

A Real-Time Indoor Evacuation Simulation System Using Indoor IR Sensor Information

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Contents

- Introduction
- Related Works
- System Development
- System Test
- Conclusions

Introduction

■ Evacuation Simulation Programs

- ▶ In order to minimize damage from increasing disasters such as fire, earthquake, collapse in indoor spaces, it is **simulation system** for understanding **evacuation situations** in advance
- ▶ Many research been actively studied overseas rather than domestic and research has increased in the 2000s domestically
- ▶ Existing evacuation simulation was developed focusing on **building safety evaluation** to use virtual data



Pathfinder



Simulex



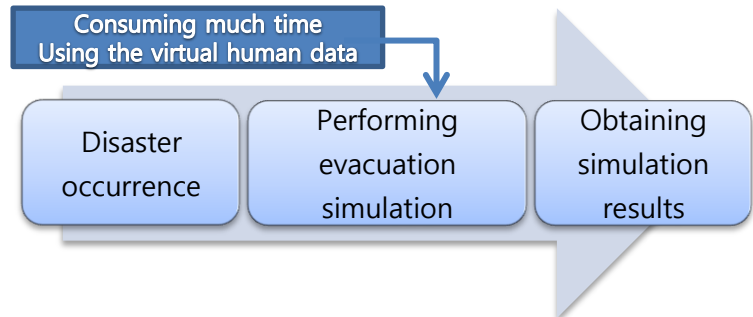
buildingEXODUS

Introduction

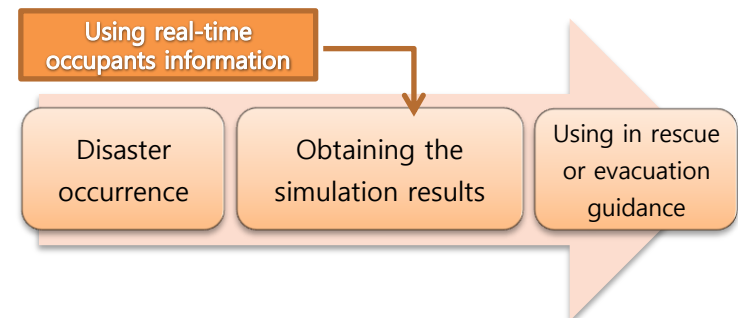


- Time Constraints: It takes much time to generate simulation results

- Existing simulation system



- Improved simulation system



Introduction

■ System Overview

▶ Evacuation simulator

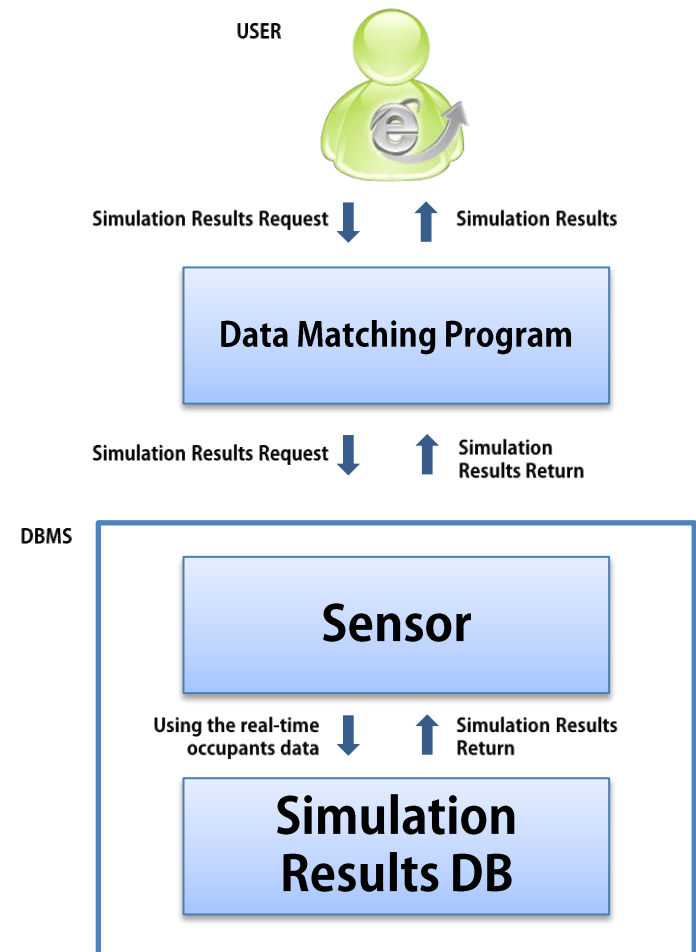
- Using pedestrian model based CA
- Storing the resulting data in DBMS

