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Ambulance Vehicle Routing using BAT Algorithm

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***Abstract*— In this paper, ambulance vehicles are routed using BAT algorithm. The city map is created by node method. The control station receives the information about accident place and then this information is communicated to the ambulance and hospital. The drive feed the data i.e., node position of the accident and ambulance vehicle in the bat algorithm based vehicle routing method and it provides shortest path for reaching accident place to driver. After reaching accident place, drive feed the position of the accident place and hospital position in the bat algorithm vehicle routing method and it provide shortest path for reaching hospital to driver. Shortest bath and quick reach time is generated using this algorithm.**

Keywords*— *Ambulance vehicle, Routing, BAT Algorithm

I. INTRODUCTION

The disaster and accidents can occur naturally, or because of human consequences. These disasters or accidents, on a larger scale, can affect both existing infrastructures and people. Effective logistical operations are difficult to carry out in such circumstances and thus effective medical assistance cannot be delivered on time , which in turn causes further losses. Therefore, rescue and assist operations must be well organized after a disaster or accidents and must be carried out efficiently [1]. In an emergency situation , people who have been wounded need to be taken to hospitals first. In order to carry out this mission effectively, we need to know the location and amount of people injured, the amount and capability of ambulances as all these values are the input to the problem solution. We have to establish an emergency schedule after collecting these inputs so that accidents can be moved to hospitals in a short time [2]. The aforementioned issue relates to the Capacitated ambulance Routing Problem (CARP) which is a form of Ambulance Routing Problem (ARP). Victims and their requests are in ARP. The goal is to reduce the total distance by an ambulance from the ambulance station location to accident location and accident location to hospital for transfer of victims according to emergency occurred [3]. The ambulance is loaded from the accident place with victims and the victims are handed out to the hospital. If the victims are transported are running out the ambulance will return to the nearby ambulance station. CARP proposes different types of solutions: exact solutions, heuristic, or meta-heuristic approaches. Some researchers are proposing approaches for finding the exact solution. However, since the CARP is known as a non-deterministic polynomial problem (NP-hard), these methods may be infeasible during complex situation of the accident. Thus, meta-heuristic and heuristic approaches are typically used to solve CARP efficiently with a optimal routing of the ambulance to accident place. Generally, CARP was solved by Simulated Annealing, Particle Swarm Optimization, Ant Colony, Genetic Algorithm etc. The solution qualities of the various meta-heuristics are not considered to be significantly different for these types of optimization problems. We opt to use the BAT algorithm in this paper for its mature methodology and proven robustness.

The rest of this paper is structured according to the following. Section 2 gives the relevant work on the ambulance routing and relevant literature. Section 3, explain about ambulance vehicle routing scenario, mathematical for calculating distance between source and destination location and details of the bat algorithm. The simulation and corresponding results are discussed in Section 4 and finally section 5 addresses findings and consequences.

II. RELATED WORKS

In [1], shortest path algorithm has been developed for ambulance routing between accident spot to the hospital. Dijkstra's algorithm has been used for finding shortest path in set of node location. In [2], effective communication metrologies implemented using ambulance to traffic light controller communication. This method also use vehicle to infrastructure communication technology for changing the traffic light signal. In this method, wave short message from the ambulance i.e., ambulance position and route details send to core network via communication protocol. The core network control the traffic light based on position of the ambulance. In [3], a star algorithm used to find shortest path between accident spot to the hospital and it transferred to ambulance route control system. In [4], video image processing concept used for effective control of traffic light signal to allow the emergency vehicles such as ambulance, fire engine etc. In this method, vehicle density of the road is analyzed by using image processing and also this system receives the RFID signal of the emergency vehicle. Based these information traffic light is controller and traffic congestion is minimized. In [5], RFID based traffic congestion control was presented for the emergency vehicle routing application. The RFID system read the information of the all vehicles via road side capturing unit and this information sends to traffic main control unit. If any emergency vehicle crossing the road side unit then main traffic control unit change the traffic signal to pass the emergency vehicle safely.

