Fire Evacuation using Ant Colony Optimization Algorithm

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ABSTRACT
ACO is one of all-powerful meta-heuristics algorithms and some researchers have expressed the strength of some applications with the algorithm the evacuation route planning is the key aspect in case of fire disaster.Ant Colony Optimization (ACO) can be used in rescue planning. Altered ACO applied as the algorithm to demonstrate the potential path during emergency rescue. Physical interference during building rescue such as blockage or disaster complication has been studied in transitional probability rule of ACO.There exits multiple route from source of fire to the exit, hence the selection of shortest path is the fundamental objective of evacuation route planning.The objective of the algorithm is to minimizes the entire rescue time of all evacuees.The ant colony optimization algorithm is used to solve the complications of shortest route planning. Presented paper gives a comparative overview of various emergency scenarios using ant colony optimization algorithm.

Keywords
ACO, QACA

1. INTRODUCTION
The current most familiar shortest route algorithms include dijkstra algorithm, bellman ford, krushkal, prim's algorithm, imitated annealing, ancestral algorithm. These conventional algorithms have complicated calculation and also low efficiency. Positive feedback parallel catalytic mechanism is considered in heuristic ant colony algorithm which has good feature of vigorous power and assigned computer. The algorithm presented by the Italian scholar Dorigo who built the ant shared in behavior by mimic the characteristics' of directing a community-based heuristic heroic eloquent systems in the early1990s[3].The design approve limited amend practice andhas made immense advancement after all it was expected[4].

The most important aspect in design of modern world with increasing railways, hospitals, stadiums, building, etc. , is evacuation analysis , i.e., in case of disaster (fire, earthquake, etc.) [7][1]. unfortunately, decision makers are not supported by the complex view of hazards and the various potential exits routes. The situation is more complicated with the fact that, the people who are successfully escaped from the affected area without any contact with the rescue personal, so that the other person will also follow the same path. In addition, the crisis situation is so chaotic and has a dynamic nature, so the path will be changes dynamically with the increases in disaster time. There is no doubt that evacuation route planning to find out the optimal path with minimum risk is often difficult challenging task in the fire evacuation. However, to determine the best suitable task with the low risk is the most important aspect of evacuation route planning. In fact in most of the evacuation scene evacuees are not familiar with the physical structure of disaster place; hence evacuees are not aware of path to follow to reach the exit. This is because the evacuees are not familiar with the physical structure also they do not complete information about the optimal path to the exit. Similarly the rescue personal are also not know the location of evacuees these physical condition and the some other factors like the degree of temperature, flames of path to be considered by the evacuees and the other various obstacle that can appear dynamically in the path of evacuees to the destination exit. This makes evacuation route planning particularly difficult [5].

2. ANT COLONY OPTIMIZATION ALGORITHM
Ant colony optimization algorithm is a heuristic algorithm. It is deliver on the probabilistic technique to search the latter clot after initiation. It creates some meta heuristic optimizations. It is based upon real behaviour of ants searching route from their colony to a origin of food after finding source of food ants return back to their nest while laying down some chemical called pheromone trail. The probability of choosing that same path by other ants is depends upon the amount of concentration of pheromone trail on that path. However, the trail starts evaporate, and the probability of choosing that particular path starts reducing. The more amount of time will take to travel down the path, more amount of pheromone trail evaporate. The pheromone is also considered to be as communication medium among ants during their journey.

We considered the rescue initial node to be as ant den and the exit node to be as food sources that ants stare for. The ant starts randomly from any node and move to next based upon probability, and will terminate on reaching exit node.

2.1 Edge Selection
The colony of ants constructs a solution iteratively wherever the intermediate state is considered to be as solution state. At each iteration of algorithm, the ant act from estate i to estate j, which corresponds to further entire result. For each ant k, the probability pij k from state i to state j depends upon two values, viz., 1. The amount of trail level which indicates the desirability of that move. 2. $\eta_{i\ j}$defines the heuristic which indicates the visibility of that act.