▶ DBMS

- Simulation results
- Distribution of the real occupants

▶ Data Matching Program

- It performs queries and returns the query results by connecting to the simulation results database and the sensor detection occupants database



Related Works

■ Pedestrian Modeling

▶ Social Force Model

- Considering the all neighborhoods, slow computation speed

▶ Floor Field Model

- Considering the near neighborhoods, fast computation speed
- Using two field values
 - » static floor field and dynamic floor field
- Sensitivity parameters
 - » The cooperative regime case
 - » $K_s = 0.4$, $K_d = 0.1$, $\alpha = 0$, $\delta = 0.3$

Related Works

■ Indoor occupants detection sensor

- ▶ In order to find out the indoor occupants distribution or the number of indoor occupants, a variety of sensors have been used
 - Infrared (IR) sensors, RFID, heat detection sensors, weight detection sensors, Zigbee sensors, and camera sensors
- ▶ In this study
 - The required information was **the distribution of occupants** by each room
 - Accurate location information for each occupant was not needed
 - **IR sensor** is appropriate for acquiring information of the occupants

System Development

■ Generation and storage of the simulation results

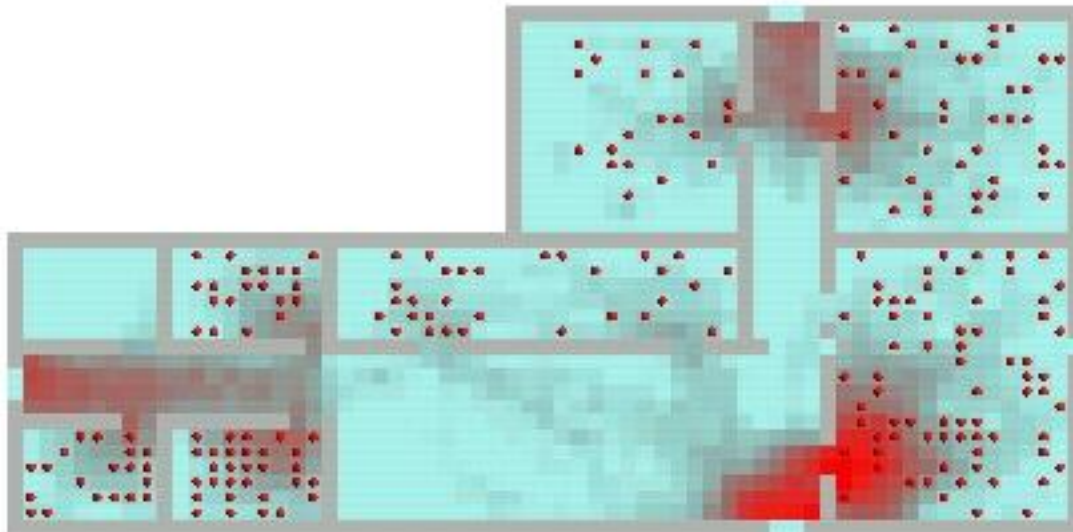
- ▶ In this study, a large number of simulation results were stored in the DBMS beforehand

TYPES OF THE GENERATED DATA

Resulting data	Information to be stored in DBMS
Initial occupants distribution	Initial location coordinates for each pedestrian
Total evacuated occupants	Total evacuated occupants
Total evacuation time	Total evacuation time
Algorithm parameters	The algorithm parameters used in the FFM
Evacuated occupants by exit door	Evacuated occupants collected by each exit door
Evacuation route by each room	Coordinates list for the travelled route by selecting a representative occupant for each room randomly
Expected bottleneck spots	Cell occupancy degree value for each cell by calculating pedestrian's occupancy

