A Study on evacuation simulation for evacuation assistance to vulnerable people

Jae-Soon Jang · Sang-Hyun Park · Tae-Ho Jung · Keum-Ho Oh† · Hyo-sun Kweon* · Do-Hoon Koo*

National Disaster Management Institute Safety Research Division, National Rehabilitation Research Center*

1. Abstract

Recently, many patients in a hospital are threatened life by fire disaster. Because many patients like vulnerable people have more evacuation problem than ordinary person. So a patient who can escape by oneself with walking assistance device like crutches or wheelchair and another patient who can't escape by oneself are should be supported safety technologies and service. Earlier research of 'hospital evacuation' led by actual experiments or computer evacuation simulation. Actual experiment is effective to gain credibility of result but it is difficult for patients to experiment repeatedly and it requires consideration for spatial problem and economic problems. Although computer evacuation simulation has been used to solve these problems, almost have concluded only results based on velocity without evacuation device.

In this study, evacuation results with support device application or not are analyzed used by computer evacuation simulation based on MAS(Multi Agent System). As a result, it is drawn through proof of efficiency of evacuation device in the vertical space like stairs that can improve the evacuation plan for vulnerable people in the hospital.

2. Research background

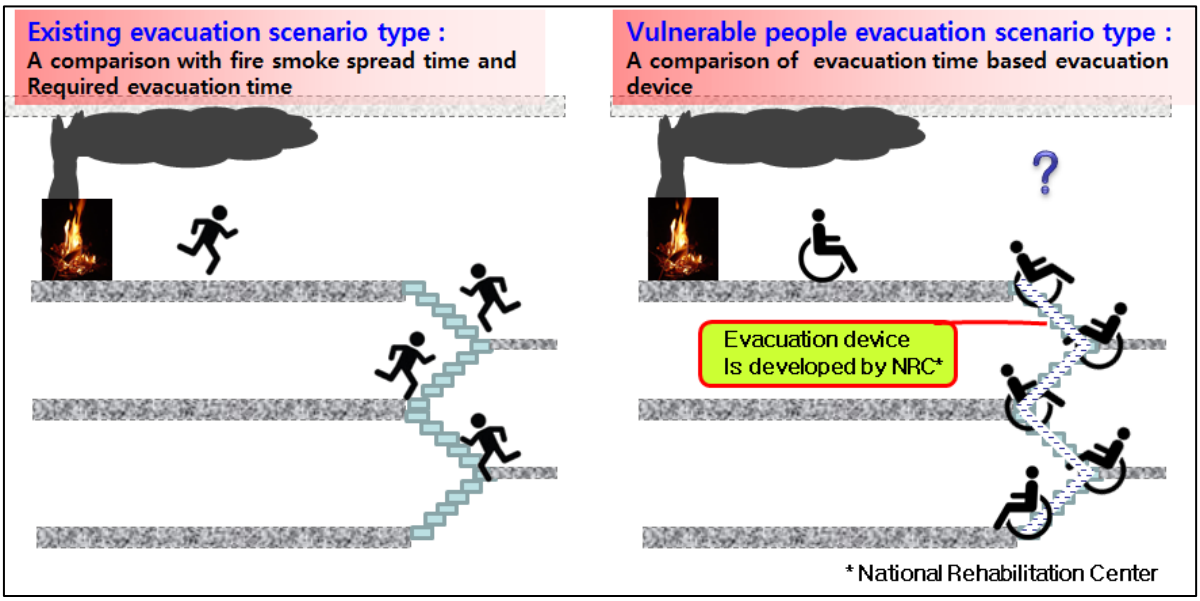
Last 2014 year, many accidents occurred in Korea. Especially, according to statistics, fire broke out 67 times in hospital. Representatively 21 persons were dead by Jangsung hospital fire. They couldn't evacuate by themself because they were patients who can't walk. Also, approximately 1000 persons were evacuated from Seoul police hospital because Nitric acid was leaked out. Through these accidents, we can see that there are serious evacuation problems in Medical Facility. First, Many vulnerable people are resident in medical facility. Second, it is difficult vulnerable people to evacuate by themself. Third, In the event of fire or disaster, it is easy to be damaged**.** So, it is essential for wheelchair patients to be possible to evacuate on the stairs.

