The Method of Finding Path for Emergency Cars Based on Minimal Time

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Abstract

Traffic, one of the most annoying conditions of modern life (if you own a car), often can be unpredictable. Roads have carrying capacities, but even drivers on closed tracks have shown that traffic jams appear to be hardwired in human nature. This paper shows short review of existing methods of finding the minimal time routes in big cities using road map and traffic map and then authors explain the main problems of these algorithms: they do not consider time as an important value for traveling. Instead they pass the cars to a path having the shortest length. This paper suggests some way for finding a path with minimal time for emergency cars. Time is the most important parameter. Also, the way of existing methods used is proposed in this paper. In conclusion authors show the minimal requirements for suggested solution and its limitation.

Keywords: Vehicle Routing Problem; Emergency Situation model application; an intellectual control system.

1 INTRODUCTION

In this chapter, introductory information about how traffic will make a problem for traveling and transportation and how we can find the best traveling time.

1.1 ABOUT THE TRAFFIC JAM AND CURRENT SOLUTIONS

In the modern life now we have lots of new things that can help us for better life such as new cars with new and more options faster and more comfortable but more cars mean more street and more traffic and the result is the traffic jam. Now lots of new applications exist for routing but in general, they work well in normal situations but we want to handle the situation in an emergency situation. The vehicle routing problem in an emergency situation is a recent and challenging extension of the well-known vehicle routing problem [1].

In addition to the usual task routing constraints, routing for emergency cars require further synchronization between vehicles, concerning spatial, temporal, and aspects.

The main problems mostly about the traffic in emergency situation. Traffic congestion is a condition on transport network that occurs as use increases and is characterized by slower speeds, longer trip times, and increased vehicular queueing. As demand approaches the capacity of a road (or of the intersections along the road), extreme traffic congestion sets in. When vehicles are fully stopped for periods of time, this is colloquially known as a traffic jam or traffic snarl up. Traffic congestion can lead to drivers becoming frustrated and engaging in road rage [2].

1.2 OF THE MAINTAINING THE INTEGRITY SPECIFICATIONS

When traffic demand is great enough that the interaction between vehicles slows the speed of the traffic stream, this results in some congestion. While congestion is a possibility for any mode of transportation, this article will congestion on public roads.

2 ROUTING METHODS IN TRAFFIC

In this paper, will consider two methods for how to find short path in one time routing in the traffic jam.

1. MILP (Mixed Integer Linear Program) [3]
2. Collision Resolution - Impulse-based Method [4]

2.1 MIXED INTEGER LINEAR PROGRAM

This is the formulation of the dynamic traffic signal control problem without any consideration for emission. As we mentioned in the introduction, a link-based LWR model will be considered, the derivation of which employs the variational method:

$$\frac{\partial\left(f\left(\rho\left(t,x\right)\right)\right)}{\partial t}+\frac{\partial\left(f\left(\rho\left(t,x\right)\right)\right)}{\partial t}=0,$$

where $\rho\left(t,x\right)$ denotes the vehicle density in a spatial-temporal domain; f is the fundamental diagram that describes the macroscopic relationship between vehicle density and flow on the link. Throughout this paper, f is assumed to be triangular of the following form:

$$f(\rho)=\begin{cases} v\cdot\rho, if\ \rho\in[0,\rho_c] \\ -w\cdot(\rho-\rho_{jam}), if\ \rho\in[\rho_c,\rho_{jam}] \end{cases},$$

where ρ denotes vehicle density; v and w are respectively the speed of the forward and backward propagating kinematic waves; ρ_c is the critical density at which the flow is maximized and ρ_{jam} denotes the jam density.

Moreover, we let *C* be the flow capacity and *L* be the length of the link. We allow all these quantities and variables to depend on a specific link and we will always use subscript to indicate such a dependence.

