



Evacuation Modeling and Route Generation of Human Crowd using Spatial Evacuation Simulation in Emergency Situations

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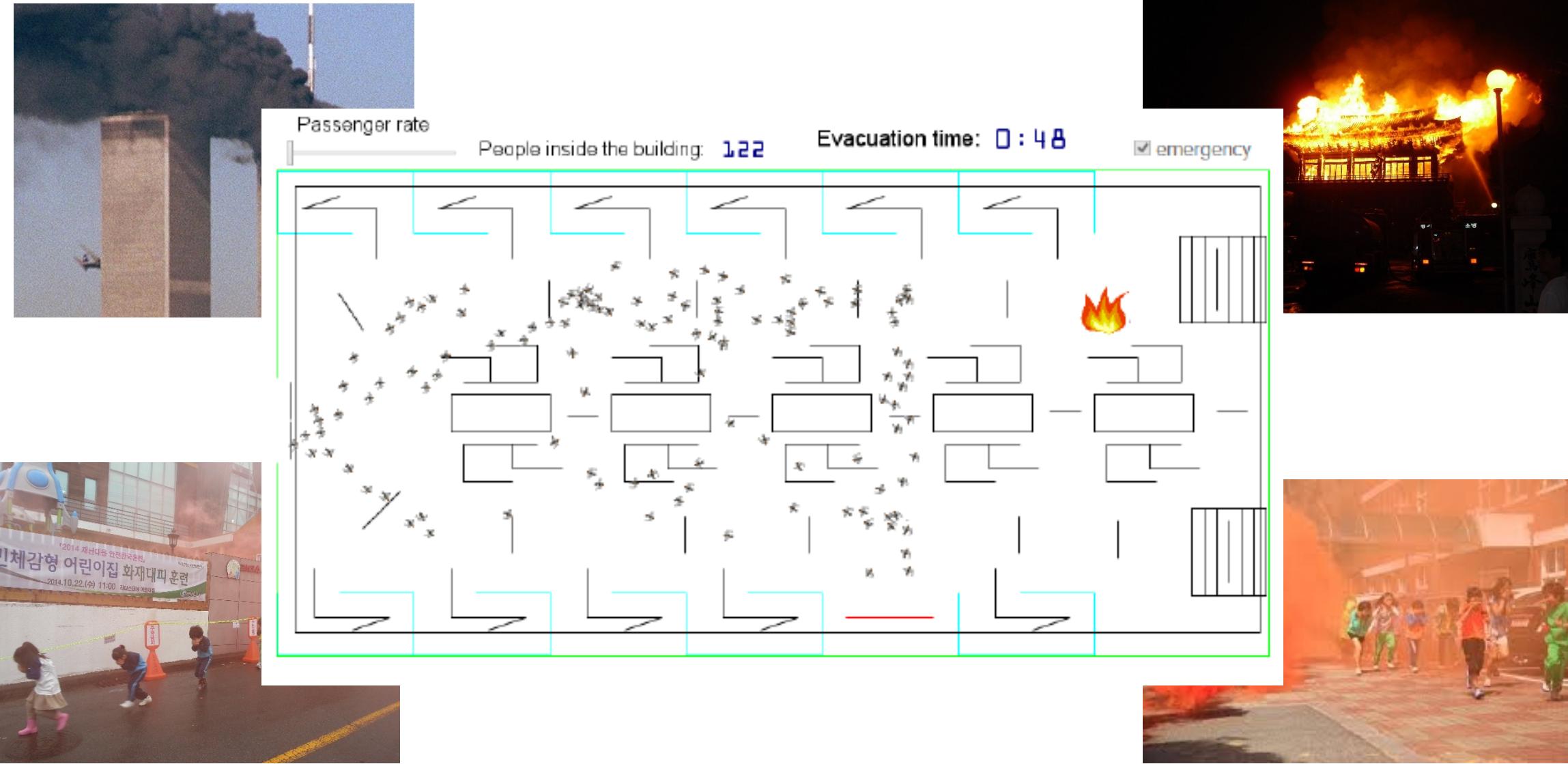
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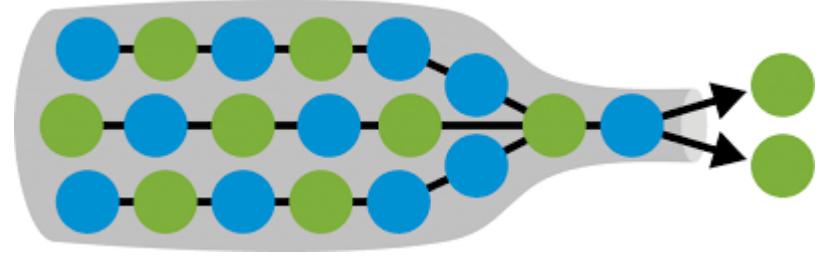
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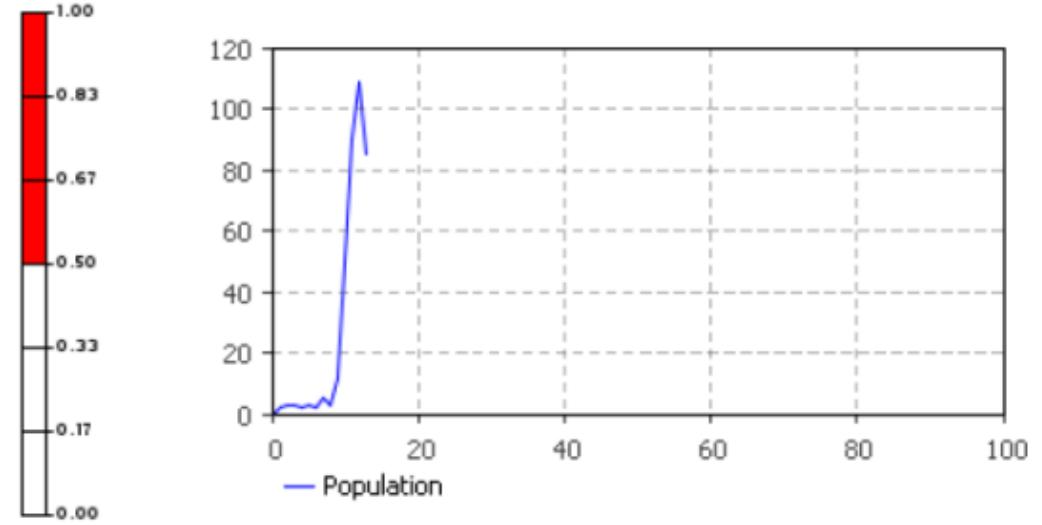
Motivation I





The Bottleneck

pedDensityMapLegend



The measurement of evacuees' crowdedness

<i>Research studies</i>	Application areas and characteristics	Considerations of human crowdedness
<i>Christensen and Sasaki (2008)</i>	<ul style="list-style-type: none"> - Four story buildings : consideration of visual / physical/hearing / lower stamina impaired agents 	-
<i>Watron (2009)</i>	<ul style="list-style-type: none"> - Fire Evacuation : Internal walls and rooms 	-
<i>Torrey (2010)</i>	<ul style="list-style-type: none"> - School domain :classrooms and hallways 	<ul style="list-style-type: none"> - Measured as an output

[Lee, 2016]

