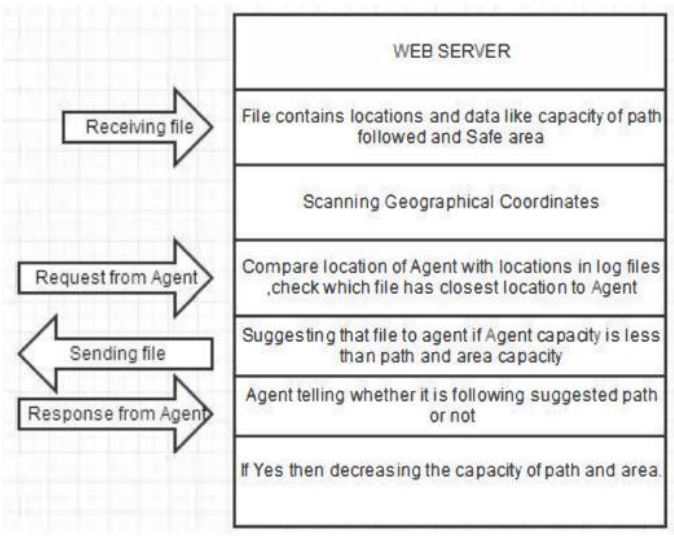

Figure 3. Web Server at work (Source adapted from (3))

The system works like the behavior of ants. Agent alone or with a group of people who is in safe location sends his location to the disaster management server the server runs the algorithm on log file stored and calculate the distance of location, capacity of path and closest path and sends the calculated path coordinate to the stranded agents which is stored in log file. The log file is in GPX format which can be viewed on google maps using apps like GPX logger. If the agent is in the same location, then the server search for other location stored by other agents who already reached to the safe location and direct them to that location if there are two paths close to each other, Then those paths are merged together which creates a new path; if there is no log file stored previously in server then server waits till the agent strays and reaches the safe location just like ants (3).

D. *Received signal strength based dispersion of swarm of autonomous ground vehiclesby Midhun Vijay. et. al.*

ThisResearch is about algorithm for dispersion of swarm of Autonomous Ground Vehicles (AGVs). By using this algorithm, we can find out the unknown place, exact target detection, search and rescue people, mine detection and implantation. Using this algorithm, we can help people if someone trapped in any area and also we can use in military for mine detection and etc.

This Research focuses on dispersion with algorithm of obstacle avoidance, which is required for all other algorithms to perform effectively and accurately. Obstacles Avoidance algorithm gives the optimum distance by using distance sensor which helps robot to identify obstacle and move in the best direction far away from obstacle. Every time robots checks the distance and sensor value at each time and then on detecting any obstacles it avoids the obstacle. The robot moves forward based on the optimum values by using distance sensor, the robot move forward or process the movement in that direction until the obstacle is detected. The obstacles avoidance algorithm is to avoid the collision between swarm obstacles robot while robot in motion moves in particular direction, the obstacles avoidance algorithm is used in sensor which can measure distance or range sensor like ultrasonic, laser or even IR sensor.

RSSI based dispersion algorithm is developed based on the intensity of wireless signal.

By using this algorithm wireless communication is used to share the information or local communication between the robots, In the time of communication the robot exchanges the information between the robots through transmit or receive wireless signal. So on reception of the signal, robots will calculate and receive signal strength parameter called RSSI (Received Signal Strength Indicator)

These bots can be implemented in disaster affected areas by finding the trapped and people who are stuck in disaster. (4).

E. *Swarm Intelligence Optimization Techniques for Obstacle-Avoidance Mobility-Assisted Localization in Wireless Sensor Networksby Abdullah Alomari. et. al.*

In this research it has been seen that in Wireless Sensor Networks(WSN) localization is a big challenge. There has been many researches done to overcome these

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challenges, but in some way or the other these works are not solving the problems completely. Multiple models and algorithms namely SCAN, Hilbert models, Circles, MAALRH (Mobile Anchor Assisted Localization Algorithm based on Regular Hexagon), LMAT (Localization algorithm with Mobile Anchor Node), H-Curve, Z-Curves, etc. have been developed in the last few years to overcome the issues of localization and to optimize it.

