Strategy Development for Emergency Call Estimation using Agent-Based Platform: PRISM

Geon Kim[a], Jinkyun Park[b], Gyunyoung Heo[a*]
[a] *Department of Nuclear Engineering, College of Engineering, Kyung Hee University, Yongin, Republic of Korea*
[b] *Risk Assessment Research Team, Korea Atomic Energy Research Institute, Daejeon, Republic of Korea*
[*] *Corresponding author: gheo@khu.ac.kr*

1. Introduction

From the perspective of an accident management, a radiation emergency means a situation in which the radiation level is increased release of radioactive materials or urgent countermeasures are required due to the high risk of their release. Such a state of emergency can be defined as a series of events that begin with the actual (or potential) release of radioactive materials that are transmitted to affected areas within the community through the current or future environment. Recent journals and papers have mainly covered evacuation in case of radiation emergency.[1]

According to the 2nd National radiological emergency response plan (proposal), an emergency response hub is secured in the site in case of a severe accident. Emergency response hub is used as a place to protect, command, and control accident response agent. This is called the advancement of the on-site command system. In the Federal Emergency Management Agency (FEMA), "Accident managers use emergency assessment to select emergency response interventions. In addition, we can predict future disasters and proceed preemptively to protect people in the end," they said, referring to the on-site command system importantly. Through this, we recognized the importance of agent's emergency call time for field command in case of a radiation emergency.

In this paper, we intend to obtain the distribution of completion time for the entire emergency calling process using an agent-based model. Agent-based model is a major way to respond to fluctuation that may occur in a radiation emergency. In addition, this paper introduces a new verification method by supplementing the existing verification method.

2. Methodology

2.1. Organizations for Emergency call

Articles 10 to 12 of the Regulations on Radiological Emergency Measures for Nuclear Operators explain the contents of the Emergency Operation Facility (EOF), Technical Support Center (TSC), and Operational Support Center (OSC). [2] Tables 1 to 3 specify the installation criteria for each emergency response facility.

Briefly, the EOF is in charge of accident response by nuclear power plant operators and cooperation and support from external radiological emergency agencies. The TSC carries out the management & support for the main control room. Finally, the OSC performs maintenance & relief activities and functions of using them as a waiting area for maintenance human-resource.

Table 1. Installation criteria (TSC)

1. Close to the main control room and within the same building
2. Largely enough area to install equipment and data necessary for emergency response activities and operation of emergency personnel. (*200* m^2)
3. Withstand the worst possible conditions during the design life of the facility.

Table 2. Installation criteria (OSC)

1. Largely enough area to install equipment and data necessary for emergency response activities and operation of emergency personnel. (*150* m^2)
2. Be equipped with materials and equipment necessary for operation so that it does not interfere with the performance of functions.
3. Be equipped Emergency power supply facilities in case of radiation emergency.

Table 3. Installation criteria (EOF)

1. Largely enough area to install equipment and data necessary for emergency response activities and operation of emergency personnel. (*400* m^2)
2. Withstand the worst possible conditions during the design life of the facility.
3. Located within 10 km of the outside of the radiation emergency planning zone

From the above, the agents of the emergency response facilities should respond to prepare for a radiation emergency. In other words, the function of the field command center should be established.

2.2. Tuning Strategy using PRISM

An agent-based evacuation simulation called PRISM (Platform for Radiological emergency Integrated SiMulation) has already been developed. The currently created agent-based platform [1] focuses on sensitivity study in exigent conditions (e.g., evacuation situations, emergency situations), which is a bit different from the viewpoint of the purpose of this study. Therefore, emergency call simulation is performed based on PRISM, but it is necessary to perform tuning work suitable for this.

Figure 1 schematically illustrates a method to tune PRISM for the purpose of modeling emergency calling. First, a normal state platform needs to be setup. A normal state is to create a situation like everyday life without emergency conditions.