Characteristics of cooperative modeling protocols

Literature Review II

<i>Research studies</i>	<i>Algorithm Or Model</i>	<i>Research studies</i>	<i>Algorithm Or Model</i>
Evacuation Analysis for a Passenger Ship Using a Cellular Automata Model with Group Behavior	-Cellular Automata	Network models for building evacuation	-Network Models
An Optimal Model for Indoor Pedestrian Evacuation considering the Entire Distribution of Building Pedestrians	-Genetic Algorithms	From crowd dynamics to crowd safety: A video-based analysis	-Pedestrian dynamics -Macroscopic Pedestrian Models
Modeling and Optimization of Building Emergency Evacuation Considering Blocking Effects on Crowd Movement	-Macroscopic Model -Macroscopic pedestrian -Network-flow models	Self-organized pedestrian crowd dynamics: Experiments, simulations, and design solutions	-pedestrian crowd dynamics -granular flow

$\pi^*(s) = \arg \max_a [r(s, a) + \gamma V^*(\delta(s, a))]$ where s = a status,
A = an action
 $r(s, a)$ = a reward value in (s, a)
 γ = a discount learning rate
 $\delta(s, a)$ is a state transition function
And, $V^*(\cdot)$ is an evaluation function

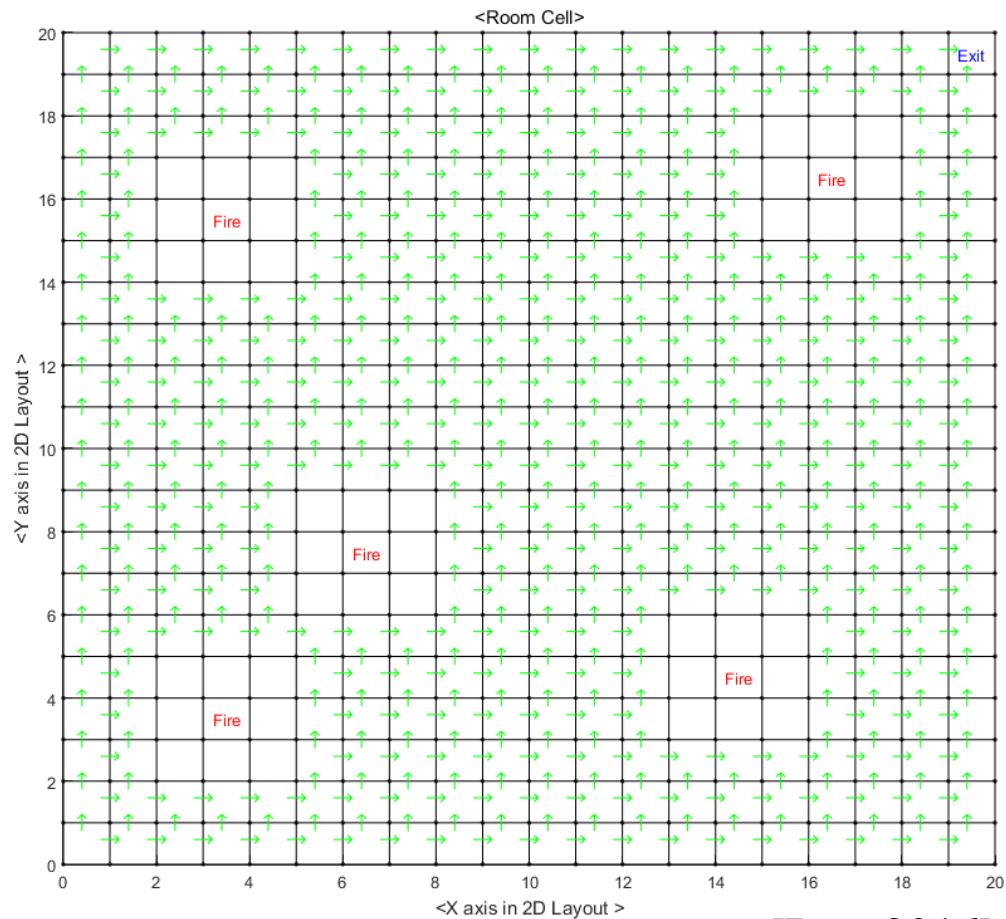
$$V^*(\delta(s, a)) = \max_{a'} Q(\delta(s_t, a), a')$$

where $a' = \arg \max_a Q(s, a)$

$$Q(s_t, a) = r(s_t, a) + \gamma \cdot \max_{a'} Q(\delta(s_t, a), a')$$

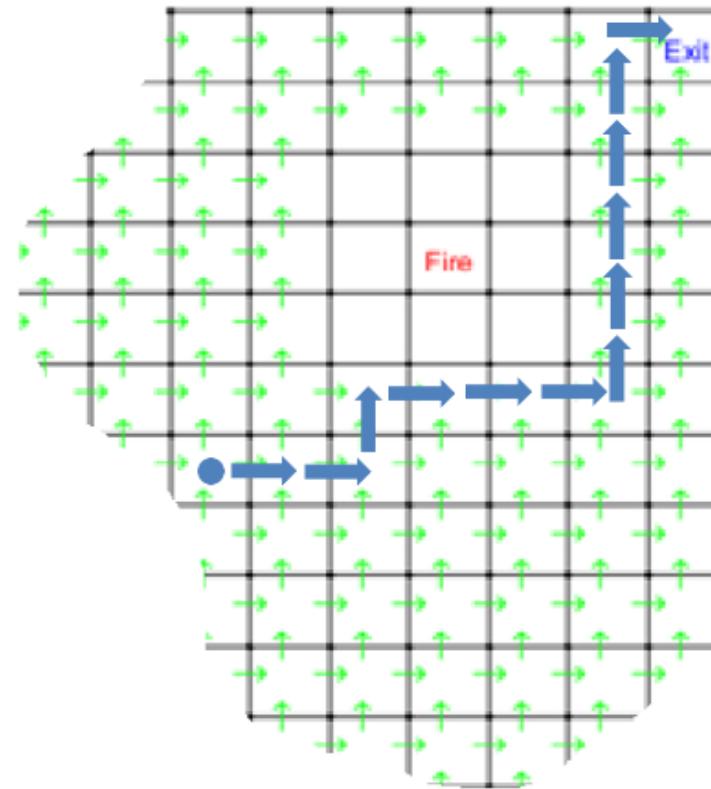
$$Q(s_t, a) \leftarrow r + \gamma \cdot \max_{a'} Q(\delta(s_t, a), a')$$

Evacuation Modeling



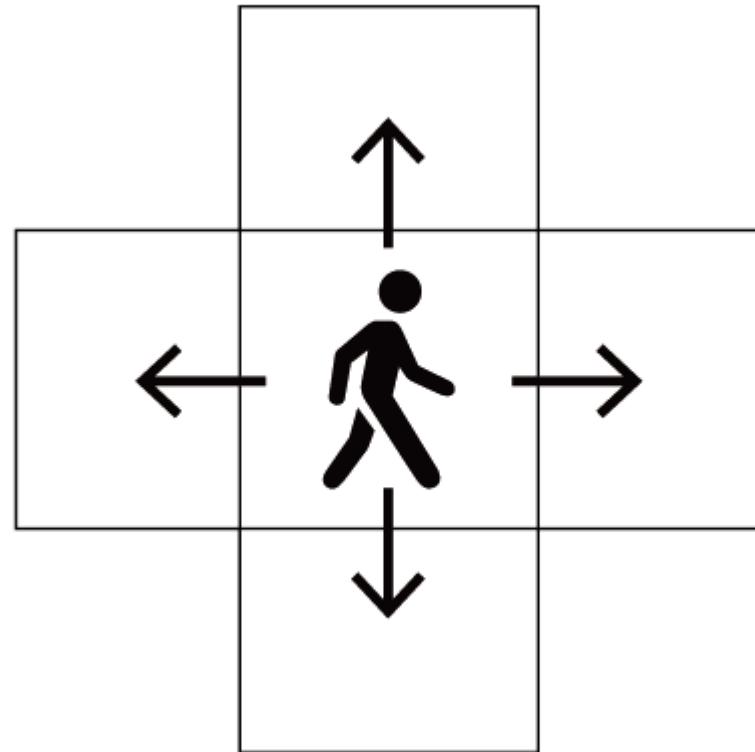
[Lee, 2016]

