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MODELING EVACUATION PROCESSES IN URBAN ENVIRONMENTS: ANALYSIS AND INNOVATIVE APPROACHES

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Abstract. *This article discusses modeling evacuation processes in urban environments: analysis and innovative approaches.*

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Introduction

Evacuation processes in large urban and public areas are of great importance in various man-made and natural emergencies. In such situations, it is necessary to use modern modeling methods and innovative technologies to ensure the safety of people and effectively organize evacuation. This article discusses the main methods of modeling evacuation processes in an urban environment, their capabilities and innovative approaches.

1. Modeling evacuation processes in an urban environment: Applied methods

A number of different methods are used to model evacuation processes in cities. The most popular of them are:

1.1 Agent-Based Modeling (ABM)

Agent-Based Modeling (ABM) is used to simulate the individual and group movements of people in public spaces. In this method, each agent (person) makes its own movement decisions, and their interaction forms the overall movement dynamics. Agents make decisions to overcome various situations and obstacles. For example, while people try to move quickly in a panic situation, evacuation activities may encounter special obstacles as a result of natural hazards (wildfire or earthquake).

1.2 Cellular Automata

Cellular automata are used to model the flow of people in individual or mass evacuation processes. Each cell represents an individual's movement, location, or obstacle. This model allows for the control of the distribution and movement directions of people. It is very effective in analyzing the flow of people in subways, bus stations, and shopping malls.

1.3 Graph Theory

Graph theory is used to model road networks in cities. If we imagine the paths of people interacting as points on graphs, the flow of people can be determined by considering the obstacles to each path and exit. Using graph theory to model traffic jams in roads and transportation systems is important for effective evacuation management.

1.4 Machine Learning

Machine learning technologies are used to analyze human traffic and optimize evacuation processes. In particular, learning algorithms can systematically and dynamically review data.

This allows the evacuation strategy to be adapted to each event. Reinforcement Learning models are used to make decisions on how to avoid obstacles and find the most efficient route.

2. Innovative Approaches: New Technologies and Methods

Modern technologies and innovative approaches are essential for effective management of evacuation processes in urban environments.

2.1 Internet of Things (IoT) and Sensors

Internet of Things (IoT) and sensors can be used to monitor the situation in cities in real time. Sensors can be used to monitor the flow of people, traffic jams in the subway and buses, and detect the spread of fire and smoke in dangerous areas. There are also opportunities to optimize evacuation systems using accelerators and GPS technologies.

2.2 5G and Mobile Technologies

The use of 5G technologies to manage evacuation processes in cities will increase the speed and efficiency of data transmission. Using mobile devices, people can receive information about the evacuation process and act accordingly. Mobile applications can provide information about evacuation routes, identify safe routes, and provide information about the status of vehicles.

2.3 Drones and Robotics

Drones are used to monitor evacuation processes and distribute information between people. To increase the efficiency of evacuation, robots can be used to direct the movement of people and guide them to safe routes.

3. Practical examples of application

3.1 Great Britain (London 2012 Olympic Games)

During the London 2012 Olympic Games, people flow was modeled using Cellular Automata and Graph Theory. These models allowed for effective evacuation management in public transport and large public spaces.

During the Shanghai Expo, people flow, traffic jams and evacuation strategies were developed through simulations written using Agent-Based Modeling and Machine Learning technologies.

After the 9/11 incident in America, important research was conducted on people flow management and fire spread analysis using Agent-Based Modeling and CFD (Computational Fluid Dynamics) models.

4. Conclusions and recommendations

The use of modern technologies and methods for modeling evacuation processes in urban environments will help develop effective evacuation strategies. There are new opportunities in managing evacuation processes through agent-based models, graph theory, machine learning and IoT technologies. Also, innovative approaches based on 5G, drones and robotics will play an important role in organizing evacuation processes in urban environments more efficiently and safely.

In conclusion, the article concludes that today's technologies allow for more efficient, safe, and dynamic management of evacuation processes in cities, while also playing an important role in ensuring the safety of citizens.

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