We consider a link expressed as a spatial interval [*a, b*], and ignore for now the subscript for notation convenience. We define a binary variable $\bar{r}(t)$, which indicates the traffic state at the entrance of the link: $\bar{r}(t)=0$ if traffic is free flow and $\bar{r}(t)=1$ if traffic is congested. A similar notation $\hat{r}(t)$ is used for the exit of the link. We also define the link inflow $\bar{q}(t)$ and the link exit flow $\hat{q}(t)$. The key results of the link-based kinematic wave model, derived from the variational theory, are as follows.

$$\bar{r}(t)=\begin{cases} 1, if \int_0^t \bar{q}(\tau)d\tau = \int_0^{t-\frac{L}{w}t} \hat{q}(\tau)d\tau+\varphi^{jam}\cdot L \\ 0, if \int_0^t \bar{q}(\tau)d\tau < \int_0^{t-\frac{L}{w}t} \hat{q}(\tau)d\tau+\varphi^{jam}\cdot L \end{cases}$$

$$\hat{r}(t)=\begin{cases} 1, if \int_0^{t-\frac{L}{v}} \bar{q}(\tau)d\tau = \int_0^{t} \hat{q}(\tau)d\tau \\ 0, if \int_0^{t-\frac{L}{v}} \bar{q}(\tau)d\tau < \int_0^{t} \hat{q}(\tau)d\tau \end{cases}$$

In addition, we introduce the notions of demand and supply of a link which, under the assumption of a triangular fundamental diagram, reduce to the following:

D is the demand of link I

$$D(t)=\begin{cases} C, if\ \hat{r}(t)=1 \\ \bar{q}\left(t-\frac{L}{v}\right), if\ \hat{r}(t)=0 \end{cases}$$

$$S(t)=\begin{cases} C, if\ \bar{r}(t)=1 \\ \hat{q}\left(t-\frac{L}{w}\right), if\ \bar{r}(t)=0 \end{cases}$$

2.2 COLLISION RESOLUTION – IMPULSE-BASED METHOD

We define the impulse J between two colliding rigid bodies of mass m_A, m_B with initial speeds v_A, v_B in *1* dimension by

$$J=-(1+\varepsilon)\frac{v_A-v_B}{\frac{1}{m_A}+\frac{1}{m_B}},$$

where ε is the coefficient of restitution, a term describing the elasticity of a collision.

We will consider only systems where all bodies have the same mass so this simplifies to

$$J=-(1+\varepsilon)\frac{v_A-v_B}{2}$$

Since impulse is equal to a change in momentum, we can express the above in terms of the post-collision speeds v'_A, v'_B

$$J=m_A(v'_A-v_A)$$

Newton's third law of motion justifies that an equal but opposite impulse will be experienced by the second body

$$-J=m_B(v'_B-v_B)$$

As we know one of the most important reasons for making traffic is collision, we can calculate speed differences between current car and all colliding cars. The array `test speeds` hold the current speed of each driver for the current time. Hence picking the *i* term gives the speed of the *i* driver. We want a generalised approach so that it scales for N colliding bodies.

3 SUGGESTED SOLUTION

Our suggestion for solving the problem for skipping the traffic jam for an emergency car is using routing algorithms in a form with the best decision-making algorithm. Finding the best traveling time during the routing and guiding cars, open the way for them and save more lives.

Tow type of system exist now:

- Distribute system
- Main Brain Process

3.1 EMERGENCY SITUATION

Every day we hear new predictions about how the Internet of Things (*IoT*) is going to change the world and transform our way of life. What you may not realize is that best traveling time, has changed the way we respond to emergencies and is saving lives.

3.1.1 Useful algorithms

This paper trying to find best algorithm, that now working with best performance:

- Dijkstra [5]
- A*[6]
- K shortest path routing [7]

Dijkstra and A* both are most useful and flexible algorithm for routing that we can use all or value in this algorithm and will show us the best results.

And if we find the same value for the different way so we will use K shortest path.

in the text, we will explain why these algorithms.

For routing the car, we need two very important points:

- first of all, shortest path;
- the second of all, which path is faster.

It is so clear shortest path always is not the fastest path.

3.1.2 General problem:

So how we have to recognize which path and how we have to use these algorithms?

