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Development of Large-scale Evacuation Simulation System Using GPGPU

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SUMMARY

Evacuation simulations have been developed and applied to evaluate the safety of buildings or urban environments. Agent based simulation are particularly well suited to pedestrian behaviors from a set of simple individual rules. However, when we apply such simulation tools to large-scale urban environments, it is difficult to compute crowd behavior in real-time because this computation load mostly comes from the O (n^2) complexity of the algorithm needed for the interactions of all agents. Relevant previous works reduce this complexity by using special data structures such as grids. On the other hand, researchers demonstrated significantly increased speed-up after adapting existing CPU-oriented algorithms to parallel processing. Furthermore, modern GPU (Graphic Processing Unit) have many cores; they offer large performance benefits for parallel processing at low cost. In this study, we present a GPU based implementation of agent-based evacuation simulation and visualize crowd flow in a large-scale underground shopping mall interactively.

In order to model evacuation behavior, we implemented the social force model. The social force model solves the motion equation of a pedestrian, which is represented by an agent. An agent that has mass and a constant radius is subjected to a force exerted by other agents and obstacles and exit position. These steps perform all operations on a GPU. Parallel processing and the GPU's many cores produce huge computational power, enough to update massive pedestrian crowds in real-time.

As a result, the GPU version presents better scalability than the CPU version. In a case study, when the number of agent is 10,000 in a large-scale underground shopping mall, the GPU version is approximately seven times faster than the CPU version and sustained interactive frame rates. Therefore, this simulation has potential effectiveness as a tool for designing and evaluating disaster-prevention design of large-scale urban environments.

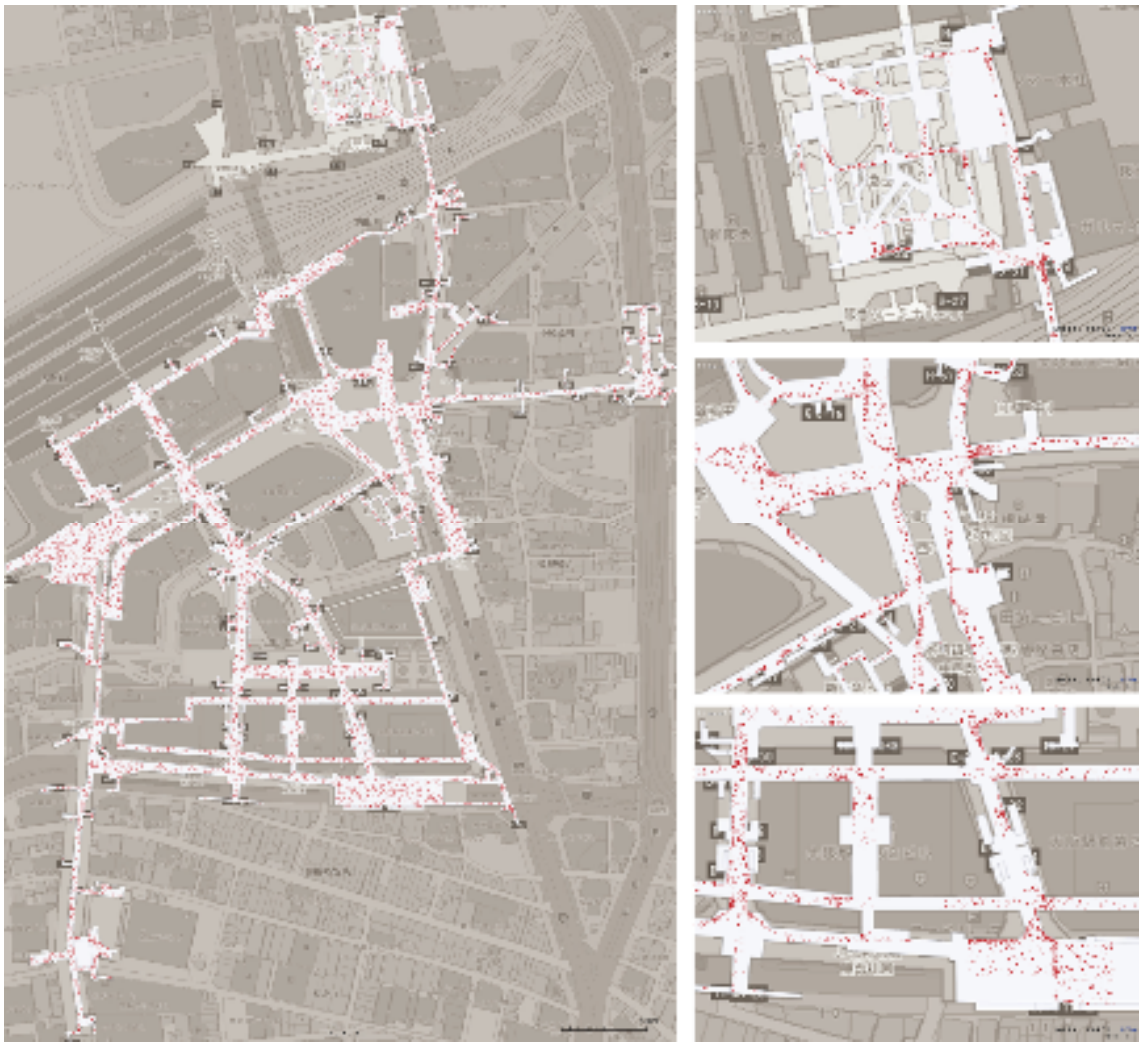

Figure1: Crowd Flow in Large-scale Underground Shopping Mall