The Fire Trucks Line Modelling for Fires Mitigation in Dense Settlement Population Using Agent Based Model Simulation Apporoached

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ABSTRACT
Emergency response conditions were an important part of the disaster phase scenario. The level of coordination of people and fire fighters agencies in the event of fire emergency response in coastal residential areas was quite low. This research was a simulation study and evaluation of information system mechanism and government coordination in fire disaster response in the dense settlement population of Tarakan, North Kalimantan. This study also presented an Agent Based Model simulation that were modeled the mobilization of fire trucks to the location utilized Net Logo. The time and speed of mobilization of fire trucks had been determined in some parameters. The results showed that the shortest path and optimal mitigation time were determined based on the accuracy of information and accessability to the fire location. A best-case scenario had been produced in a simulation modeling the mobilization of fire trucks. Fire trucks had an accessable moving towards the biggest hotspot when victim evacuation had been performed well.

Keywords: *Agent Based Model, Fire Trucks, Movement, Mitigation, Simulation*

1. INTRODUCTION

Fire disasters usually occurres in dense settlements, the traditional market was one of them. Big fire broke out the traditional market, Pasar Batu, Tarakan on Monday, 20 January 2020 (Figure 1). The fire was occurred during 5 hours then caused 500 buildings failured. Almost all buildings had made of wood material, hence it were easy to be burnt. The fire trucks accessibility for fire mitigation should be considered. The dense settlement and so many obstacles caused the truck fire could not access the fire spot easily. This research emphasized on the truck fire movement to achieve the fire spot. The truck fire movement was modelled in Agent Based Model by utilizing NetLogo.

Figure 1. Fire location

Dai and Zhang [1] had conducted research by using agent-based models to simulate the spread of fire in a community. The simulation model considered four factors: ignition point, heat dissipation rate, road density, and wind effects. Research area had been located in the City of Avondale in Georgia, USA States, with an approximate size of 0.8 km^2. The results showed that information on the number of victims, area high risk, choice of escape route, and timing evacuation.

Dobson et.al [2] had conducted hhe research about application of Agent-Based Modelling (ABM) used to support strategic decision-making in the emergency services. Here the resulting ABM-driven Decision Support System (DSS) (called 'Premonition') was designed to help practitioners engage with a complex and dynamic environment of co-evolving fire risk behaviours through time.

Sandana [3]The case study of this research had been defined in the dense coastal settlement area of Pasar Batu Tarakan, North Kalimantan. The community evacuation simulation were based on the Agent Based Modelling (ABM) by utilizing the NetLogo software. The results showed a scenario 3 had the largest people number who passed out the exit way. The selection of the route based on the distance and width parameters for the number of people save. They had very significant correlation (R^2 = 98,34%).

Sun & Turkan [4] proposed a comprehensive simulation framework that integrated Agent-based Modelling (ABM) and Geographical Information Systems (GIS) to efficiently simulate both human behaviour and transportation crowds. In particular, ABM bridges the technical gap between GIS and a multi-agent system (MAS) for simulation design efficiently and effectively. To study the evacuation performance (measured by the number of agents being sheltered or refused to evacuate), our modelling solution enables altering relevant model parameters in wildfire evacuation scenarios.

2. METHODS

In general, this research was conducted the truck fire movement in fire mitigation where located Pasar Batu, Tarakan, North Kalimantan. The emphasis of this research is on fire trucks movement (agent) to the nearest fire spot. The agents movement on the road network away from hotspot sources go to 3 entry way, back line Harmonis Hotel, gate of the Pasar Batu closed to a Moslem shop and a small bridge to the left of the Pasar Batu location (Figure 3). Next to represent This research model is in the form of a simulation, especially Previously, the Agent Based Simulation protocol was used namely the creation of ODD (Overview, Design Concept and Details) to describe a system agent-based so it's easy to understand.

Overview

This agent-based simulation model has modeled the fire hazard in dense settlements, as a decision support system. The analysis carried out, several disaster scenarios have been carried out. Entity: fire engine and site are defined in the state variables: fire engine bound based on residential area density, fire engine movement including steps and how to move when finding a fire location. Entity; This simulation predicts the amount of time for all

fire engine movements in the fire area per minute. The stages of the research can be seen in figure 2.

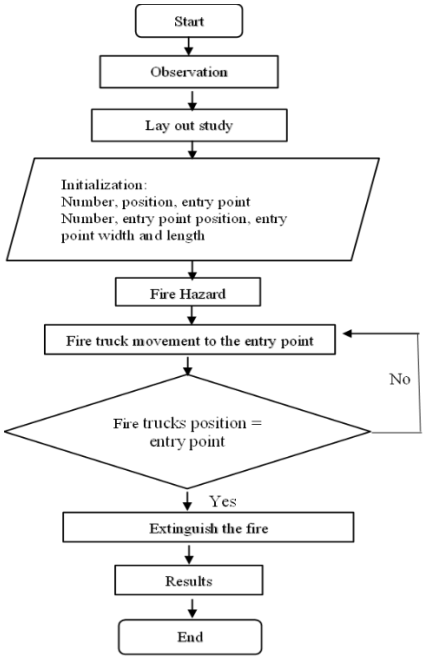

Figure 2. Research flow chart

Figure 2 showed the research flow chart. The observation of fire truck movement was accorded into fire truck path from the basecamp to the fire location. Some parameters had been evaluated in this research. Number and position of fire trucks also had been considered with the path length and width parameter also had been involved. This research had been classified into 3 scenarious. Scenario 1 modeled the narrow (0,90 m) path but had the shorthest distance (71,0 m) to the entry point (Figure 3). This alternate path had high obstacles level.