The best way has analyzed the matrix of each path, with all the points and we will route with all algorithms and then we will compare the answers together and we will decide which one is better. We will analyze the matrix we will read from the map. And then we will use the algorithm we made it for routing, then we have to compare the time. Time is the most important element for us. Mathematically, congestion is usually looked at as the number of vehicles that pass through a point in a window of time or a flow. Congestion flow lends itself to principles of fluid dynamics. In this paper, we want to finding best time for transporting for emergency cars from point A to B. This is not mean shorter path because of we have one important element here and that is TIME. This is a fact that always shorter path is not faster so we need to find a solution for time traveling and also find a solution for an exception situation in some place traveling is possible just in one way. Sometimes we encounter situation that we have no choice for new path or all the traveling times return to us same value or even that emergency is in the place that exactly is of middle of traffic jam. Although we have some more elements which are involved in our decision such as weather, traffic pic and so on. In this article, we try to find a minimum traveling time for our traveling in traffic jam.

3.2 USING ALGORITHM

For simple formulation, we have t and t is most important element for us. So, we should provide $t \to \min$.

Time is the sum of all the time we will spend include of an effect of weather will make for us or traveling time in the pic of the day for instance in big cities from 8 A.M till 10 is the traffic jam. Due to this time, lots of people want to go to their work. That's how we can find t sum of lots of element.

Here, ρ_{max} is the maximum vehicle in three lanes with standard speed (110,90,70) can drive and the cannot make traffic. But the main problem of this way just shows how many vehicles that driving in all lanes, for sure every time with more vehicle that means less gap between them and traffic will make: $\rho_{\max} = \sum_{lane=1}^{N} \rho_{lane} < 123$.

For 110 km/h means 30.5 meters have to make a gap between each vehicle, so for 90 km/h 25 meters and for 70 km/h have to have 20 meters gap.

This way for routing has a simple solution for traffic jam and figurate the problem in all possible way to skip the wasting time.

For example, when an ambulance car wants to go on a crowded street or crowded high away they need the cooperate from drivers to arrive as soon as possible.

What if some drivers do not cooperate?

How can we solve the problem? We should minimize the expression

$$t \propto \frac{1}{\sum_{n=1}^{\infty}\left(\rho_n \frac{h_s}{l} + b_n \frac{u}{f}\right)},$$

where ρ_n is number of vehicles per unit length (at fixed time), h_s is pace headway (spacing): road length per vehicle, l is the length of each line, b is occupancy or percent of the time a fixed position is occupied by a vehicle, *u is s*peed (velocity) that's distance traveled per unit time and f *is a f*low rate, b is occupancy percent of time a fixed position or it is occupied by a vehicle. Also

$$l = \sum_{n=1}^{\infty}\left(\rho_n \left(h_{s_n} + l_{v_n}\right)\right),$$

where l_v is the length of the vehicle. So, if we use average values we can get $h_s = \frac{l}{\rho} - l_v$ The flow rate f can be calculated as

$$f = \frac{h_s}{u}.$$

If we represent a simple example of the part of map (as we know map is a matrix) we can see traffic jam is possible in red cells and also every time we going to green steps we have best traveling time.

Then by the algorithms of Dijkstra and A* we can find minimum time and then if traveling time in 2 different way going to same we use the K-shorter Path algorithm.

5	7	3	1
5	7	3	1
3	8	3	2
2	9	10	10
2	10	10	4
2	10	10	4
4	10	10	9
4	9	9	9

Fig. 1 The status of each matrix with traffic data

Fig. 1 shows the price of traveling that is here is TIME and the colors showed normal situation until an emergency. With analyzing this number has a possibility to find the best traveling time and identified deadlines and problems.

4 CONCLUSION

Real time information is critical when dealing with life or death situations. The possible ways EFP can improve emergency response are endless but the sensing equipment deployed in the field is only half the solution.

The quality of paths provided by the method depends on if we have real time data about the weather, state of roads (including unforeseen event). The capability to retrieve data off a sensor, then process, store, and report in real time are minimum requirements. That's where the back-end servers and EFP software come into play. Without the inclusion of EFP software, the sensors would be marginalized in an emergency responds scenario.

But we should not forget about impossible scenarios that we are not able to skip it, for instance, an emergency situation in a deadline or middle of the traffic jam is not masked able so in this situation, it is impossible to find the better solution and this is our limitation for solving the traffic jam problem.

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