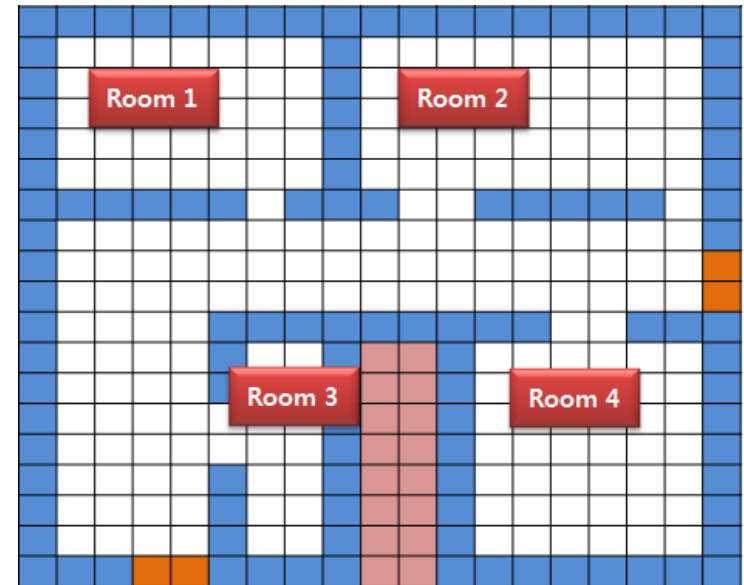
System Development

- Generation and storage of the simulation results
 - ▶ Expected bottleneck spots
 - In this study, the number of pedestrians occupied in each cell was recorded and this data was called the cell occupancy degree



System Development

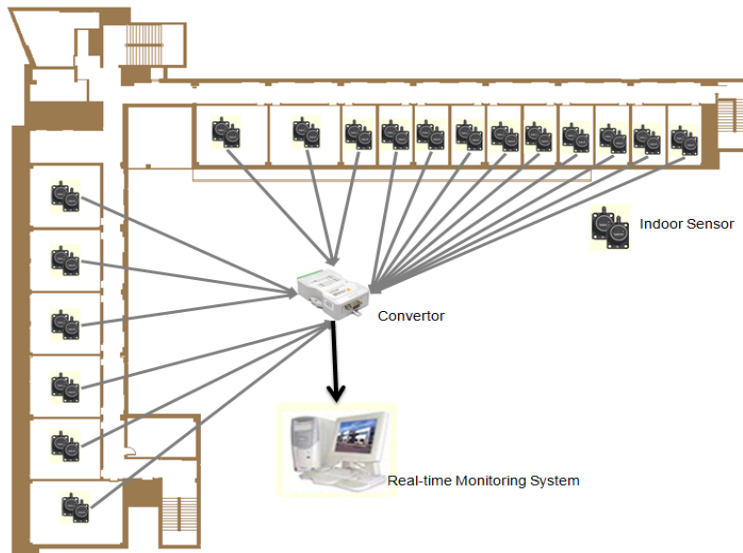
- Generation and storage of the simulation results
 - ▶ Different combinations of occupants distribution



Case	Room 1	Room 2	Room 3	Room 4
Case 1	5	0	0	0
Case 2	5	5	0	0
Case 3	5	5	5	0
Case 4	10	5	5	5
Case 5	10	0	5	0
Case 6	10	10	5	10
Case 7	0	0	10	5
⋮	⋮	⋮	⋮	⋮

System Development

- A sensor network to find out the real-time indoor occupants distribution
 - ▶ Capturing indoor occupants distribution using IR sensor at room entrance or hallway
 - ▶ Detected data are stored in the DBMS