Design Concept

Design Concept: The general concept in this simulation is to find out the effective time of firefighters in overcoming fire fighting in densely populated areas following the available road to the fire location and the relationship between the width and length of the road used when dealing with fire suppression which can affect the rate of movement to the location of the fire. location point. The available road capacity can affect the path of fire engines

Emergence: The results of this simulation model are compared with the shortest time required by the fire engine to reach several available fire points and the speed of the fire engine in getting to the fire point is calculated.

Adaptation: Agent behaviour

Tabel 1. Karakteristik agen

Agen	Karakteristik
Fire Trucks	1. Fire engine is in 3 positions (based on 3 position scenarios) and moving towards the entry point. 2. The fire engine will choose a predetermined path to the entry point.2. People choosed the nearest exit point randomly.

Entry point	1. The entry point had been defined as one of the ways for fire trucks to get to the point.

Interaction: - fire truck and entry point:
The fire engine to the entry point according to its path.
- fire trucks and tracks:
The fire engines will position themselves according to the track based on the black patch, which takes into account their position when the fire broke out. Fire engines have been directed to the patch's entry point towards the fire site.

Detail

This research has been grouped into 3 scenarios. The blackout time was determined as the dependent variable for 360 minutes (6 hours).

Scenario 1 testing has described road conditions that are relatively closer to the entry point, but the path is narrow. After walking five times the number of agents at entry point 1 or the number of moving fire trucks that move using this route.

Figure 3. Scenario 1

Scenario 2 modeled the longest (140,0 m) and width (2,00 m) path to access the entry point. This alternate path where located on people settlement. The path had been identified no obstacles (Figure 4).

Figure 4. Scenario 2

Scenario 3 modeled the moderate width level (1,50 m) and intermediate distance (87,0 m) to access the entry point. This alternate path had been identified had moderate obstacles (Figure 5).

Figure 5. Scenario 3

3. RESULTS AND DISCUSSION

The fire mitigation simulation results by utilizing NetLogo had 3 scenarious that were based on the path condition. The path had been determined as an entry point and produced data that was changed every running. That was caused by the characteristic of *Agent Based Modeling*, stocasthic. However, the variant data showed relative curve trend similar of the requiring time for fire truck closed to the fire spot. The number of fire trucks can be evaluated accorded path dimention and time achievement.

Scenario 1

The initial agent movement at the beginning simulation and final simulation showed the agent in line position. The agent move toward the entry point 1 (Figure 6). The entry point 1 located on agent position radius with smaller area because of the existing path condition. After run five times, the results showed that the number of agent in entry point 1 had recorded correspondently 2, 2, 3, 2 and 3 fire trucks (10% of total agent).

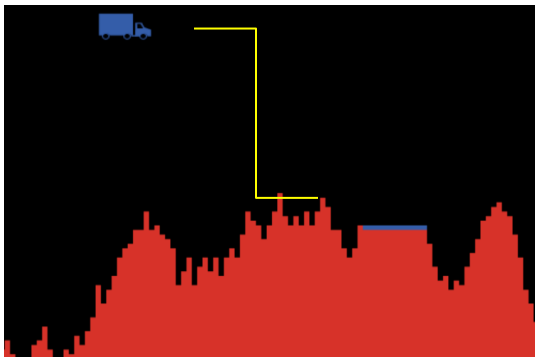

Figure 6. Scenario 1 model

Scenario 2

Scenario 2 modeled the path condition with the longest distance to achieve the entry point and low obstacle. After running five time the number of agent or moving fire truck used this path were 5, 6, 5, 6 and 6 (Figure 7). Hence about 40% of total agent. The other agents used two another alternate paths.

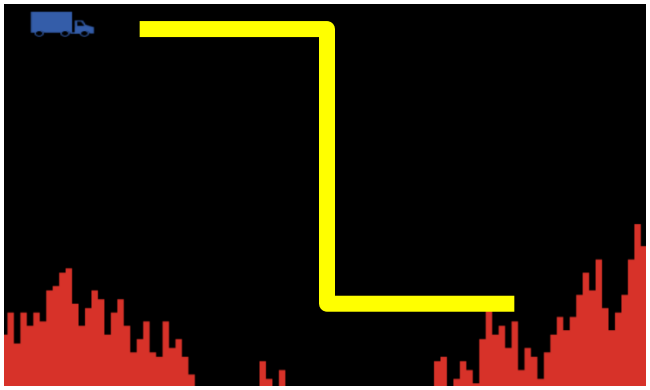

Figure 7. Scenario 2 model

Skenario 3

The senario 3 test had modelled the path condition with the intermediate distance to achieve the entry point. This alternate path had moderate obstacle level. After run five times, the results showed that the number of agent in entry point 3 had recorded correspondently 8, 6, 7, 7 and 7. The number of fire trucks who moved in this path about 50% (Figure 9).