<Figure 1> 2014. 5. 28 Jang-sung hospital fire, 21 persons death

<Figure 2> 2014. 10. 29 Seoul hospital Nitric acid spill, 1000 persons evacuation

3. Research method

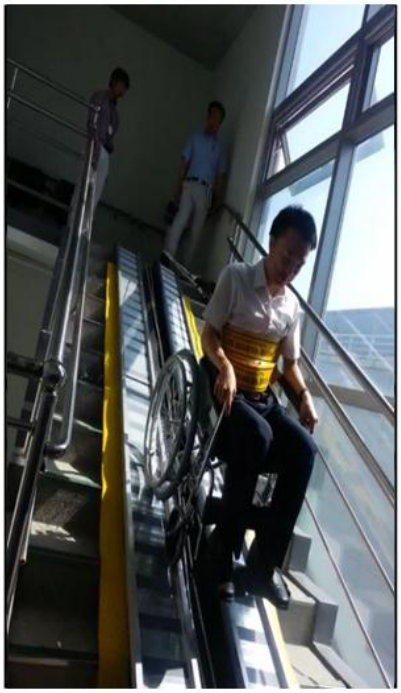
Generally, existing evacuation scenario type is to compare the evacuation time with fire smoke spread time in the building. But the evacuation scenario is for vulnerable people in this study. So, the point is to check the evacuation time based on evacuation device for vulnerable people. That evacuation device is developed by National Rehabilitation Center and our institute used the data from experiments by that device.

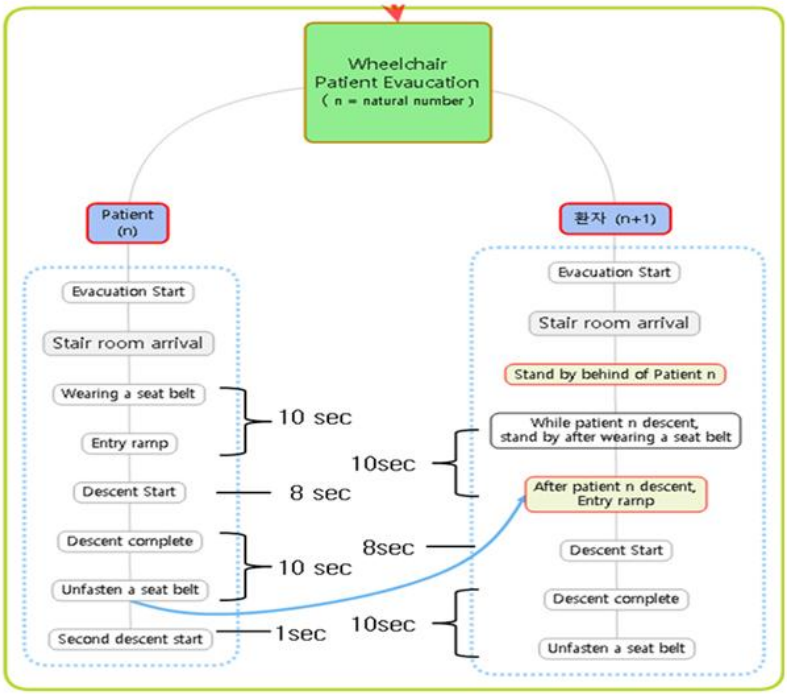


<Figure 3> Evacuation scenario type

After Slop descent experiment, we made the evacuation flow chart such as <Figure 5>.

In this flow chart, it was checked the parts of time and it was used in the evacuation simulation.

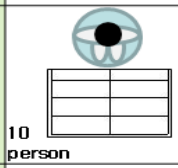
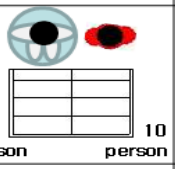
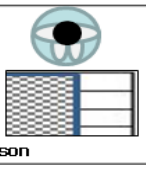
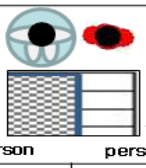
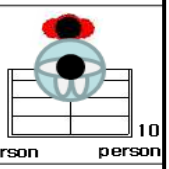
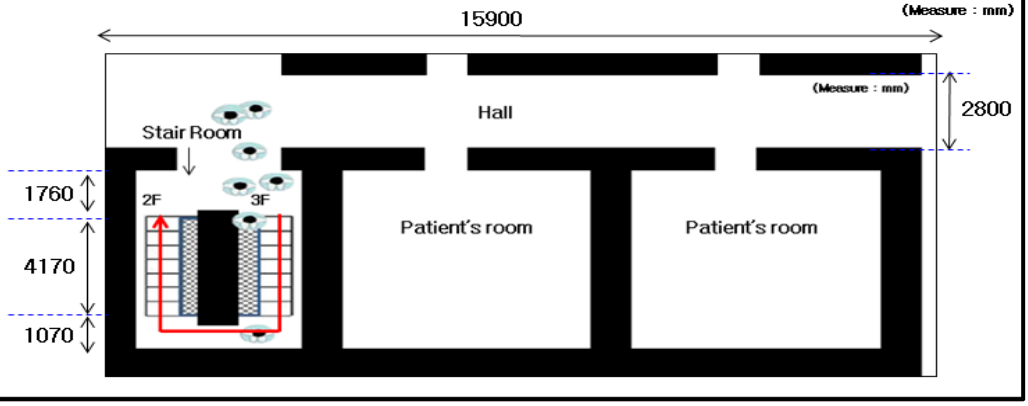