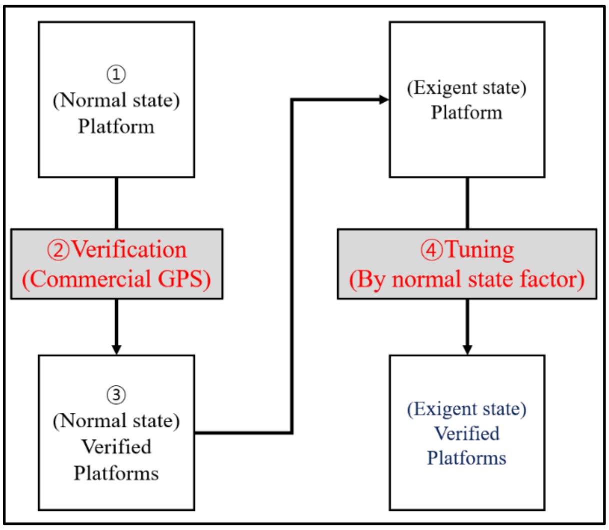

Figure 1. Schematic validation method

Second, tuning is performed while comparing the time, t, between the locations of start and end required with commercial GPS such as Naver map. Figure 2 is an example of commercial GPS, and Figure 3 is the path of the current normal state platform.

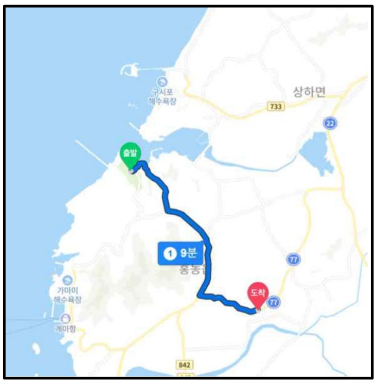

Figure 2. Commercial GPS

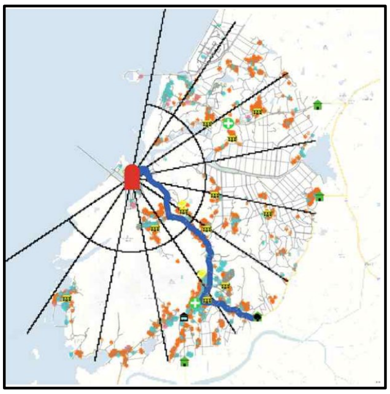

Figure 3. Current normal state platform

$$t = f(x_{car}, x_{max}, \dots) \tag{1}$$

t: spent time between start and end locations
x_{car} : number of cars x_{max} : maximum speed

In normal state tuning, the time zone (night/day, weekdays/weekends, four seasons) is weighted to "number of cars". In addition, variability due to weather (clearness, rain, snow, etc.) is performed by penalizing "maximum speed". Then we can assume that the simulation is the equivalent with the commercial GPS and PRISM can now mimic a virtual simulator to replace the commercial ones.

As an example of the above strategy, in Table 4, the normal state platform measured run-time in terms of the number of cars (i.e., agents). If so, we can figure out how many cars are usually driven.

Table 4. Estimated time required results

	Number of cars	Point 1
Evacuee algorithm	1	10m 30s
	10	12m 50s
	20	14m 30s
	50	22m 20s
GPS service	14 min	

Through this method, it is possible to check the weight of various factors corresponding to step ③ in Figure 1. For example, it can be known through comparison with commercial GPS even in situations such as day and night and various bad weather (snow, rain).

Lastly, the step ④, through the factors obtained in the normal state, it is applied (tuning) to the platform in the actual exigent state to obtain the evacuation time and emergency call time to be practically obtained.

2.3. Simulation environment

Through the tuning strategy and emergency calling simulation method described above, a simple simulation carried out. Table 5 mentions the assumptions of the simulation.

Table 5. Assumptions (emergency call)

1. There is an arbitrary nuclear power plant, and an immediate evacuation and emergency call are in progress.
2. The number of emergency call agents consider only the emergency call of EOF agents.
3. The initial location of the emergency call agents are located in a radius of 5 km.
4. The number of emergency call agents consider both vehicles and people on foot.