In recent years, meta heuristics have been applied in many fields and these denotes the algorithms and frameworks that are designed to deal with complex optimization problems. Two algorithms have been proposed, Grey Wolf Optimization(GWO) and Whale Optimization Algorithm(WOA).

GWO (Grey Wolf Optimization) algorithm that is meta heuristic and it mimics the natural leadership hierarchy system of the grey wolves. They have a special hierarchy that is dominant and divides groups into four hierarchies, and the top level wolves can lead lower level wolves.

WOA (Whale Optimization Algorithm) is a new swarm intelligence optimization model. WAO imitates the social behavior of humpback whales. An interesting social conduct of whales is that they have a unique strategy of hunting, called bubble-net feeding. This algorithm is based on upward spirals.

When these algorithms are applied to MA (Mobile Anchor) certain rules are applied. The network area will be divided into lines virtually, each line has a set of guide points etc. Few factor have been defined to evaluate the success rate of these optimization algorithms for the localization issue.

Localization accuracy is calculated with localization error. Higher accuracy gives assertiveness about the localization estimation. If localization error is low localization accuracy will be higher and vice versa. Average localization error for every movements models are applied. Impact of resolution is also evaluated when there are different maximum distances. Resolution exhibits the relationship between the communication range and the distance between every two points.

The proportion of localization errors smaller than certain threshold error value is called localization precision. There are five precision values considered here: less than 1 m, less than 3 m, less than 5 m, less than 7 m, and less than 9 m. Where m is localization error.

Localization ratio, or coverage, indicates the number of local nodes divided by the total number of nodes. High localization ratio gives the impact of how successful the path planning is.

Computational time has also been evaluated, it refers to the amount of time spent in the first execution of the code till it ends. Computational time is calculated in seconds.
In this research two obstacle avoidance path planning models, called GWPP and WOPP for mobile anchor-assisted localization in WSNs. These algorithms work on real-time information from the network. These models work on optimizing the paths by avoiding the obstacles located in MAs and path they also design an optimized path when MA has limited movements (5).

F. Formal analysis in a cellular automata ant model using swarm intelligence in robotics foraging taskby Danielli A. Lima. et. al.

The concept of foraging is defined in as action for searching an object and homing it in nest. The multi-agent system is design for adapting any application like search and rescue, garbage collection exploration, cover and surveillance. The strategies for multi-agent provides the separation of the task equally over each agent as well as provide provides cooperative behavior. The foraging task is divided in two parts searching and homing. Foraging task are used for search and rescue for any object. The foraging task is used for searching an object in environment and grab that object then send it back to the nest. There steps are as follows for searching object. Steps are searching, grabbing, homing, depositing, and again searching if there any object remains in environment.

In a foraging task when robot is in searching state if any object is detected in a robot's radius then robot goes in grabbing state then the robot makes a movement towards the detected object. Once robot reached to the object robot picks up the object and then it goes into homing state during the homing state robot find the nest, if robot finds the nest then robot goes in depositing state. If there are no objects present in the environment, then the process is finished.

The representation of bi-dimension in environment is structured and divided into regular cells and in two layers. The environment is represented as first layer, where each obstacle and the pheromone are detailed. The smart grid is represented as second layer. Individual finite state machine controls the behavior model of each robot which switches in four state cycle: searching->grabbing->homing->depositing->searching (6).

G. Cooperative bat searching algorithm: A combined perspective from multiagent coordination and swarm intelligenceby Haopeng Zhang. et. al.

This research discusses about Bat Searching Algorithm and Cooperative Bat Algorithm. Bat searching Algorithm is developed in recent year in (SI) which is based on optimization algorithm it took inspiration from real world environment of bat as they have echolocation ability.

In cooperative bat searching algorithm the conversion rate is faster as compared to previous bat algorithm and few modifications are also done

This bat searching algorithm gives the increased diverse solution by frequency-tuning technique of population which balances exploitation during the process of search which mimic multiple variation of pulse emission rate and loudness of bats it uses automatic zooming.