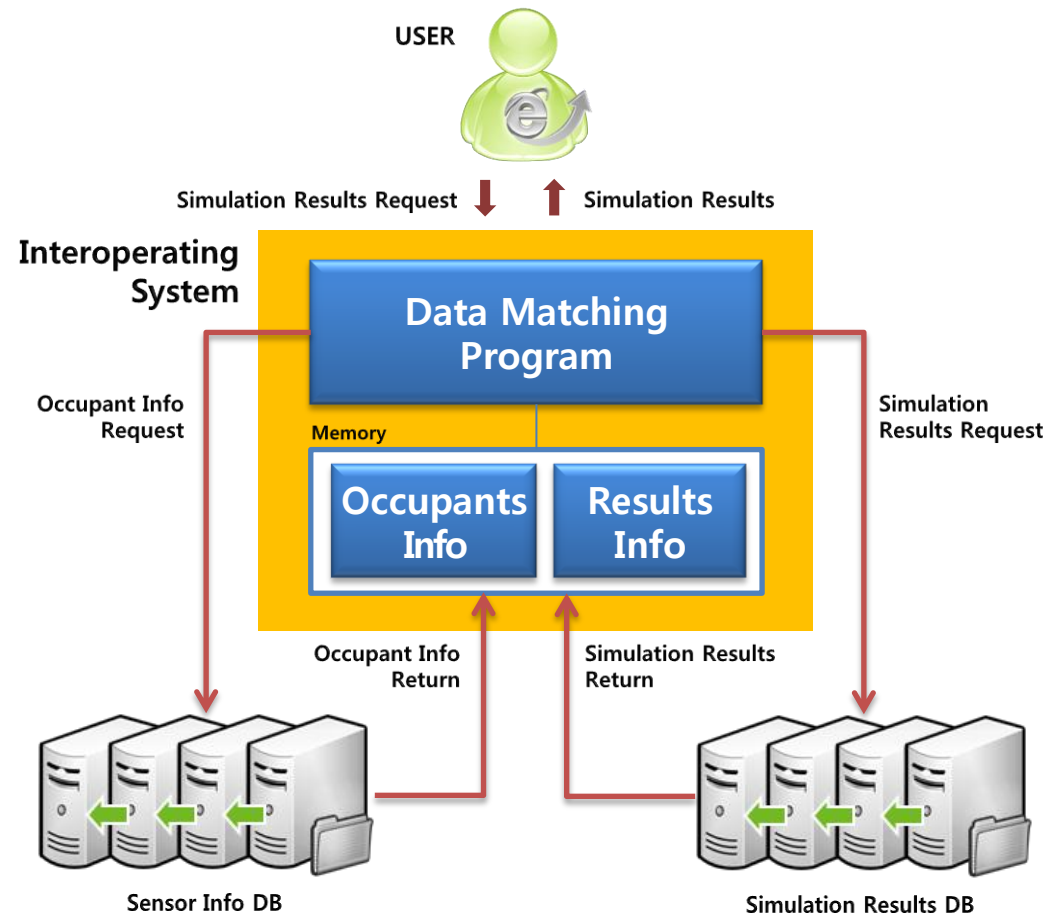
System Development

■ DBMS Schema

Table	Schema
Sensor Detection Occupants	<u>ID</u> , Person, Type(FK), Time, TotalPerson
Sensor Type	<u>ID</u> , TypeDescription
Simulation Results	<u>ID</u> , Building, Person, TotalPerson, Exit, Time, Alpha, Delta, Kd, Ks, SecPerTick, AgentPathLog, CellOccupationValue, PersonLocation