In [6], miniature model of the smart traffic light system is proposed for the emergency vehicle routing. It has two units, one is installed in the emergency vehicle and another one is installed in the main control unit. If any emergency condition in the emergency vehicle is send ia module available in the vehicle to main control unit and main control unit control the traffic signal for allowing the emergency vehicle in corresponding direction. In [7], smart traffic signal control system to smart city application was presented. In this method following modules are used such as adaptive traffic signal control(ATSC), public transport signal priority (TSP), eco-driving supporting, emergency vehicle signal preemption (EVSP), road side unit control and message broadcasting. In this method, emergency vehicle position and direction is shared with vehicle near to intersection point of the traffic light signal and thus by control the traffic nearby intersection point for allowing the emergency vehicle. In [8], Li-Fi protocol used for emergency vehicle routing nearby traffic signal. The Li-Fi model is fixed in the all emergency, non emergency vehicle and traffic light control system with some fixed modulated frequency. Whenever emergency vehicle struck in the traffic and it will communicate to nearby traffic light control system via Li-Fi protocol for changing the traffic signal.

In [9], IoT based emergency vehicle clearance control was implemented. This method has three components; one is main control server, Vehicle RFID control, traffic signal RFID control. The emergency vehicle location and position are sending to main control server and then main control server sends the route for the emergency vehicle based on traffic. Vehicle RFID control is used to change the traffic signal when nearby intersection point. Traffic signal RFIS used for change the traffic signal schedule to normal after crossing of the emergency vehicle. In [10], smart traffic light system was developed using MQTT protocol, micro controlled traffic lights, Google maps, Android app. In this method ambulance driver use the Google map for finding the shortest path for hospital and time reaching each traffic signal in this route and send to the main traffic control centre via MQTT protocol and the main traffic control centre change the traffic signal based on ambulance nearby the traffic signal.

In[11], traffic light control based IoT concept was developed. This method utilizes the GPS system and application server to control the traffic signal to clearance of the emergency vehicle. The GPS system and android application in the emergency vehicle send the position of the vehicle to the application server and the application server control the traffic light signal based on position of the emergency vehicle. In [12], fuzzy logic based traffic management system was developed for the emergency vehicle clearance. In this method, emergency level of the emergency vehicle is send to the traffic management system (TMS). Based on emergency level, TMS fetch road map and occupancy level of the road and average vehicle speed of the corresponding route. These details are sends to fuzzy logic control and fuzzy logic generate the congestion level and congestion vehicle to the TMS. The TMS generates the emergency response plan and route and sends to emergency vehicle for fast clearance to destination. In [13], genetic algorithm based routing technique is developed for the emergency vehicle. In this method, genetic algorithm receives the details of current position of the vehicle, traffic data, origin and destination data and based on these data genetic algorithm generates the shortest path and new feasible rout for the emergency vehicle.

III. BAT ALGORITHM BASED ROUTING PLANNING FOR AMBULANCE VEHICLE

In this section, ambulance vehicle routing logic optimization using BAT algorithm has been analyzed. The victim of the accident or people near by the accident are informing the details such as accident location, no of people injured details and injured level to the control station for seeking help. The control station members are contacting ambulance station and hospital near by the accident place and convey the details about the accident. The hospital peoples are ready with necessary facility to treat the victims. The ambulance station is contacting vacant ambulance nearer to accident place and conveys the details. The ambulance is moving towards the accident place and carry the victims to the hospital for treat the victims. In this diagram, dash line indicates the road transport concept and dot-dash line indicates the mobile communication concept in ambulance vehicle routing.

The control station sends the details of the accidents to the ambulance station. The ambulance station fetches the details of the local route map and local node details relevant to the accident place. These details are feed into the BAT algorithm and BAT algorithm generates the possible optimal routes from the ambulance place to accident place and accident place to hospital place. The optimal routing plans are sending to ambulance via mobile communication and then ambulance driver follow the routing plan to carry the victim to the hospital.