The η_{ij} are amend only when all the ants have gross their solution, the decreasing or increasing value of trail analogous to move considered being as "bad" or "good" solution. In general k^{th} ant act from estate i to estate j.

$$P_m(i,j)=\begin{cases}\dfrac{\left[\tau_{(i,j)}\right]^{\alpha}\cdot\left[\eta_{(i,j)}\right]^{\beta}}{\sum_{k\in S_m(i)}\left[\tau_{(i,j)}\right]^{\alpha}\cdot\left[\eta_{(i,j)}\right]^{\beta}} & if\ \ j\in S_m(i)\\ 0 & otherwise\end{cases}$$

$\tau_{(i,j)}$j is concentration of pheromone on that path from state i to sate j , $\alpha \geq 0$ and $\beta \geq 1$ are the control parameters that control influence the of $\tau_{(i,j)}$, η_{ij} that is the preceding insight typically $1/d_{ii}$, where d is the distance. $\tau_{(i,i)}$ and η_{ii} represent the allure and trail level for the alternative possible state evolution.

2.2 Pheromone Update

The pheromone trail updated only when all the ants have gross their result, the trails are amend as:

$$\tau_{(i,j)} \leftarrow \rho\cdot\tau_{(i,j)}+\Delta\tau_{(i,j)}$$

η_{ij} is the concentration of pheromone trail (essence) that is accumulate for a state transition , ρ is the pheromone dispersal coefficient and $\Delta\tau_{(i,j)}$ is the amount of pheromone accumulated by k^{th} ant.

3. LITERATURE REVIEW

In last few decades there were number of publication that discussed the concept of feasible route determination in case of fire using ant colony optimization algorithm and its related techniques. In this section of paper survey of various emergency evacuation scene and related work has been done.

Arief Rahman et. al. 2007 In [1] describes an emergency condition, most complex aspect is how to chose the minimum path from multi exit in multi-floor building. The presented paper demonstrates the use of ant colony optimization algorithm in rescue planning. This paper uses modified ant colony optimization algorithm applied to find out feasible route during emergency conditions. The probability of choosing next node also considered the disaster problem or the bottleneck during emergency. In the simulation of algorithm the agent is defines as an exit sign who concludes the feasible routes and also guides other evacuee during rescue. Hence the modified ant colony optimization algorithm with exit sign has faster total evacuation time as compared with the familiarity of environmental exit method.

To demonstrate the optimal route during the evacuation route planning the modified ant colony optimization algorithm with the agents' architecture including (agent occupant, agent exit sign, agent corridor and the agent staircase) has performed much better. The decision making during emergency evacuation quickly follows the occupant instinct and the paper not only determine the minimum route but also determines the shortest route.

Naiwei Cheng et. al. 2009 In [2] presented paper defines an improved ant colony optimization algorithm for the dynamic evacuation route optimization. The fundamental ACO algorithm is modified in the terms of table list and the termination criteria for the simulation of human evacuation process within a building according to environmental changes the risk analysis identified the lowest risk route. The proposed method in this paper has remarkable improvement in the ability of exit system and also including the casualties caused by the fire.

The transitional probability of the modified ACO algorithm can be defines as:

$$P_{opt}=\arg\min\sum_{<i,j>\in E}\omega_{ij}$$

$\omega_{ij}=l_{ij}*(aT_j+b+c\rho_j)$

Where Tj, tj, ρjburning time, temperature and adverse gases of any point j where a, b ,c are the weight coefficient corresponding to the edge. Hence, the paper validate that the dynamic route evacuation problem can be solved through improved ACO algorithm. The evacuation route calculated for the different problem sizes for improved ACO algorithm is also investigated for? Stability and the resulted convergence have faster and high stability.

The designed fire rescue system based upon ant colony optimization algorithm cannot determine route dynamically when the environmental conditions changes due to fire. So the fundamental ACO algorithm improved and merged with fire evacuation route planning system. To determine the minimum path and also control lightning intersection on Map X establishing the floor topology is main task of fire evacuation system. This paper presented the case where fire occurs and the algorithm computes shortest path to control lights and the dynamic instructions.