Evacuation routes using the Q learning

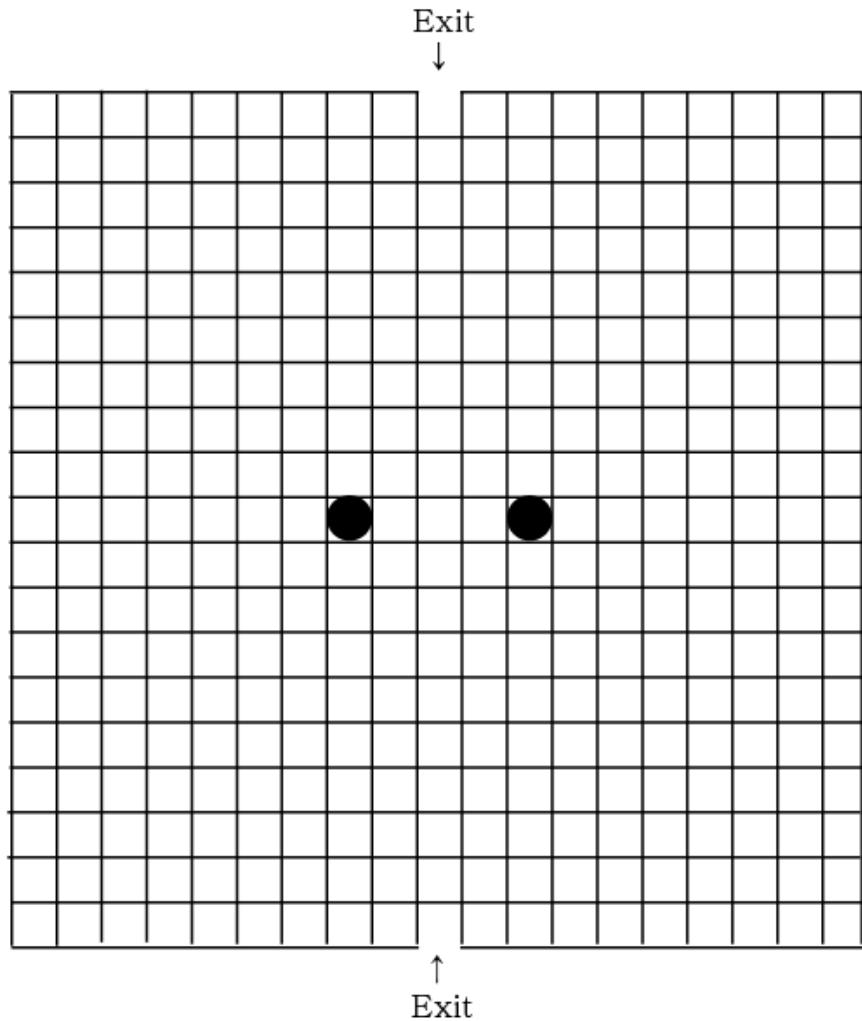


[Lee, 2016]

An evacuation route from a cell



4가지(동서남북) 방향으로 움직일 수 있다.
한번 움직일 때 한 개의 Cell씩 움직일 수 있다.
장애물을 넘어갈 수 없다.