A. *Mathematical Model of the Ambulance vehicle routing*

In ambulance vehicle routing, the ambulance must construct its own direction using its intelligence actions on the condition that it does not take unwanted route in the available route map and meet the target with limited time and resources. The emergency vehicle must either accelerate itself or follow the shortest route to meet the target in order to satisfy the above requirements. If the ambulance takes the shortest path then there should be minimal distance between source and target. The minimum distance can be defined by using the following formula (1).

$$F1 = distSD(i) = \sqrt{[(Sx(i) - Dx\ (i))^2 + (Sy(i) - Dy(i))^2]} \quad (1)$$

Where, Sx(i) and Sy(i) denotes the x and y coordinates of the source location , Dx(i) and Dy(i) denotes the x and y coordinates of the destination location, distSD(i) denotes the distance between source and destination location, i denotes the current iteration value and F_1 denotes fitness function.

Ambulance vehicle also has to take care of the undesirable route position when monitoring the shortest direction. If the emergency vehicle follows an unwanted route then the emergency vehicle waste time in the unwanted position or contributes to delay in the overall process so that the ambulance vehicle can keep the maximum distance from the unwanted route locations in order to prevent this circumstance. This maximum distance can be determined using distance formula (2)

$$F2 = distAU(i) = \sqrt{[(Ax(i) - Ux\,(i))^2 + (Ay(i) - Uy(i))^2]} \quad (2)$$

Where, Ax(i) and Ay(i) denotes the x and y coordinates of the ambulance vehicle location , Ux(i) and Uy(i) denotes the x and y coordinates of the unwanted route location, distAU(i) denotes the distance between ambulance vehicle and unwanted location, i denotes the current iteration value and F_2 denotes fitness function.

The objective function or fitness function for ambulance vehicle routing as follows (3),

$$F = F1 + \frac{1}{1+F2} \quad (3)$$

From objective function (3), the best local and the best points of the Global path are determined. The new route point for emergency vehicles is determined based on the best global direction point. The loop continues until at the target position the ambulance reached.

B. *BAT Algorithm*

The bat algorithm takes advantage of bats 'echolocation activity. Such bats emit a very loud sound pulse (echolocation), and listen to the echo that echoes back from the objects around them. Their amplitude of the signals varies according to nature. Each sound signal has an emission rate of pitch, loudness, and duration. Some bats use tuning frequency signals while the majority use fixed frequency signals. Such animals have a frequency range of between 25 KHz and 150 KHz. Bat algorithms are based on the following aspects; both bats use echolocation and the distinction between victim and obstacle is separated. Bats travel at random speed, at a random venue, with variable length, loudness and pulse emission rate [14][15].

IV. RESULTS AND DISCUSSION

In section, the simulation of ambulance vehicle routing using BAT algorithm is explained. The program for the ambulance vehicle routing using BAT algorithm was developed using MATLAB R2017 and tested under i3 Intel processor with 1.7 Ghz speed Personal computer. The specification of the BAT algorithm as follows, Bat population is 100, Maximum number of iteration is 100, minimum frequency is 0, maximum frequency is 1, pulse rate is 0.5, loudness factor is 0.5. the coordinate details of the taken area are as follows, x coordinate varies from -10 to 10, y coordinates varies from -10 to 10, x coordinate unwanted route location points are 1.5, 4.0, 1.2, 8.0, 1.2, 4.8, 4.9, 5.1, 2.8, 5.6 and 7.3, y coordinate unwanted route location points 4.5, 3.0, 1.5, 9.0, 5.6, 4.8, 6.3, 6.5, 8.9, 1.4 and 7.6 and diameter of the unwanted location points are 0.2 for all. Figure 1 shows the unwanted node details of the considered area.