Bat searching algorithm is improved in performance by introducing multiagent coordination idea.

Bats provide accurate and best solution as well as exchange the current velocity information using communication graph topology.
the cooperative searching technique essentially change the original bat searching algorithm by introducing communication topology to share their information in real time (7).

H. Swarm intelligence based image fusion for thermal and visible imagesby Bhavna Bharath. et. al.

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Image fusion is a process of merging images together to get good visualization of the area for analysis. There is multiple image fusion technique but each technique has certain drawbacks. Thermal images are images are obtained from infrared waves because of heat production and visible image is obtained from the reflection of light. Processing image is a complex and difficult task for visual image and are captured in condition which are not ideal, thermal image is not affected in any condition and light illumination.

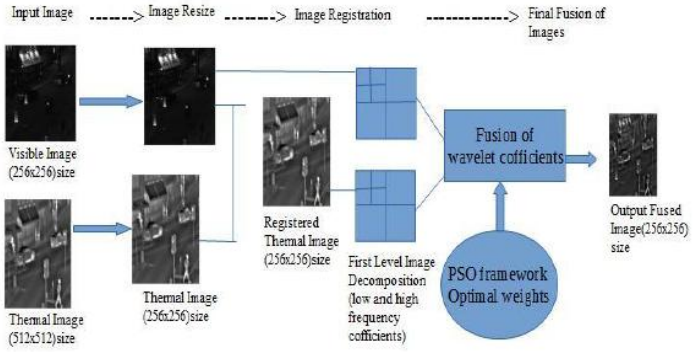

Figure 4. Architecture Diagram (Source adapted from (8))

Thermal images are used in military and medicine and in many other areas. Both image have their own quality so merging these image would provide image with much more detail and these image will not loose and imaging detail of curve along with edges. The author describes the major drawback of existing image fusion MRA (Multi-resolution approach that it loses the data of edges along the curve and these algorithms only merge the image data together without examining the source of image or weighing it. To overcome these drawbacks and to improve state-of-art fusion methods an optimized image fusions framework is introduced which will generate an accurate and detailed image which is rich with information and there is minimum root mean square error(RMSE). The first step is Image Resizing as our target image is Thermal image so it has to be of the same size as of the visible image which is reference image, the resizing of image uses Bicubic interpolation which calculates weighted average of the pixels that belong to the nearest 4 by 4 neighborhood this image gets sharper by this technique.

Image registration is an important step as data is coming from different sensors, devices and depths which make data comparison easier also corrects geometric distortion. Image Decomposition using curvelet Transform helps in preserving the corner and edges in an image and maintain geometric properties of structure. Determination of optimized Weights using PSO is a computational approach it uses the mathematical approach to find the solution of the problem by taking multiple alternate solution or particle when the best solution is calculated an optimized weight of an image is used to form the final fuse image with maximum information content and minimized error. Image Fusion is the final step where image is fused by computing inverse curvelet transform which contain detailed corners, edges, points and curves and less information loss.

This image fusion technique can be used in various disaster affected areas like Flood, Earthquake etc. To get the detailed image of the stuck and trapped lives in the affected area or with the help of drones(8).

I. Implementation of swarm intelligence in obstacle avoidanceby Dankan V Gowda. et. al.

The implementation of swarm intelligence is done for obstacle Avoidance in cost and time effective manner. Swarm is in general means a large group of insects especially ants, honey bees etc. Study of Swarm intelligence is based on artificial intelligence which works in collective behavior of decentralized and self-organized system.

There are three robots considered in this research which have master and slave relationship. Out of these three one robot is considered as Master and other two are Slave. The Master robot is a server bot which contains ultrasonic sensors (HC-SR04), Xbee Series 2, Arduino UNO R3, Motor driver IC (L293D). Where moto driver helps in locomotion of bots. Arduino UNO Acts as a thinker. The Slave bot which is a client bot does not have the sensor the data is shared from Master to his Slave which is client to avoid the obstacle using Xbee's using serial communication. The Master which is server bot is made to move freely in the space where server will avoid the obstacle through its eye which is ultrasonic sensors and through its mind which is Arduino UNO and change the path according to the information collected by the server and this information is then directly shared between the client and they will act according to the server information and change the path which will save time, power etc. The distance between the obstacle and Server bot is dependent on how much time receiver of ultrasonic sensor takes to receive the triggered ultrasonic wave or signal.