In this evacuation system was established through ACO algorithm Map X. In case of fire, for each point the shortest evacuation path is calculated using five points, lamp status was shown on Map X and also actual test is carried out for the truth and efficiency of knowledgeable fire structure. Hence the modified proposed design would emerge sub-optimal evacuation path.

XinluZong et. al. 2010 In[4] discussed Planning routes for an emergency situation is an important aspect for emergency rescue planning. A multi intention model is defines for multi-exit evacuation using ACO algorithm. The proposed algorithm defines route in a multi-exit building. The two objective of the model are: 1. minimizes the total path crowding degree 2. Also the total evacuation time for are the evacuees respectively.

The model is formulated using some constraints are defines for an emergency network dwell of a directed graph $G(N, A)$, where $N = \{1,2,..., n\}$ is the bent of clots and $A \subseteq N \times N$ is the bent of arcs. The criterion described as follows: I is the index of grid clots, M is figure of rescues, d_{ij} is the gap form span(i, j) to unsafe region k, $t_{ij}$is the time drive over span(i, j) of evacuee k under panic position, $crowding_{ij}$is the people mass degree of arc (i, j), $Path_k$ rescue route of evacuee k, s0 is the starting clot of rescue v^k_{ij} (t)is the velocity of evacuee k on arc (i, j), v_{ij} (0) evacuation speed on arc (i, j) under ordinary situation, l_{ij} is the diameter of span between clot i to clot j, $N_{ij}(t)$ is the number of rescues on arc (i, j) at time t, C_{ij} is the road size of span (i, j).

In this paper, the proposed model with the two objectives defines for talking complex multi-exit evacuation problem. The experimental result shown that there are set of non-dominated solution a bit than signal objective optimization. However the non-dominated solution proves helpful to choose flawless rescue plan that verifies the two intention. The simulation result display that the model and the modified ACO algorithm can plan efficient, brisk and intact paths for all the evacuation.

Changbo Wang et. al. 2011 In[7] discussed Emergency rescue has many functions in computer animation, safety science, constructive reality, construction planning etc. However, current simulation methods have mostly focus on the agent-based modeling. The human behavior and their reliabilities are doubtable are not found in the result of simulation. The most complex aspect of method of simulation environment is to mimic the big-scale mass in real-time and authenticate the evacuation records. On the basis of analyses the human behavior characteristics of in emergent situation, a ant colony evacuation model based on mixed geometry-based is firstly proposed. The best evacuation path can be calculated considering the human's ominous time, autonomous avoidance, and preferential route selection. The empirical results displays that the presented algorithm has an effective method for the simulation of big-scale mass in real time, because the approval proves that simulation is decisive as well as making virtual scene realistic and simulate logical human behavior.

As per to the various characteristics of big-scale crowd rescue, proposed paper presents a physical approach for realistic modelling and translation the rescue in real time. From the analysis compared using performances, it is prove that proved approach is rapid, highly scalable, and can be good proficient compared with hundreds of thousands of casts' rescue in absolute time. Future work includes: includes the security of model seeing multilayer rescue and the other factor such as influence of smoke, etc; to broaden the solution domain of our model different formulas of behavior have been combined, while diminishing the computational amount and developing the scalability of the fluid solver, etc.

Pengfei Duan et. al. 2012 In[5] describes the most complex aspect to rescue mundane perfectly in big public architecture under panic situation. In this paper a multi intentional optimization model is proposed planted on heuristic ant colony algorithm for an emergence eviction. This model has two intentions is to diminish the entire route mass intensity and to diminish the rescue approval time. The ant colony algorithm defines heuristic into account the gap between the unsafe or safe goal and the evacuees. In addition, to mimic the whole rescue process this model is applied to a huge gymnasium. Experiments prove that results are realistic that studied the rescue' true feedback to the discipline are control. With this model the process of simulating the mundane exits, the algorithm results display the likely results, and provided a basis for the scientific guiding for the real evacuation process.