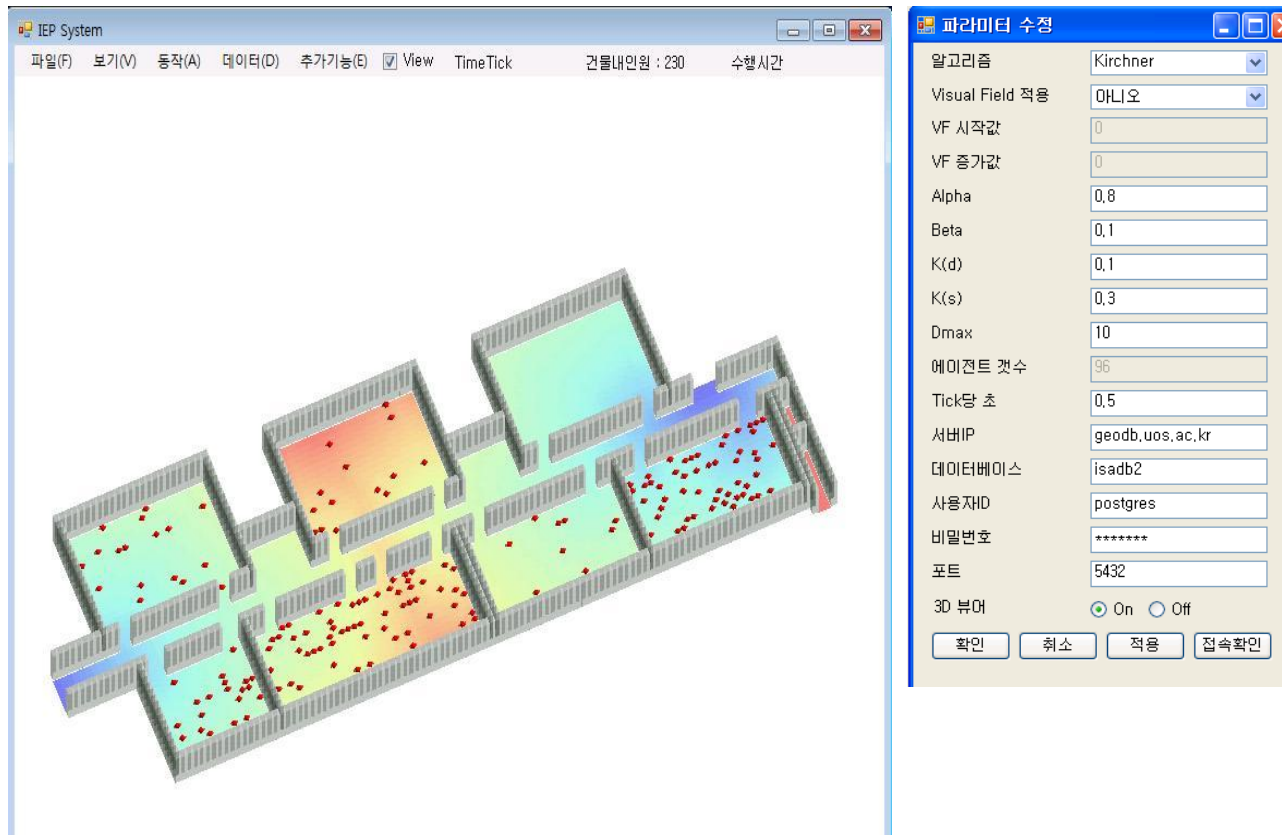
System Development

- Searching the evacuation simulation results about detected occupants



System Test

Test Area & Parameter setting



System Test

Main Interface of the Matching System

FindResult

서버주소: geodb.uos.ac.kr
데이터베이스: isa_uos
사용자ID: isa
비밀번호: ***
포트: 5432

검색
접속확인
상세정보 보기

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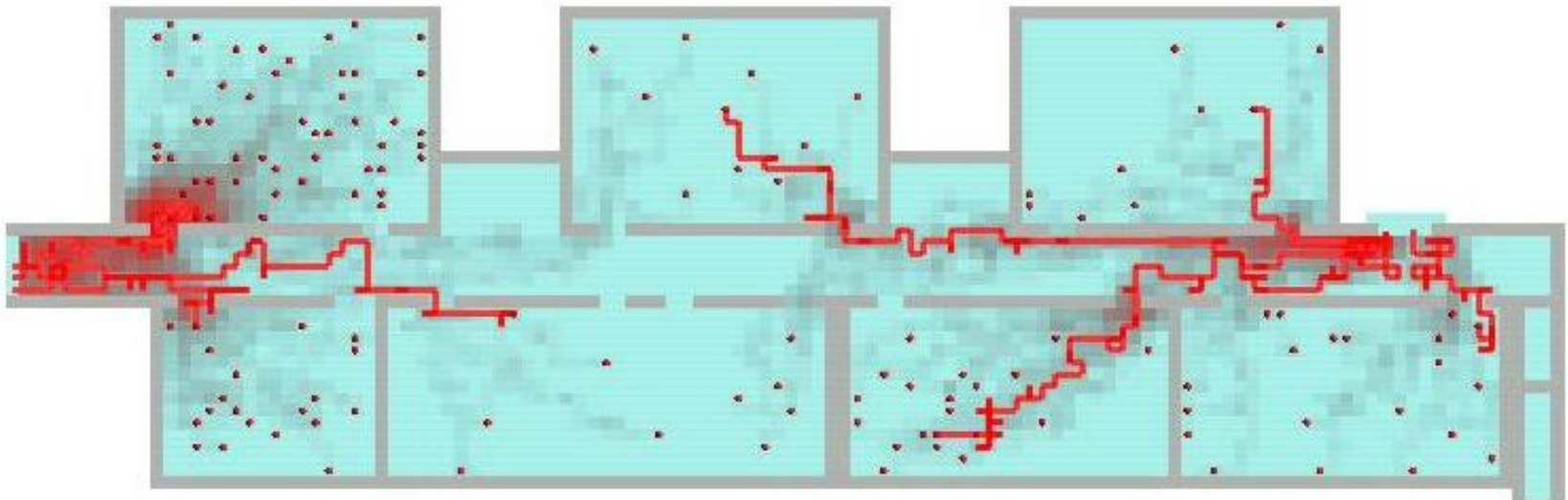
00:00:00,4440252 체인원 : 148