Evacuation without consider
obstacle & crowdedness



$$\min W_j^i$$

W: way
J: 사람수
i: 탈출구의 개수

Evacuation considering obstacle



$$\min W_j^{io}$$

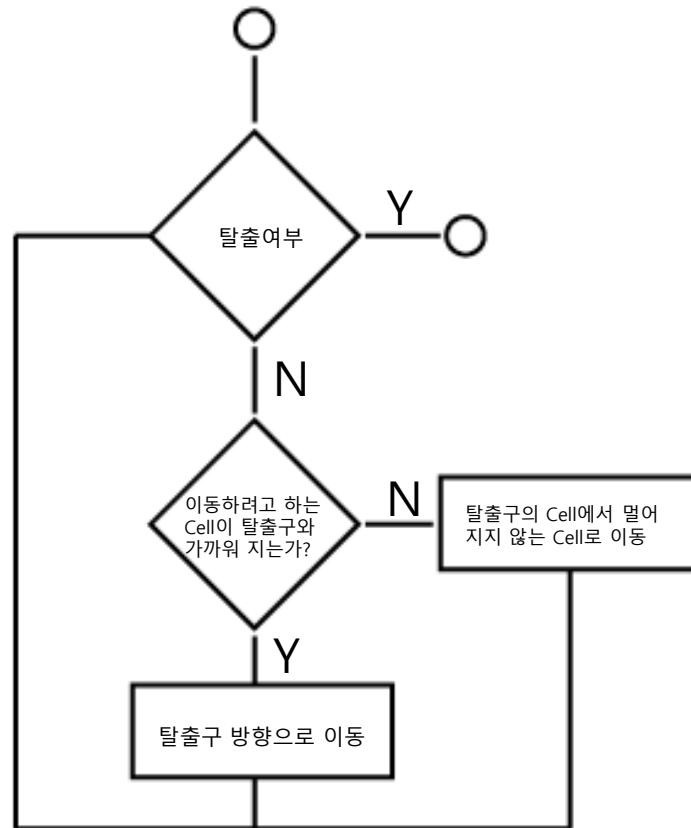
W: way
J: 사람수
i: 탈출구의 개수
O: 장애물의 개수

Evacuation considering
obstacle & crowdedness

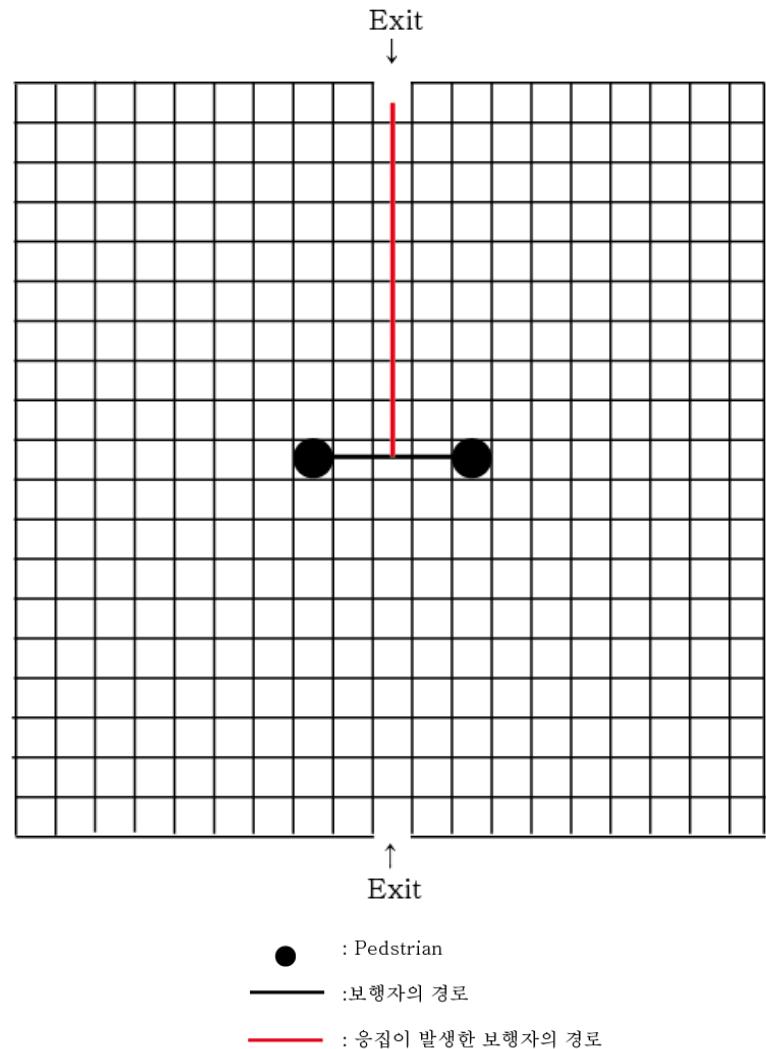


$$\min C(W_j^{io})$$

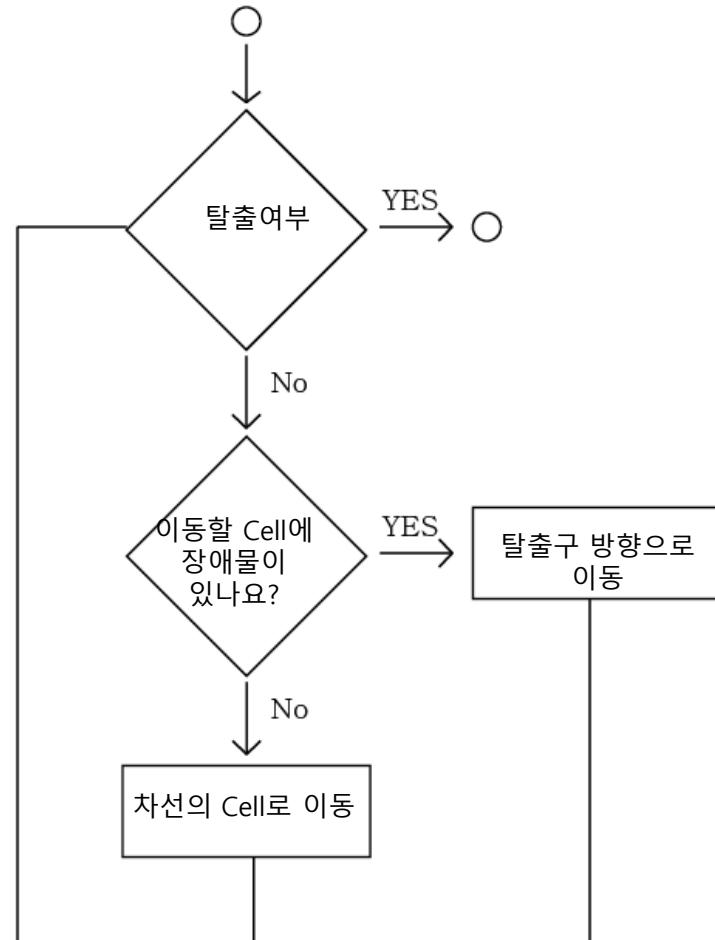
W: way
J: 사람수
i: 탈출구의 개수
O: 장의물의 개수
C(): crowdedness의 함수



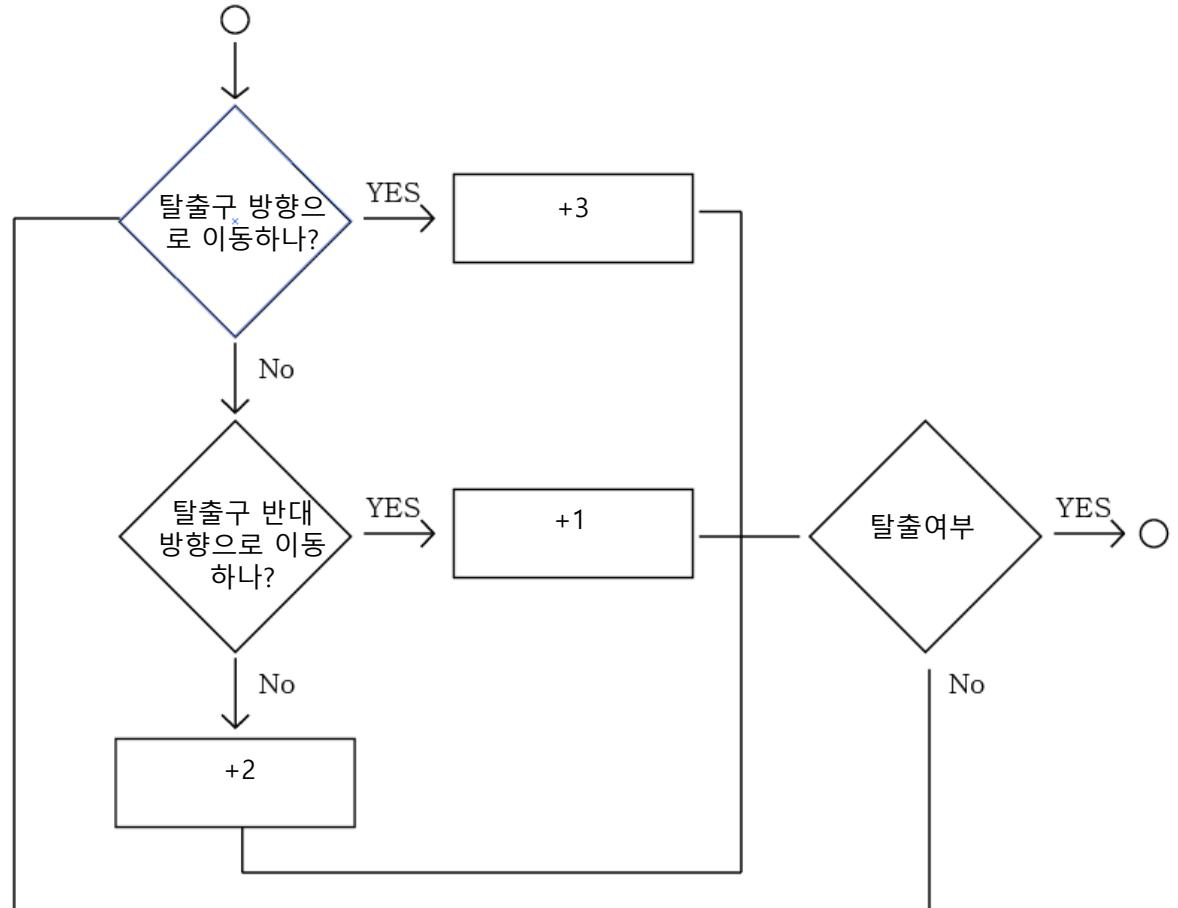
Evacuation without consider
obstacle & crowdedness
Flow Chart



장애물과 응집을 고려하지 않고 경로를 흐름도 대로 설정할 경우 한 개의 출구로만 모이게 되는 현상이 일어남.