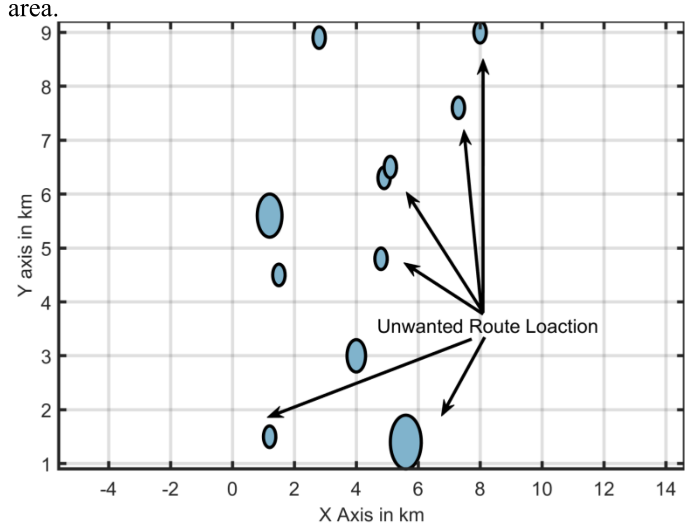
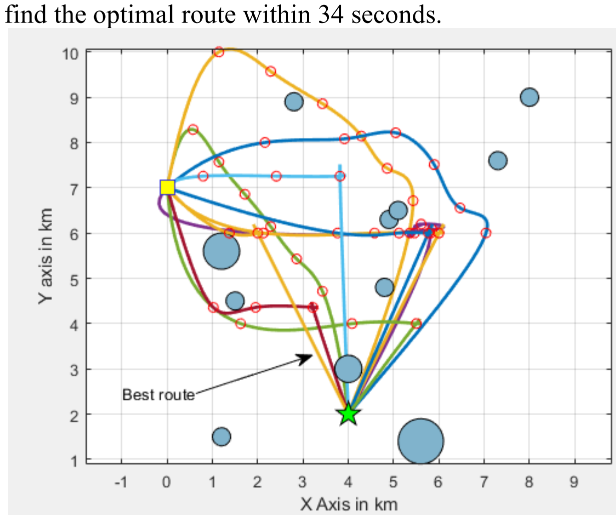
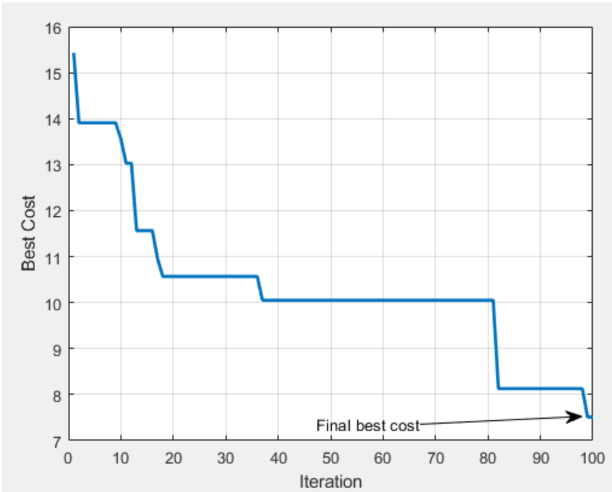