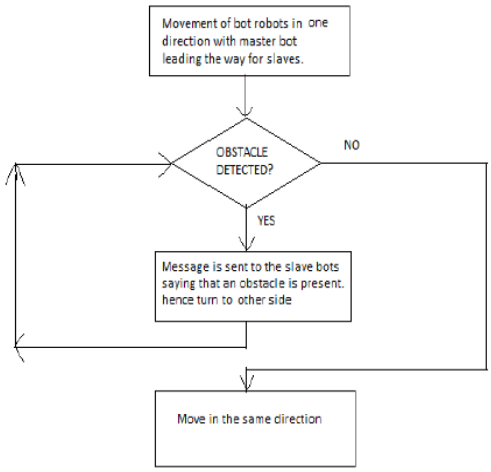

Figure 5. Flowchart of the proposed systemv(Source adapted from (9)

This Obstacle Avoidance with swarm intelligence can be very useful and time efficient in disaster management. In case of earthquake or fire in building these bots, can be deployed to make a clear path for rescue team to rescue people (9).

J. A cloud based autonomous multipurpose system with self-communicating bots and swarm of dronesby Himadri Nath Saha. et. al.

In this paper the author stresses on the capability of swarm intelligence with drones and bots and its use in various areas like agriculture and disaster management. Swarm Intelligence is a part of artificial intelligence which is rising area in collective robotics that uses completely distributed control paradigm and comparatively easy robots to attain coordinated behavior at the cluster level, swarm intelligence is generally

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adapted form biological study of insects, ants and other fields in nature wherever a swarm behavior happens.

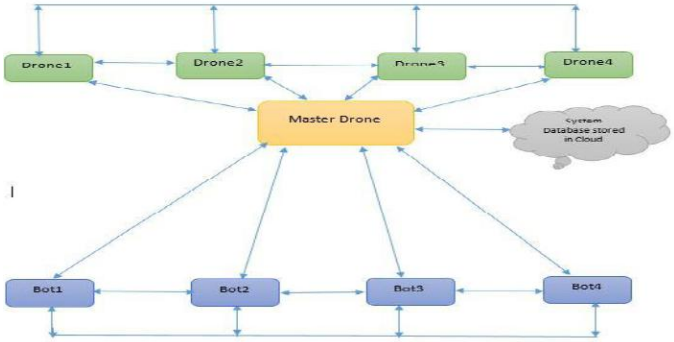

Figure 6. Model of proposed system (Source adapted from (10))

This Research explains the background study of swarm intelligence and proposed the system where there are bots on the ground level which collect the relevant information of the area and send that information wirelessly to a single flying drone which is Master Drone and the master drone will store the data containing information in Cloud. The Master Drone will analyze the data and give relevant instructions to the ground bots as well as to the other drones which are with the Master Drone, the information which is collected is important and should be confidential, so the researcher says they have their own Cloud ESXi Database instead of using public Cloud storage. The Master Drone is preprogrammed with different expert test cases to take the correct action which should be taken with the provided information. The author takes Case 1 (Here the information flows from the bots to the drones initially) of agriculture where ground bots have moisture sensors, gamma sensors etc. Where they can check the condition of crops and send the information to the master drone which will then give necessary instructions to the ground bots as well drones the, drones will follow the commands and direction given by the Master Drone they may also interact with each other if necessary to achieve the intended task e.g. Drones here may spray required amount of pesticides as well as fertilizers on the agricultural field under inspection. Case 2 (Here the information flows from the drones to the drones initially) in case 2 the author takes example of disaster where the drones having UAVs with GPS and other sensors differ in functionality to collect data of the area where disaster occurred by capturing photo from different angle and source, looking for a stuck living body or human through thermo-cam attached to it. The collected information will be sent to the Master Drone via wireless network and stores the necessary data in Cloud ESxl database as well as gives command and exact latitude and longitude of the specified region to the ground bots to take necessary action the bots will then follow the command of Master Drone and interact with each other to accomplish the intended task. For e.g. the bots may help in rescuing stuck human lives from a battle field or a disaster scene(10).