<Figure 4> Slop decent experiment

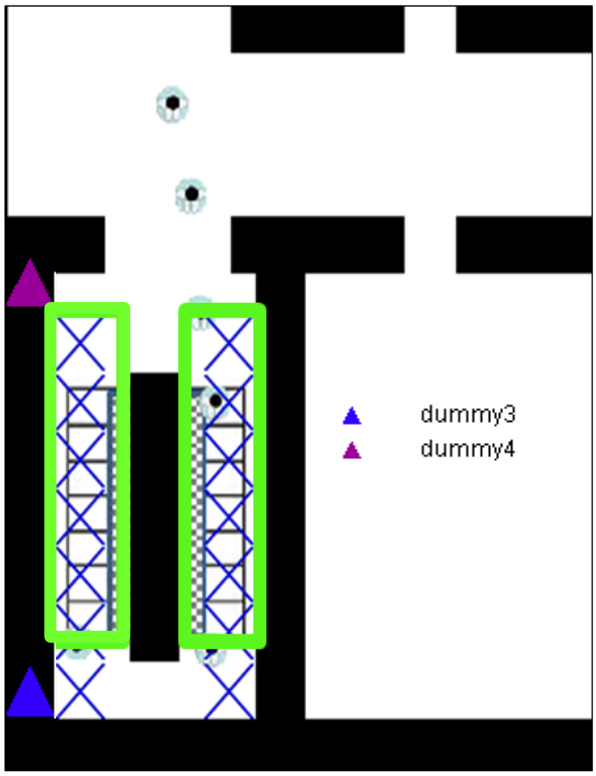
<Figure 5> Evacuation flow chart

<Table 1> is the simulation scenario condition and there are 5 Scenarios. This table shows the simulation models by evacuation conditions.

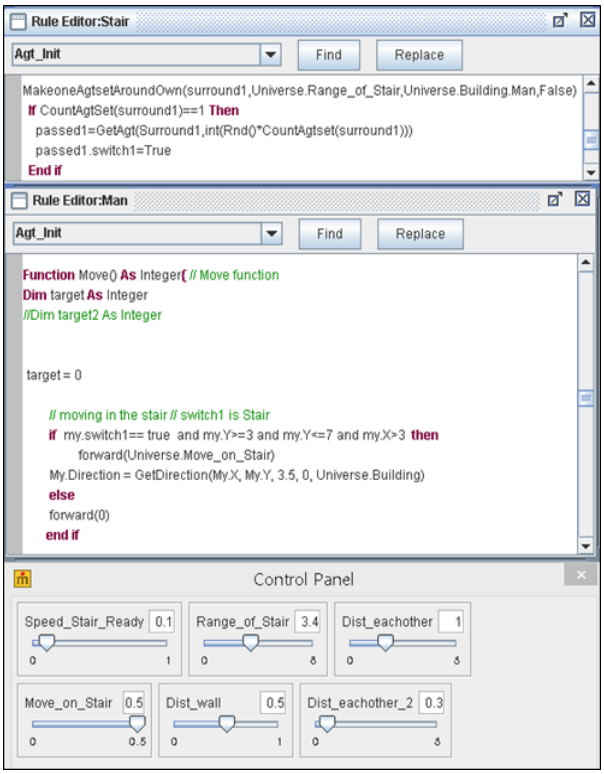
Scenario	Case 1	Case 2	Case 3	Case 4		Case 5
Evacuation Model	Wheelchair	Wheelchair + Normal	Wheelchair Assistant device	Wheelchair Assistant device + Normal		Wheelchair + Helper
Evacuation Model Figure						
Enter velocity	–	–	0.1 m/s	0.1 m/s	–	0.1 m/s
Vertical Move velocity	–	–	0.5 m/s	0.5 m/s	1 m/s	0.1m/s, 0.3m/s
Horizontal Move velocity	0.83 m/s [1]	0.83 m/s	0.83 m/s	0.83m/s	1 m/s	0.91m/s [1]
Evacuation Space Figure						

<Table 1> Simulation scenario condition

Case 1 is the evacuation situation with general wheelchair on stairs. In the Case 2, normal was added and it is an extension of Case 1. Normal means the ordinary person. In the Case 3, Wheelchair Assistant device is used. The vertical move velocity data is based on actual experiments. Case 4 is an extension of Case 3, normal was added. Case 5 is classified as two types. In this case, helper can assist the wheelchair patient to move on the stairs. The reason for velocity classification is difference of proficiency to assist. Actually, almost helper is the old woman, so they can't move quickly.