Figure 1. Unwanted node details of the considered area

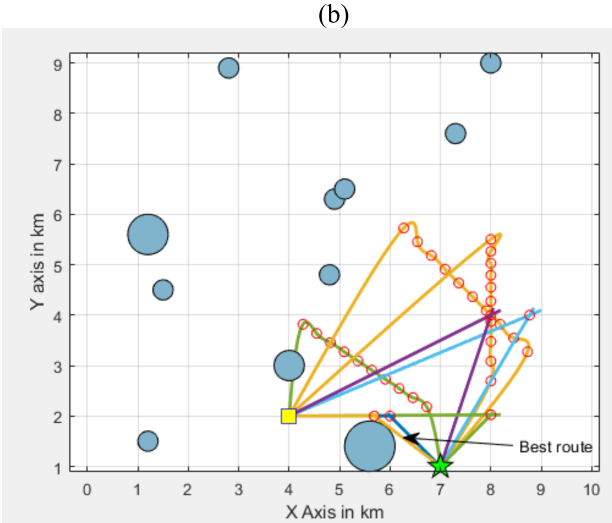
The developed bat algorithm based ambulance vehicle routing is tested such as finding optimal between coordinates (0,7) to (4,2) and (4,2) to (7,1). For this test, the corresponding results such as route variation at every iteration of the BAT algorithm is shown in Figure 2(a) and Figure 2(c). The convergence graph is shown in Figure 2(b) and Figure 2(d). From this Figure 2(b), during starting of iteration total distance between coordinates (0,7) to (4,2) is around 15.5 km and it reduced every iteration and end of the 100 iteration total distance between coordinate is around 7.5 km. the bat algorithm find the optimal route within 34 seconds.



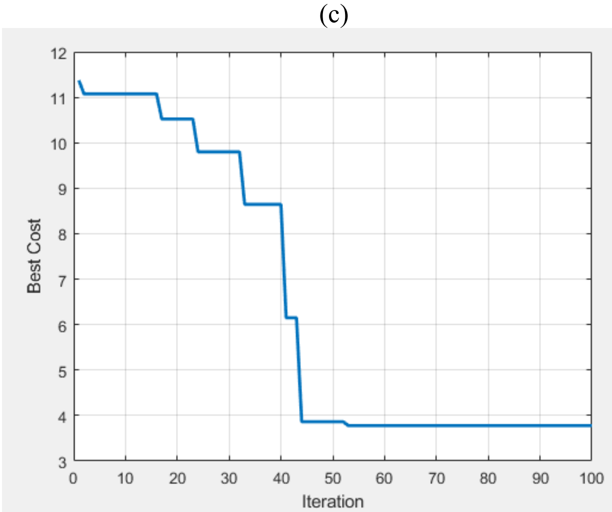
(a)



(b)



(c)



(d)

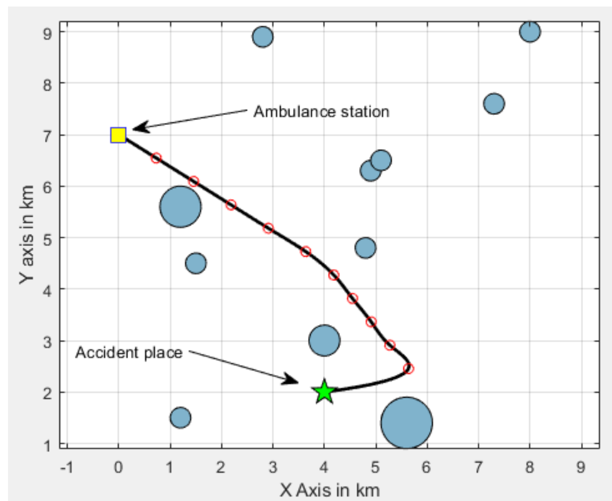
Figure 2. Simulation results for with two test conditions, a) Best route between (0,7) to (4,2), b) Convergence graph, c) Best route between (4,2) to (7,1), d) Convergence graph

From this Figure 2(d), during starting of iteration total distance between coordinates (4,2) to (7,1) is around 11.3 km and it reduced every iteration and end of the 100 iteration total distance between coordinate is around 3.7 km. the bat algorithm find the optimal route within 36 seconds. The developed bat algorithm based ambulance vehicle routing is also tested with following sample accident coordinates, ambulance location, hospital location and details are given in the Table 1.