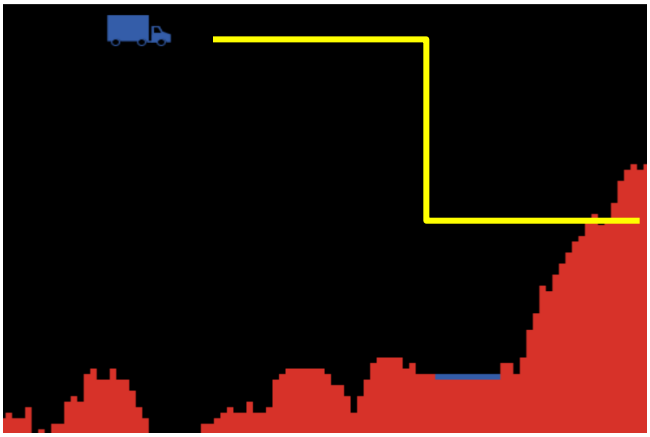

Figure 8. Scenario 3 model

Scenario Comparison

Based on the NetLogo simulation test results showed the fire truck movement pass the 3 paths condition (scenario 1, scenario 2, and scenario 3). The test had been conducted in five time run and the results showed that the agent number (the fire truck moved on the path) in scenario 1 had 2, 2, 3, 2 and 3 fire trucks (10% of total agent). Scenario 2 had 5, 6, 5, 6 and 6 fire trucks (40% of total agent). The scenario 3 had 8, 6, 7, 7 and 7 (50% of total agent). Based on the results the scenario 3 had largest number of fire truck that passed the path (50% of fire trucks). The results had been validated by double linear regression. The validation compared number of fire trucks in entry *point* on path dimension (existing and model). Validation value had recorded 97,44%.

Table 2. Path characteristic

Entry point	Width (m)	Distance (m)
1	0,90	71
2	1,50	140
3	2,00	87

The agent movement time to the entry point had been quantified in minute (*ticks*). Based on NetLogo model simulation results time for passing the condition path in Pasar Batu traditional market area fire affected about 300-360 minutes (5-6 hours). The required time recapitulation of the the agent for every entry point can be shown in Figure 9.

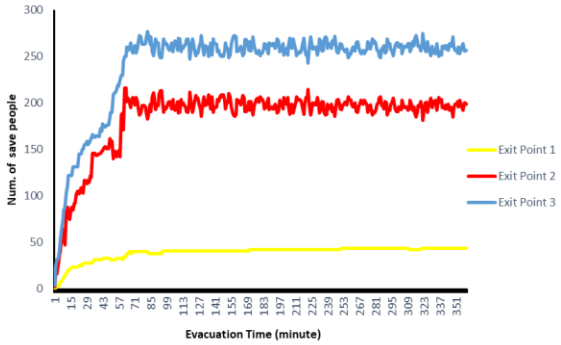

Figure 9. Time for 3 paths

Figure 9 showed the agent movement curve for 3 entry point. The largest agent number had been shown for entry point 3. This situation was caused by the path dimension sufficient for fire truck passed. Conversely, the entry point 1 had the lowest agent number because the path that was used insufficient for fire truck passing away. The curve move fluctuated because located on agent position radius with smaller area because of the existing path condition. Hence, when the agent did not achieve the destination point correctly then the agent position had been assumed outside of the entry point. All agents position had been located in entry point in 60th minute. In this condition the curve showed linear asympthotic trendline.

Validation

The results of multiple linear regression analysis were used as model validation in this study. Multiple linear regression equation obtained the regression equation as shown by the following equation.

$$Y = 3{,}435 - 5{,}409\ X_1 + 510{,}8\ X_2$$

with:
Y = number of people crossing the exit point in 1 hour
X_1 = Route distance
X_2 = Route width
with a correlation coefficient (R2) obtained by 97.44%.

4. CONCLUSION

Based on the modelling simulation analysis results, there are some points can be concluded:

1. Modellng for fire hazard mitigation were based on *Agent Based Modeling* (ABM) by utilizing NetLogo software had been described in 3 scenarious was accorded into path condition and produced fire trucks number which passed away the path.
2. Running results for 5 times showed that agents number (fire trucks) which passed away the path in scenario 1 respectively 2, 2, 3, 2 and 3 (10% of total agent). Scenario 2 produced agent number: 5, 6, 5, 6 and 6 (40% of total agent). Scenario 3 had 8, 6, 7, 7 and 7 fire trucks (50% of total agent).
3. The agent number (fire trucks) which passed away the path in scenario 3 largest among another alternate paths (50% fire trucks passed away this path).

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