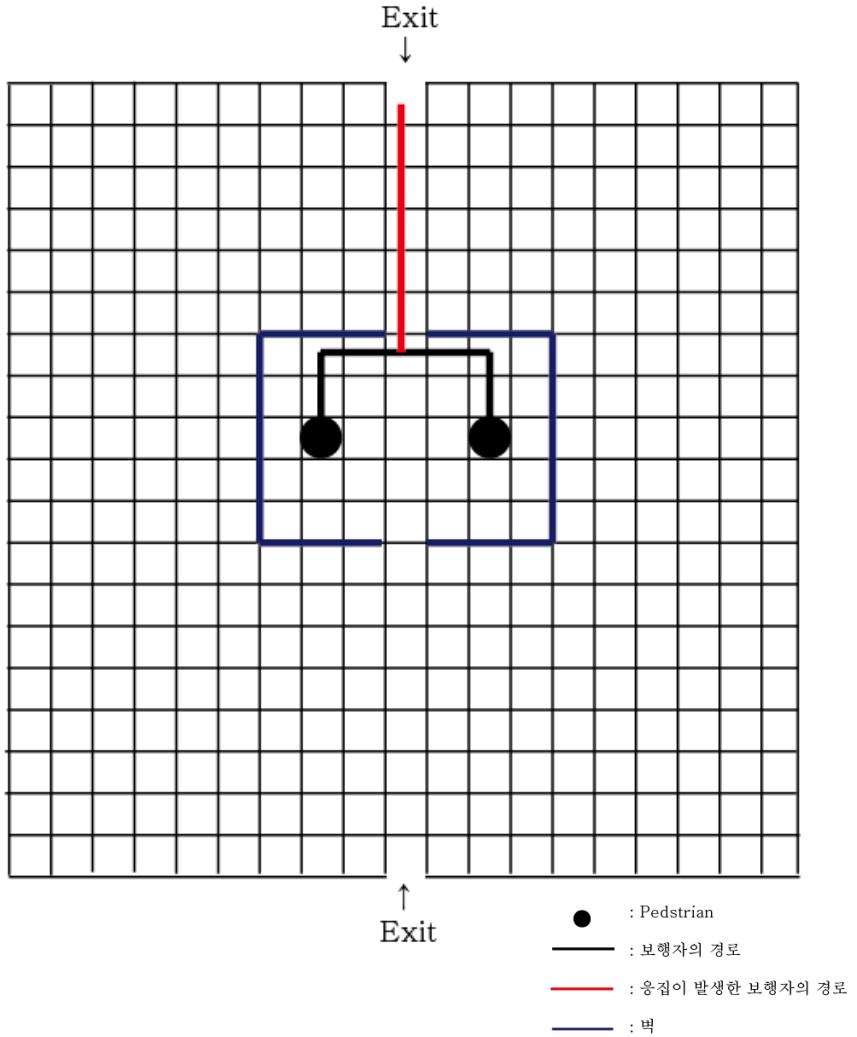
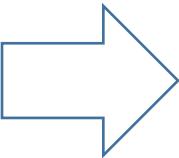
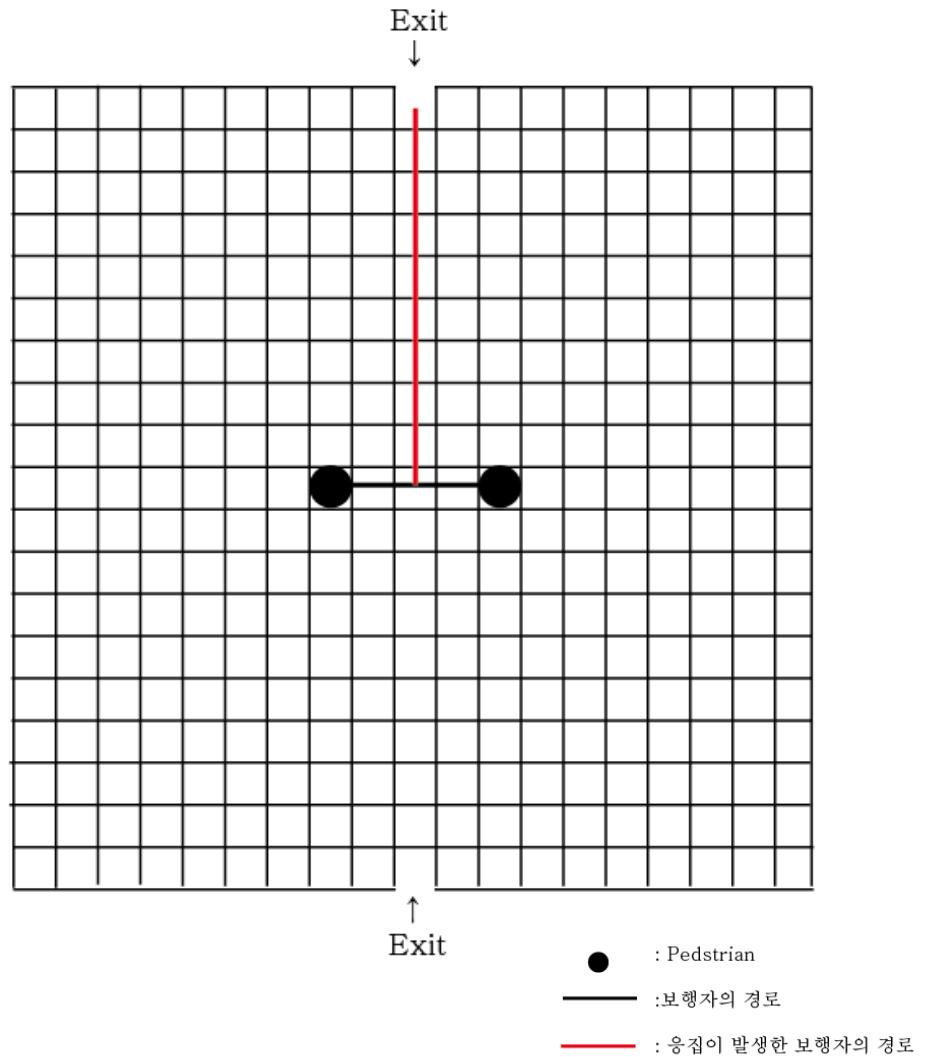