ID	전체인원	방별인원	매치율	출구별대피인원	탈출시간
13948	140	R101 50 R102 10 R103 10 R104 20 R105 10 R106 20 R107 20	12.806	E0 79 E1 61	225
12179	120	R101 50 R102 10 R103 10 R104 10 R105 10 R106 10 R107 20	14.967	E0 73 E1 47	189
19058	120	R101 50 R102 10 R103 10 R104 10 R105 10 R106 10 R107 20	14.967	E0 73 E1 47	206
14610	130	R101 50 R102 20 R103 0 R104 10 R105 20 R106 10 R107 20	14.967	E0 84 E1 46	206
10138	130	R101 50 R102 10 R103 10 R104 20 R105 20 R106 0 R107 20	15.62	E0 88 E1 42	224
12860	160	R101 50 R102 20 R103 0 R104 30 R105 20 R106 20 R107 20	16.248	E0 97 E1 63	279
8864	120	R101 50 R102 0 R103 10 R104 20 R105 10 R106 10 R107 20	17.436	E0 77 E1 43	186
15525	120	R101 40 R102 10 R103 10 R104 20 R105 10 R106 10 R107 20	18	E0 71 E1 49	179
12454	120	R101 60 R102 0 R103 0 R104 20 R105 10 R106 10 R107 20	18	E0 88 E1 32	195
12663	110	R101 50 R102 0 R103 0 R104 20 R105 10 R106 10 R107 20	18	E0 76 E1 34	185
10093	130	R101 50 R102 0 R103 0 R104 20 R105 20 R106 20 R107 20	18	E0 86 E1 44	199
7402	130	R101 40 R102 20 R103 10 R104 20 R105 10 R106 10 R107 20	18.547	E0 73 E1 57	207
16632	120	R101 50 R102 10 R103 10 R104 10 R105 20 R106 10 R107 10	18.547	E0 81 E1 39	219

시뮬레이션데이터	인원	센서데이터	인원	차이
R101	50	R101	55	-5
R102	10	R102	14	-4
R103	10	R103	6	4
R104	20	R104	20	0
R105	10	R105	17	-7
R106	20	R106	13	7
R107	20	R107	23	-3

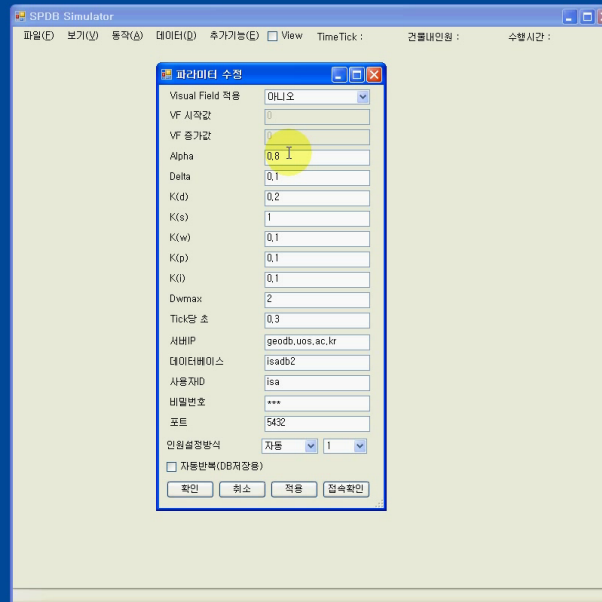
System Test

■ Visualization of the result data



System Test

■ Simulation



System Test

■ Matching the result data



Conclusions

■ In this study

- ▶ A real-time evacuation simulation system was developed by using indoor sensors and DBMS
- ▶ By using infrared sensors, the actual distribution information of occupants was detected and applied
- ▶ The evacuation simulation results were stored in the DBMS
- ▶ The simulation result data was provided by matching with the sensor detection occupants
- ▶ A visualization module for the result data was developed

Conclusions

■ In this study

- ▶ We demonstrated that evacuation simulation results can be used in **application to the actual disaster situation** through our proposed system

■ Further challenges

- ▶ The characteristics of the occupants (e.g. age, sex, disposition, etc.) via sensors, our proposed system can be improved further to obtain the simulation results which incorporate the characteristics and distribution of the occupants.

Thank You!

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