3. Results

The results include all of the contents described above. The current results are not the results of a specific analysis. However, if an emergency call is made through the agent-based model, the result will be as follows.

The red vehicle is an emergency call agent, and the black is an evacuation agent. Figure 4 shows a simulation of an evacuation and an emergency call. Figure 5 shows a graphical representation of the emergency call results.

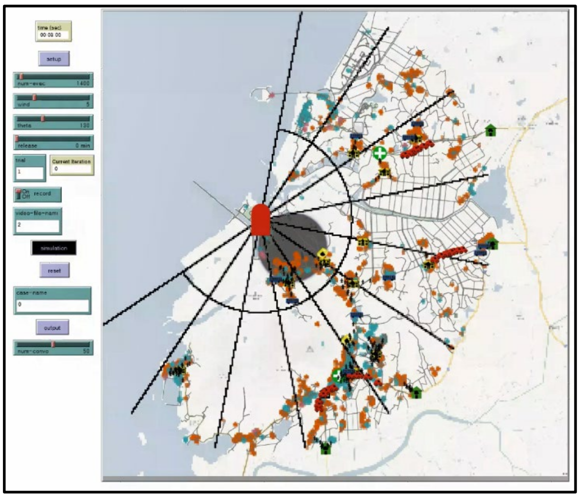

Figure 4. Simulation progression

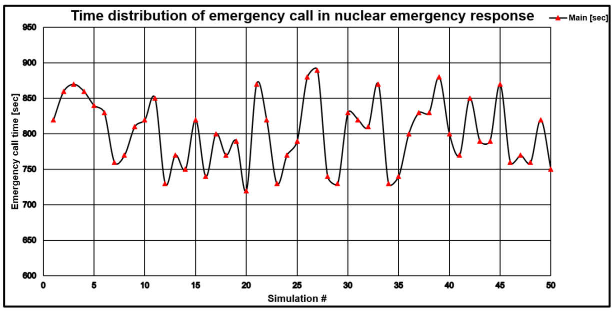

Figure 5. Time distribution of emergency call

Table 6. Simulation result

Simulation #	50 trials
Emergency call #	50 people
Average time	801.4 sec
Standard deviation	47.98 sec

In Figure 5, the distribution of the complete time for the emergency call has fluctuation. The main reason for time distribution(result) fluctuation is the bottlenecks and random distribution of emergency call agents.

During an emergency call, traffic congestion occurred in a specific area (road). Although the road is two-lane round-trip, many vehicles were crowded because it was the shortest route to the EOF (near nuclear power plant). Therefore, it was possible to obtain through simulation results that time has fluctuation according to the distribution of emergency call agent's location and path.

4. Conclusions & Discussions

First, the conclusion of this paper is as follows. This paper developed a simulation applying the definition of an emergency call and a new verification method. This paper also confirms the distribution of simple emergency call time through the developed simulations.

Next, the discussion of this paper is as follows. Currently, we collect annual data and meteorological data by commercial GPS. Through this, we want to obtain specific weights. And next paper, we intend to develop specific simulations, including TSC and OSC agents. OSC agents often live outside a 5 km radius. Therefore, next paper needs to expand the radius from 5 km to 10 km to obtain a more realistic distribution of emergency call time.

Acknowledgment

This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korean government (MSIP:Ministry of Science, ICT and Future Planning) (No. NRF-2021M2D2A1A02044210).

Geon Kim is grateful for financial support from Hyundai Motor Chung Mong-Koo Foundation.

REFERENCES

[1] Kim, G., & Heo, G. (2023). Agent-based radiological emergency evacuation simulation modeling considering mitigation infrastructures. Reliability Engineering & System Safety, 109098.

[2] Regulations on Radiological Emergency Measures for Nuclear Operators, Article 10-12.