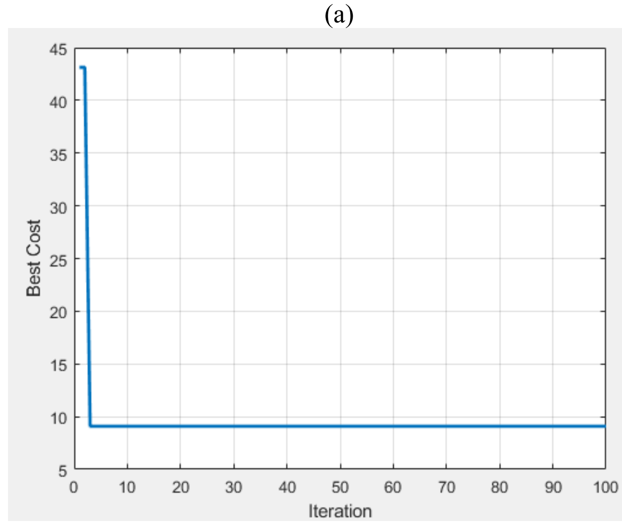
Table.1. Sample Coordinates for Ambulance location, accident location, hospital location

Accident location		Hospital location		Ambulance location	
X	Y	X	Y	X	Y
4	2	7	1	0	7

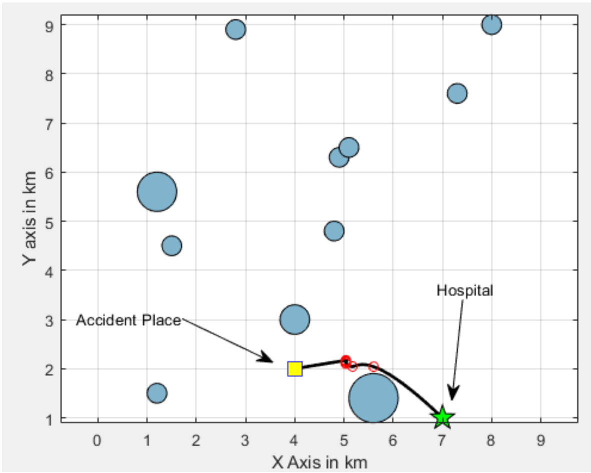
Figure 3 shows the simulation results.



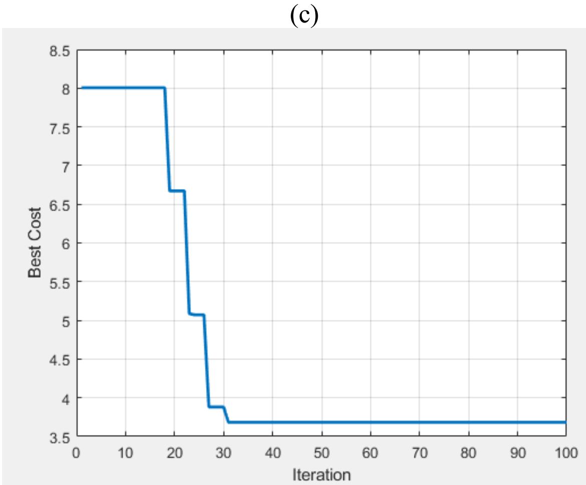
(a)



(b)



(c)



(d)

Figure 3. Simulation results, a) Route from ambulance place to accident place, b) convergence graph, c) Route from accident place to hospital, d) convergence graph

From the test results, total distance between ambulance station to accident place is optimized around 8.2 km and total distance between accident place to hospital is optimized around 3.6 km and time taken for finding optimal route is around 63 seconds.

V. CONCLUSION

In this article, we developed a solution based on BAT algorithms for the effective routing of ambulances following a tragedy or accident. We observed, through extensive simulation experiments, that the proposed bat algorithm creates better solutions. The bat algorithm system attained shorter total tour distances with rapidly in all considered scenarios. Hence, we can argue that the system of bat algorithms is resilient against the changes in the underlying topologies and the number of locations. Thus, although the significant problem parameters differ, the bat algorithm is continuously generating better results.

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