Evacuation considering obstacle Flow Chart

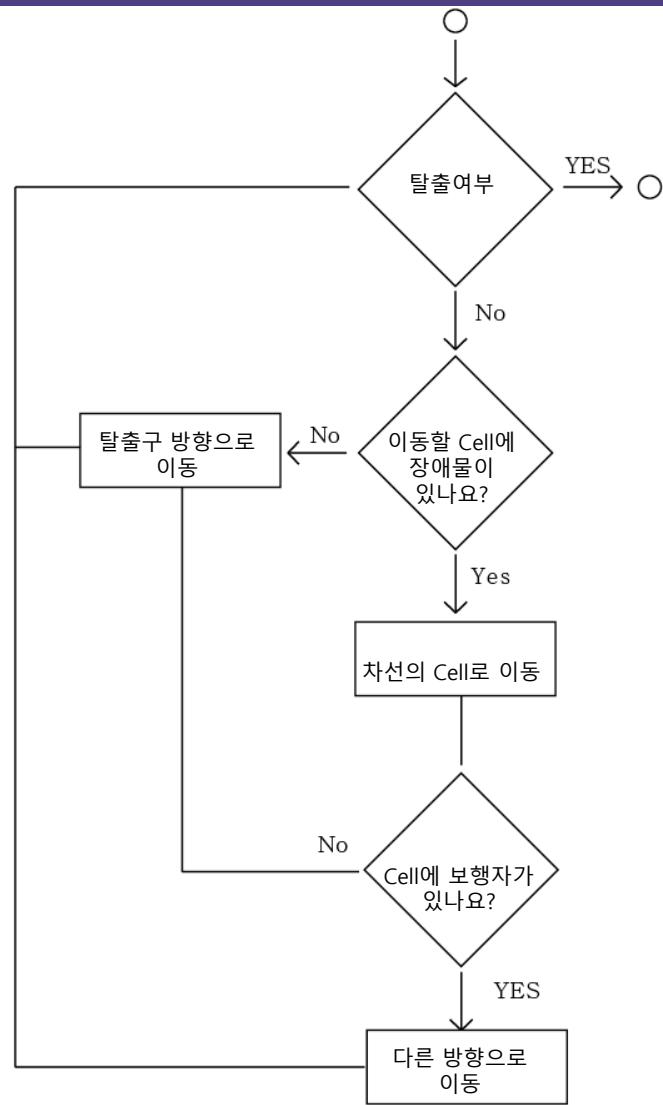


장애물을 만났을 때 스코어링 Flow Chart

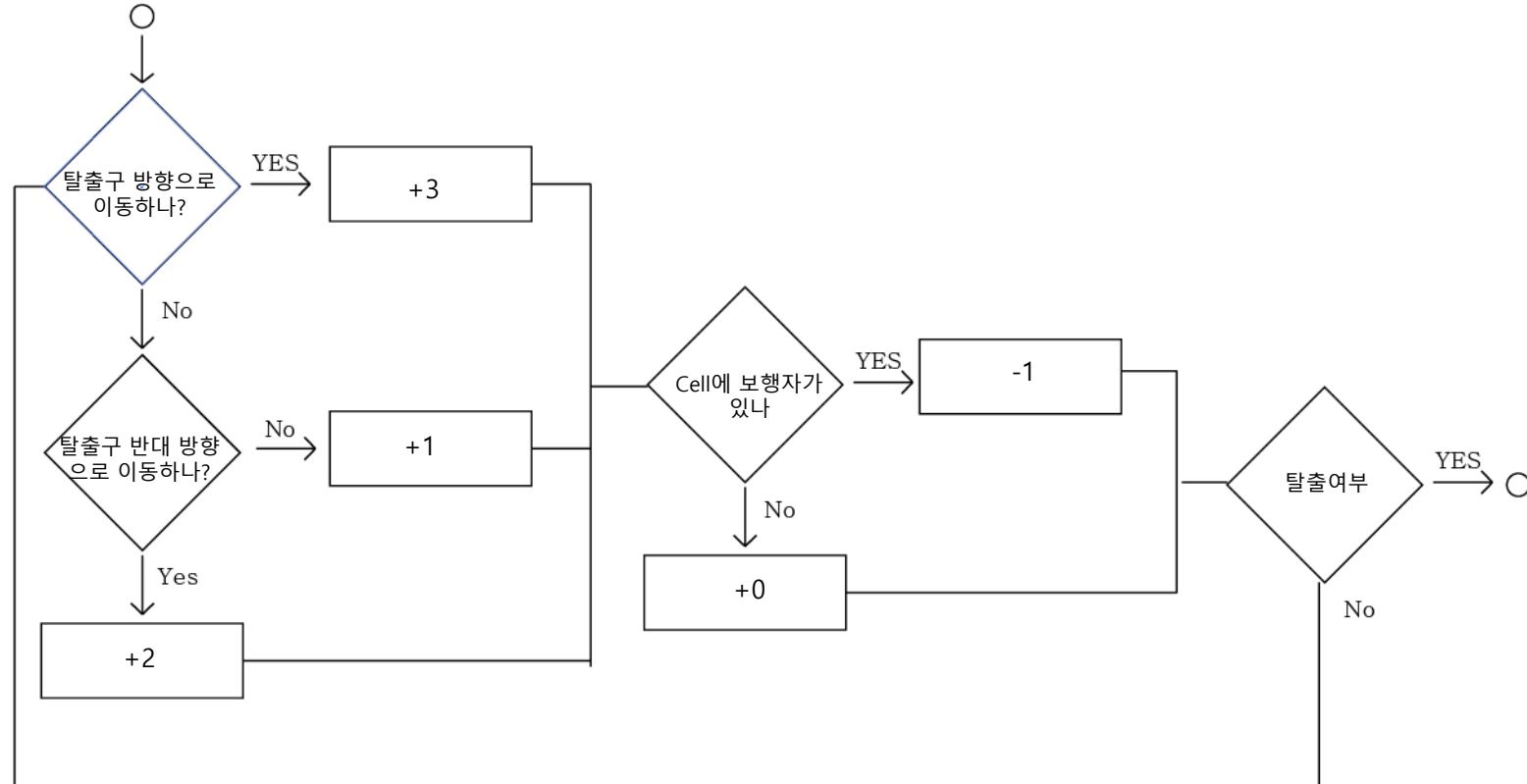