<Figure 6> Waiting space in the stair



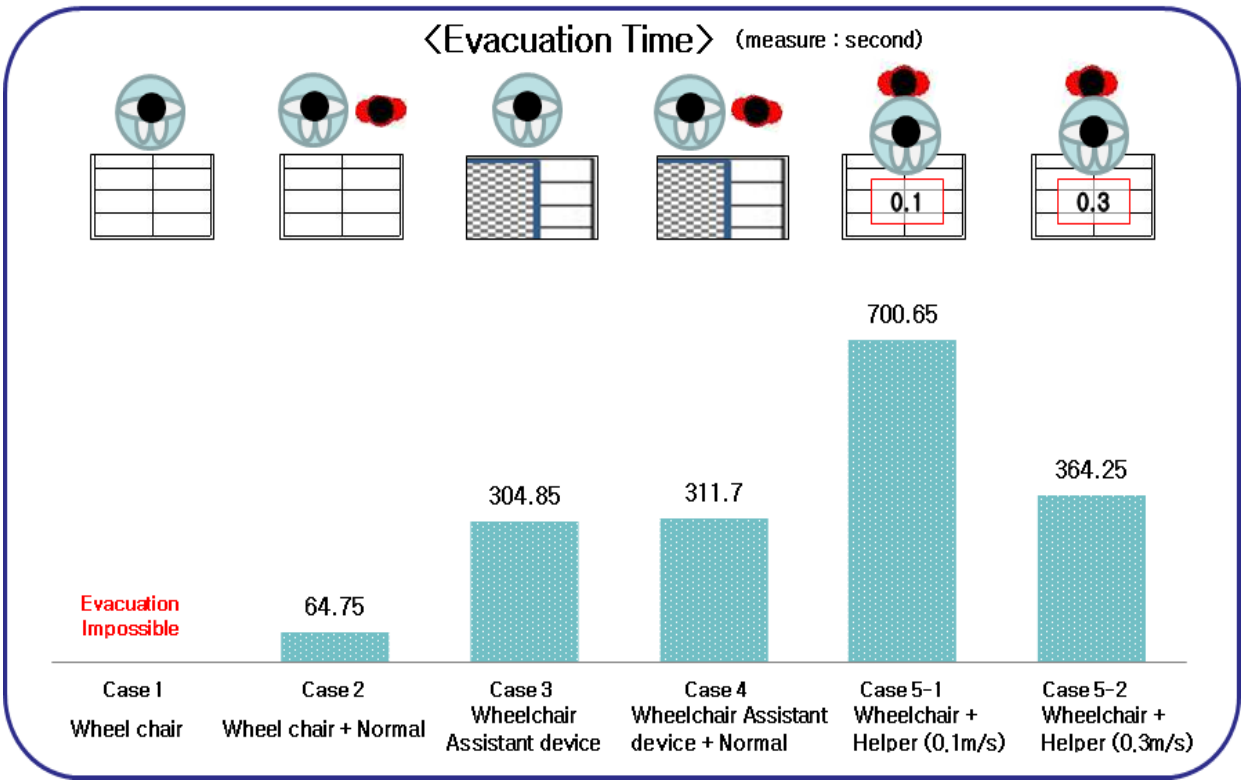
<Figure 7> Setting of Agents

Particularly, only one wheelchair patient can move in that green zone in the <Figure 6>. Next wheelchair patient have to wait until the front patient is finish. To implement, I use 'CountAgtSet ==1'. 'Range_of_Stair' means that it recognize other patient. Therefore it determines the distance between them. And several dummies are located in the wall to induce direction change. Other general moving rule is referenced by existing research result.[2)]

4. Simulation result

The following <Figure 8> is the graph of evacuation time. Case 1 shows that without a help, wheelchair patient can't escape on the stair. In the Case 2, only normal can escape in 64.75 seconds. Case 3 shows wheelchair patient can evacuate without help. 10 patients were

waiting their evacuation order in front of stairs. In the Case 4, although they evacuated with normal, the evacuation time was not little different from Case 3. In the Case 5, it shows that to evacuate quickly and safely, helper need more convenient device or they need to increase their skills to help.



<Figure 8> Simulation result

5. Conclusion

Proceeding from what has been said above, it should be concluded that

1) Transfer efficiency on the stair should be considered to assist vulnerable people by helper.
2) Application of evacuation device can increase evacuation efficiency because of providing a stable maintenance to evacuation velocity on the stairs.

Reference

1) Lee, Jeong-Soo et al., "A Study on the Architectural Design and Management Guidelines through Reviewing of Evacuation Behavior in the Ward of General Hospitals", Architectural Institute of Korea, 2005
2) 城田拓耶, "マルチエージェントによる避難計画を踏まえた教室配置の検証", 芝浦工業大学 システム工学部 環境システム学科, 2011