Feng Zhang et. al. 2013 In[6] discussed the optimization of rescue route in the hazard area exercise an vital act in diminishing social harm and preserving assistance time the human. In this paper, a traditional ant colony optimization algorithm modified for emergence rescue route selection based on quantum ant colony algorithm (QACA) is presented, and it speeds up the confluence to the comprehensive optimal result and also avoids premature convergence. In the proposed algorithm, the pheromone is represented by Q-bit is, the pheromone is updated by using and the rotation gate. The mimic solution show for the presented algorithm is proved to be feasible and effective. in the case of emergency evacuation Optimization algorithms placed on flock brilliance has been generally used. To compute the problem of confluence using basic ant-based path selection algorithm, ant-based route selection algorithm was modified as quantum algorithm. The emergent environment describes using directed graph, then quantum ant colony algorithm (QACA) is presented algorithm for emergence evacuation route selection. The Simulation of proposed algorithm results proves that simulation was feasible and it also speeded up confluence rate to a big grade.

Jang Yang et. al. 2014 In[3] discussed an emergency, the most complex aspect of emergency evacuation of pedestrian of safely from the large multi-floor public building. The ant colony optimization algorithm is defines for the multi-objective optimization model for the problem of evacuation. The first objective of optimization model is to diminish the evacuation approval time and the second intention of the model is total path crowding degree should be minimum. The heuristic ACO algorithm considered the distance between the evacuees and the safe targets or the dangerous places. Also the traditional probability is taken in terms of some factors are 1. Crowding degree of path 2.The distance between current and the dangerous node 3.The distance between current and safe nodes 4.The velocity of evacuees. In addition, the proposed model in this paper is paper is applied to large stadium, in order to prove effectiveness of model real responses to interaction are considered for the evacuees. The experiments result shown the feasibility of the heuristic algorithm.

In this paper, the ant colony algorithm enforced for the computation of smallest rescue route. Under normal chances each indicator lamp has ordinary situation. But under emergence circumstances, the ant colony algorithm is applied for calculation of shortest path and visible on the flooring outline. This lamp indication discipline structure can achieve better index to the rescue route and also reduce people and assets destruction. However sub-optimal path would emerge out using this algorithm.

4. COMPREHENSIVE COMPARITIVE TABLE

PAPER	PROPOSED WORK
Arief Rahman et. al. 2007	Using ACO algorithm developing an agent (exit symbol), and the agent act as an decision maker decides the feasible route and directs the evacuees during an emergency evacuation.
Naiwei Cheng et. al. 2009	Ant colony algorithm is revised in the terms of tabu list for pheromone trail and terminating criteria. As per dynamically change of nature probability of minimum risk is determine by risk analysis for upgrading the adaptability of the rescue system and slow down Accident caused by a fire.
Xinlu Zong et. al. 2010	The two intention of the model is to diminish the entire rescue time of all rescues and also to diminish the complete route evacuees' mass intensity appropriately.
Changbo Wang et. al. 2011	Through reasoning the essential of human act in emanate condition, a collective geometry-based ant colony algorithm for evacuation model

	is initially and firstly presented. Then, many acts of human are studied to calculate the best rescue route, including sovereign avoidance, human's cautioning time, and preferential path selection.
Pengfei Duan et. al. 2012	The both intention of this model are to diminish the rescue sanctioning time and to diminish the entire route mass intensity. The heuristic ant colony algorithm takes into consideration the spans between the rescuees and the formidable or safe goals.
Feng Zhang et. al. ,2013	a innovative algorithm for emergence rescue route selection based on quantum ant colony algorithm (QACA) is presented, and it neglect immature confluence and boosts up the confluence to the overall excellent result.
Jang Yang et. al. 2014	The ant colony algorithm merged with the fire rescue structure to calculate in timely manner the minimum route and controlling the lighting discipline which is displayed on this structure within this paper. By developing each flooring topology on MapX, and put lighting, care export was set relating to geographical informative environment.

5. CONCLUSION

In this paper, a review on existing ant colony algorithm for solving the various rescue route optimization problem. It will be the imminent guidance of the fire automation to merge it with ant colony algorithm. Rescue complication usually demands to amend different intentions synchronously. Likewise, there are also some to restraints enormous rescue complication.Thus, it may be conclude that there are many optimization problem that may optimize using modified ant colony algorithm in an efficient manner.

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