III. METHODOLOGY

An efficient and accurate methodology used in application of SI for disaster management play an important role for serving the community. There are several methods used in following papers that discussed here.

A. Searching Safe path and location

Searching safe path and location to manage the disaster affected plays an important role. When disaster occurs many people in community get stuck in ate area, the rescue team are not able to reach those stranded people. This is why these people who are stuck either stay at their location waiting for help to reach them or they wander away in search of safe locationto dangerous location as they do not know where they are going and lose their lives. Searching safe and location based on Swarm Intelligence can prove to be very useful in these scenarios.

Behavior of ants is considered in searching safe location. As the behavior of ants where on ants goes to a certain location leaving the trail behind so other ants can follow that ant and reach that same location. Similarly, the person with a mobile works as the agent having mobile phone and wireless network which is connected to the server. There might be people already in the safe location this safe location is stored in server in form of log file if there is no log file stored in the server then the server waits until the person strays and reaches the safe location. Server performs computation on this log file and calculatesthe capacity of path, shortest path, distance of location and sends its coordinate to the Stranded person so that person can be saved (3).

The searching algorithm of bats can also prove to be efficient in disaster management. This technique has echolocation ability as of bats in real world. The Bat searching algorithm gives the increased and diverse solution using frequency-tuning technique of population which balances exploitation during the process of search which mimic multiple variation of pulse emission rate and loudness of bats it uses automatic zooming. This algorithm gives accurate and best solution. Bats can find their prey even at night, this algorithm can be used in inspection and search the affected people and inspection of area by sending echolocation (7).

B. Obstacle Aavoidance

Bots can self-assemble and self- reconfigure itself into a particular structure which can save or even rescue a stuck person and bots have ability to move smoothly as it has locomotion ability. These bots can avoid obstacle or even can clear obstacle by self-assemble to make themselves strong enough to move obstacle. These bots have the ability of locomotion so that multiple bots when combined as one can work together these bots are also called Sambots they have sensor to avoid obstacle and work as one robot which increases their strength and can prove to be strong in clearing path and avoid obstacle (1).

Algorithm for dispersion of swarm of Autonomous Ground Vehicles (AGVs) can find out the unknown place, exact target detection, search and rescue people, mine detection and implantation. The Obstacle avoidance algorithm gives the optimum distance by using distance sensor which helps robot to identify obstacle and move in the best direction far away from obstacle. The bots distance sensor detects the obstacle from far away and change its course of direction and calculates its direction. The RSSI base dispersion algorithm disperse helps the obstacle avoidance and searching process as it distributes the information between bots, which makes obstacle avoidance more efficient and can locate stuck lives in disaster affected area (4).

There are two obstacle avoidance path planning models, called GWPP (Grey Wolf path planning) algorithm that is meta heuristic and it mimics the natural leadership hierarchy system of the grey wolves. They have a special hierarchy that is dominant and divides groups into four hierarchies, and the top level wolves can lead lower level wolves. and WOPP(Whale Path Planning) is a new swarm intelligence optimization model. WAO imitates the social behavior of humpback whales. An interesting social conduct of whales is that they have a unique strategy of hunting, called bubble-net feeding. This algorithm is based on upward spirals. for Mobile Anchor-assisted localization in WSNs. These algorithms work on real-time information from the network. These models work on optimizing the paths by avoiding the obstacles located in MAs and path they also design an optimized path when MA has limited movements. These algorithms are more optimized and can avoid obstacle in Disaster affected area (5).

In disaster management the obstacle avoidance technique plays a vital role. It is difficult to locate where person is and how to rescue that person. We can send a swarm of bots to locate lives and save them, there might be many obstacles in the area in that so bots can use obstacle avoidance technique to avoid all the obstacle and reach the location to save lives.