Control Algorithm V



Control Algorithm VI

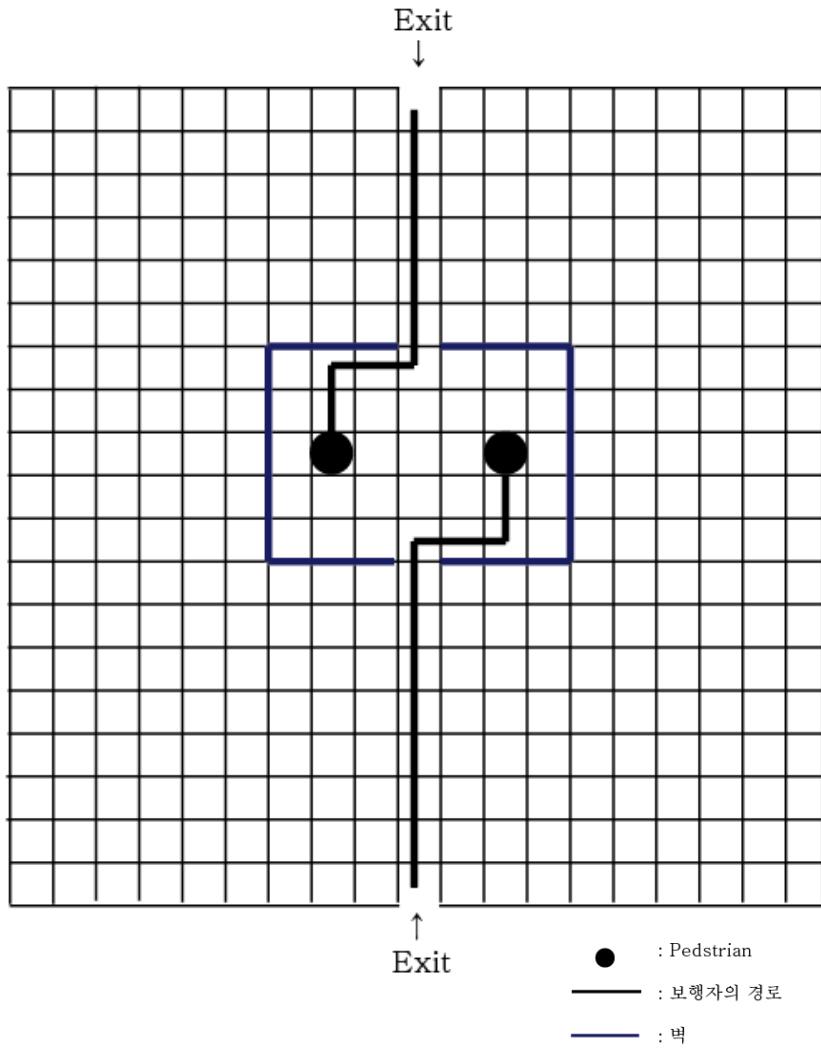
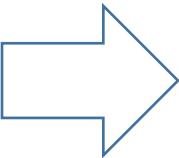
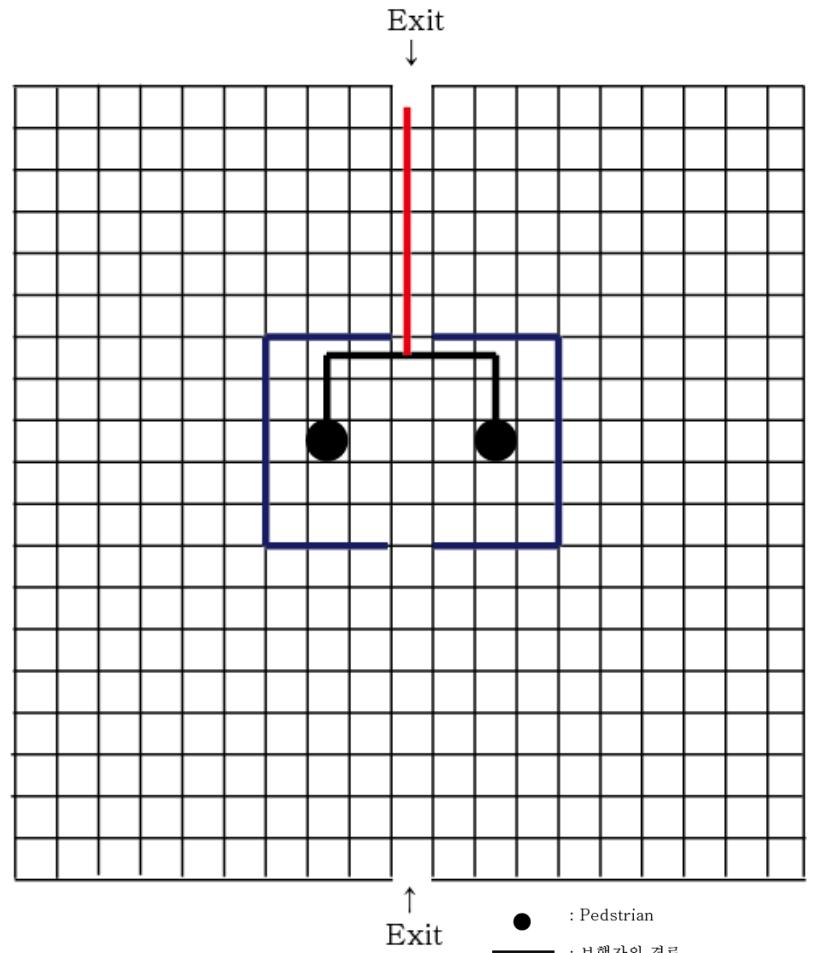


Evacuation considering
obstacle & crowdedness Flow Chart



장애물과 crowdedness가 고려된 스코어링 Flow Chart

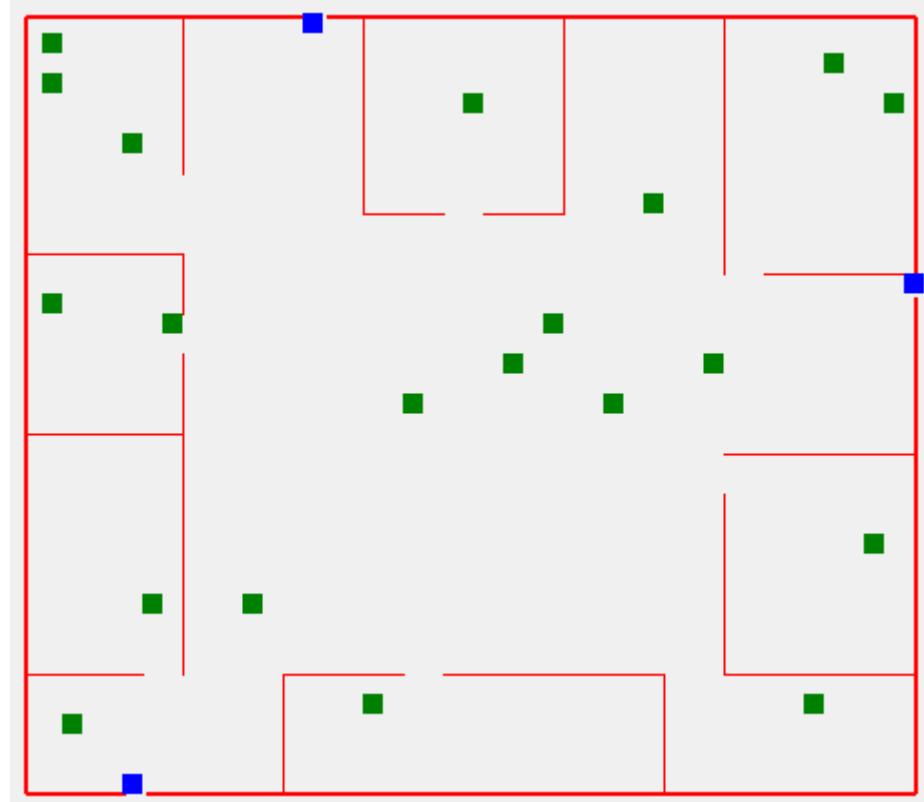
Control Algorithm VII



Implementation

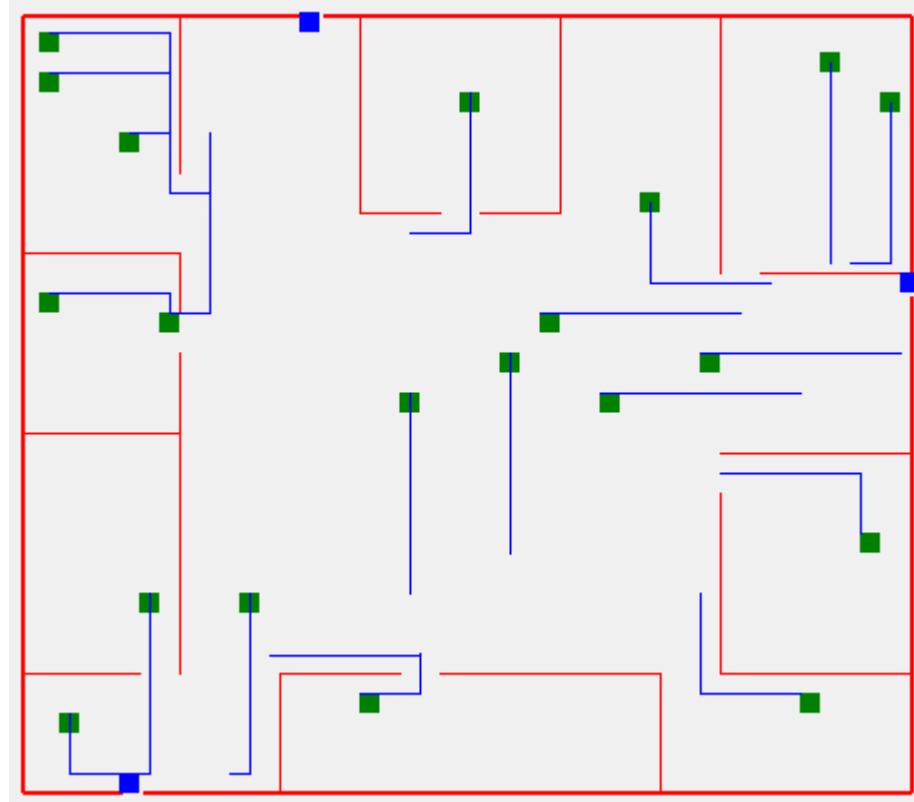
- **개발환경**
 - CPU : intel Core I7-4720
 - Memory : DDR3L 8G
 - Graphic : Geforce GTX970m
 - OS: Windows 7 Home Premium K 64비트
- **프로그램 개발 툴**
 - Microsoft Visual Studio 2013
- **프로그래밍 언어**
 - C#

Implementation



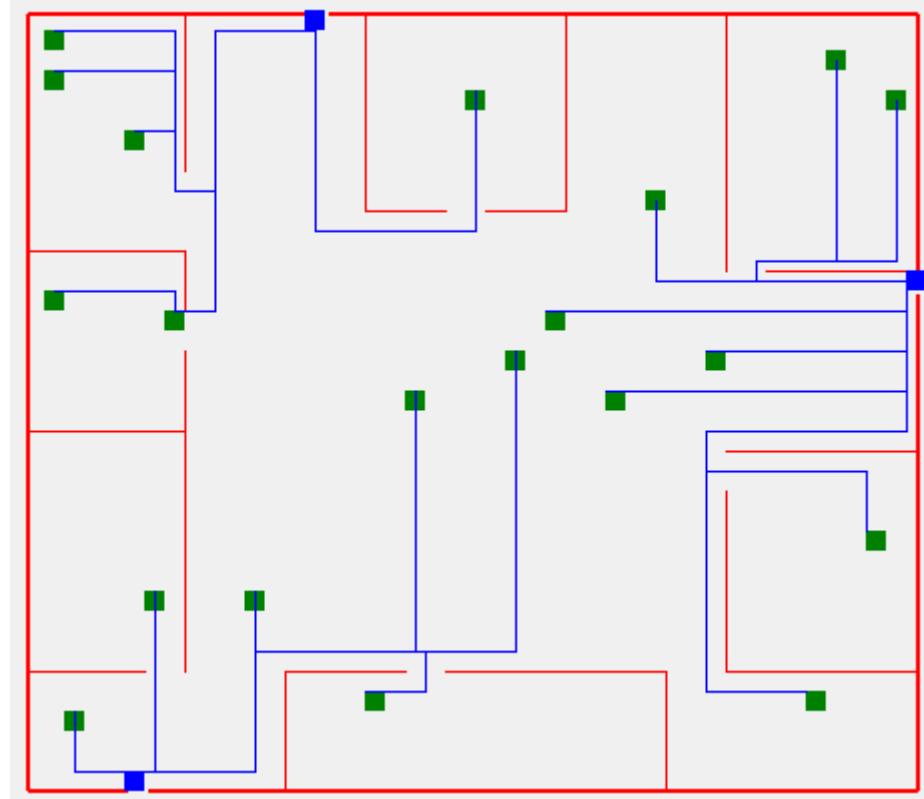
건물 내 평상시 상황

■ Exit
■ Pedestrian
— Obstacle (Wall)



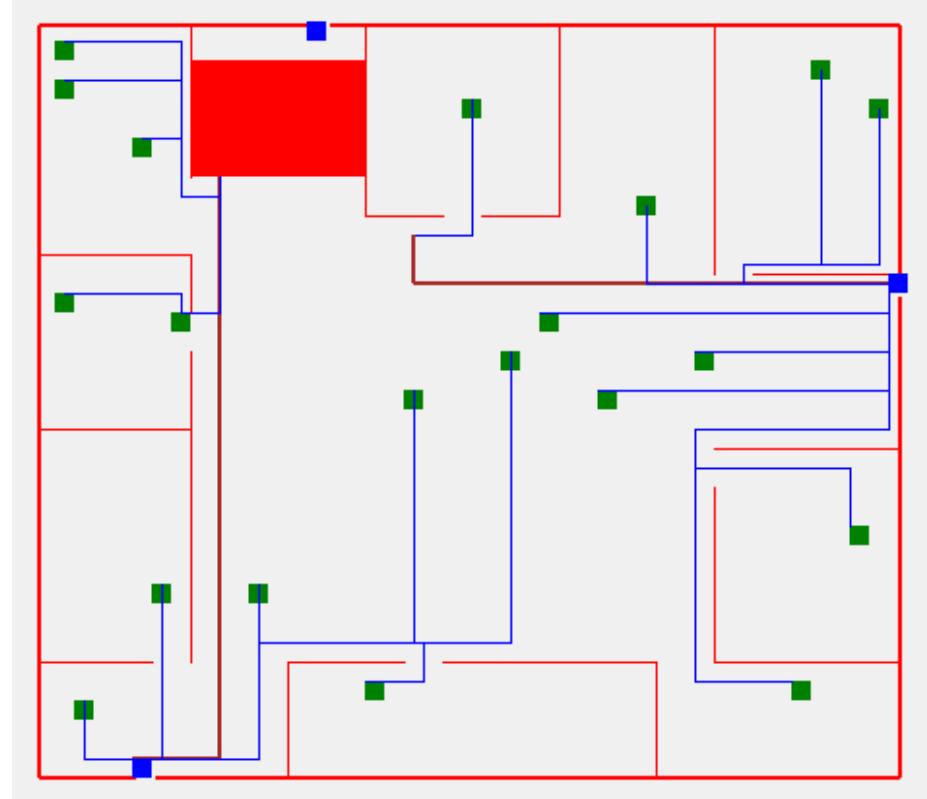
비상 상황 발생
10초 후 상황

■ Exit
■ Pedestrian
— Obstacle (Wall)
— Escape Route



전체 대피 경로
(알고리즘 적용)

- Exit
- Pedestrian
- Obstacle(Wall)
- Escape Route



대피 중 한쪽 출구가 막혔을 때 상황

결론

- 본 연구에서 보행자들의 현재 위치에서 가장 효율적인 탈출경로를 탐색하는 알고리즘을 제시.
- 건물 내부를 Cell로 분할하고 Scoring을 함.
- 알고리즘을 통해 Bottleneck이네 Blocking effect를 사전에 방지 할 수 있는 경로를 탐색하고 제시함.

발전방향

- 아직 보행자의 심리 상태를 적용하지 못함.
- 탈출구에 jam이 생길 경우 시간에 따른 dynamic한 알고리즘을 제시할 것.

Q & A