Cost effective and Time effective manner of obstacle avoidance bots is one bot which has Master-Slave relationship with other bots. The Master bot is a server bot which contains ultrasonic sensors (HC-SR04), Xbee Series 2, Arduino UNO R3, Motor driver IC (L293D). Where moto driver helps in locomotion of bots. Arduino UNO Acts as a thinker and the Slave bot does not have sensors to detect the obstacle but share data with Master bot to detect the obstacle usingXbee's serial communication. The Master bot moves freely in environment and detects obstacle with its eye ultrasonic sensors and through its mind Ardunio UNO. The data of Master bot is directly shared with the Slave bots and these bots works accordingly. This process saves time and cost. This obstacle avoidance technique can be used to create clear path for the rescue team in affected area to help community (9)

C. Drones and ground Robots

Drones and ground robots can prove to be very useful in disaster management, these robots can be very useful in in rescue operation and locating people stuck in disaster affected area.

The self-assembly and locomotion robots can be very useful in disaster management. These robots have strength to move and clear path and may even rescue lives because they have ability to combine together and work as one which increase their strength. These bots are also called Sambots. Sambots have the ability to move autonomously and self-reconfigure they also have collective behavior, these bots detect the docking interface of the bot and locks tightly on the docking grooves. These bots can self-reconfigure itselfand work as on structure which increases their strength. Multiple Sambots experiments have been performed on these sambots. These bots can be very useful in disaster management (1).

The Swarm of learning birds can help in disaster managementas these bots interconnected through SENSORNET.

The series on information are required to make decision in disaster management as in Earthquake the rescue team does not know what is the structural integrity of the building these swarm of learning birds are deployed in these areas to collect information like the structural integrity of the building or where the victim is trapped its location and which path to take to reach that victims location. These learning birds are a direct reference to the flock of birds who has collective intelligence. They provide a series of solution of the situation (2).

The ground bots and drones are interconnected wirelessly and there is one Master drone which is connected to the cloud server. These ground bots and drones can aid the community in disaster management. These bots have Master and Slave relationship, there is on Master bot and multiple bots connected wirelessly to each other. In the situation of Earthquake, the Master drone will give the instruction to other drone to analyze the are robots will analyze the area and locate the trapped victims, the master drone will collect all the information and store the information in cloud server. The Master drone will also give necessary instruction to the ground bots to rescue trapped victim (10).

Bots and drones have camera to send images to the server so accurate decision can be taken, but these images are not visible clear. Here the bots a use Thermal and visible Image fusion technique to take much more accurate image of the area. Both image have their own quality so merging these image would provide image with much more detail and these image will not loose and imaging detail of curve along with edges.Which makes the image more visible to be accurate to make decision (8).

IV. RESEARCH FINDING

When the disaster occurs all the network communication are lost, people cannot communicate to the rescue team and the internet connection is also lost because of that the people cannot figure out the situation and how to act. The Swarm of Bots and Drones are deployed this Swarm contains wireless communication for smartphoneswhich they can provide to the affected people and also provide the safest location with the shortest path to reach that location, through this the rescue team will know the location of people but the community will also have the access of network so that they themselves can reach the rescue team or the location.

The Swarm of bots and drones will be able to provide the wireless network from far away and can provide the network to multiple smartphones. Stuck people can communicate the rescue team or can move towards bots location through maps, so bots can rescue them.

V. CONCLUSION

The Swarm of bots and drones can help in multiple ways in Disaster management. These bots and drone can help in obstacle avoidance to clear the path for the rescue team to reach the stranded people. The bots can combine themselves and work together as one which increases their strength and can remove obstacle in the path. The bots can also help in rescuing the lives from disaster affected area by locating them and giving information to the rescue team by providing path and information of area. Drones can scan the area with thermal and visible image fusion which can get clear picture of the area and also give necessary information. SI can also be used in searching safe path and provide the safest location using Ant colony algorithm. SI is very useful in Disaster Management.

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