High-Performance Pedestrian Multi-Simulation Using GPU Cluster

The University Of Sheffield.

BAE SYSTEMS

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Pedestrian Simulation as a Real-Time Decision Support Tool

• Large-scale real-life emergency evacuation drills are often impractical or impossible due to many factors.

• We envision a tool that helps planners and situation commanders interactively create and verify large-scale emergency response plans.

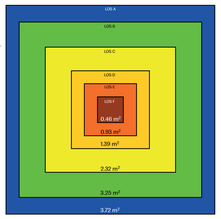
• It must be scalable, accurate and simulates faster than real-time to enable interactivity. It must also be able to simultaneously test for multiple criteria and plans with the ability to compare their effectiveness and highlight potential pitfalls.

• The tool uses a network of GPU-enabled computers for simulation, and a central host that manages the information flow between these processes. An external client can connect to the host in order to dispatch scenario data and obtain simulated data for analysis.

The Model

• Uses the social forces with contact force model for simulating interactions between pedestrians and their environment. [1,2]

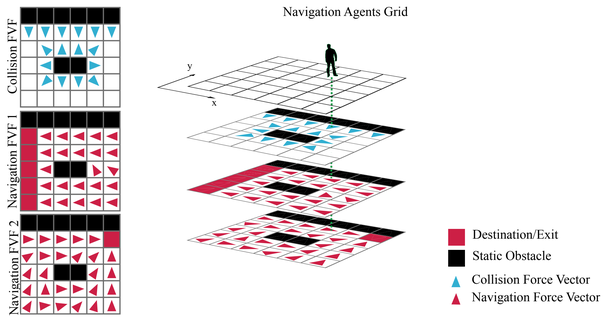
• Pedestrians have access to environment collision detection and global navigation through a grid of navigation agents that holds a set of vector force fields. [3]



• A collision vector force field holds information about static environments (e.g. walls)

• Navigation vector force fields represent the goals of the agent. It gives the shortest path to a single exit (used for normal walking models), multiple destinations (evacuations), or a gathering point.

• Industry-standard metrics are used to collect data for analysis such as the Fruin Level of Service. [4]



Faster Than Real-Time

• The simulation can run faster than real-time when visualisation is not required.

• Larger time-steps can be used in order to increase the simulation rate, with some accuracy trade-offs.

Built on the Agent-Based FLAME GPU Framework

• Agent Based Modelling (ABM) is a powerful simulation technique which is used to assess group behaviour from a number of simple interacting rules between communicating autonomous agents.

• Simulation code is generated based on the Flexible Large-scale Agent Modelling Environment on the GPU (FLAME GPU). [5]

• XML is used for model specification with extendible Schemas used to ensure correct model syntax and add GPU specific information. The model specification, along with the C-based function scripts are transformed using XSLT templates in to compilable code. [6,7]

• Complexities of GPU programming are entirely abstracted from the modelling and simulation process.

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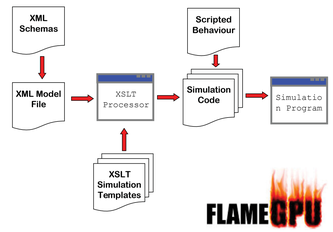
Chapter 21 p.313-324



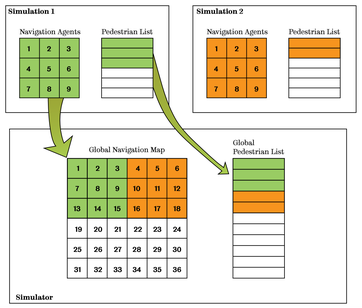
FLAMEGPU

Simulation Batching

• Smaller models are grouped together in to a single simulation. Efficiency is increased for larger simulation sizes due to reduced kernel calls and ensuring maximum thread utilization.

• The grid of navigation agents are spatially translated to its global coordinate according to their simulation ID.

• Agents are assigned IDs in order to prevent interference in boundary cases.



Distributed GPU Processing of Multiple Simulations

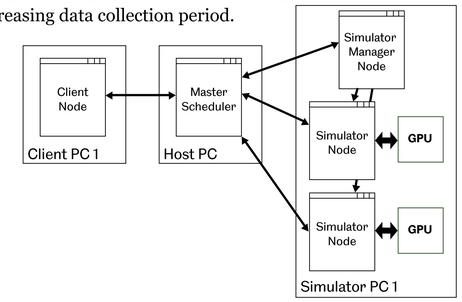
• A master computer handles the scheduling and distribution of simulations.

• An instance of a slave scheduler is present on each simulation computer and is responsible for initialising instances of simulator programs.

• An instance of a simulator is created for each GPU core on the system. This avoids complications in program design as there is no cross-communication between the simulators.

• Simulators store their simulation results locally and transmit them when requested.

• Results are collected as per user-specified simulation time period. Performance can be further increased by increasing data collection period.

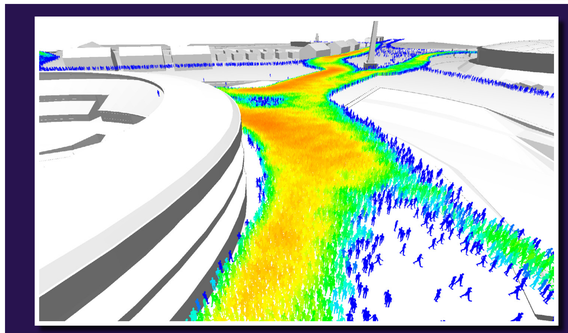


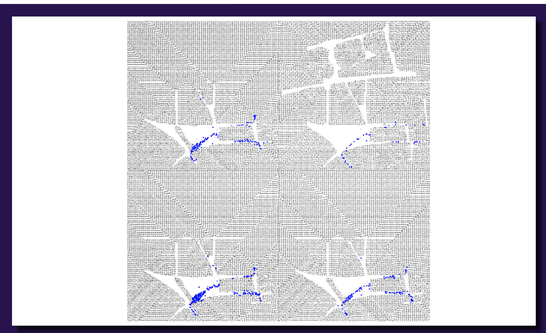
Results & Conclusion

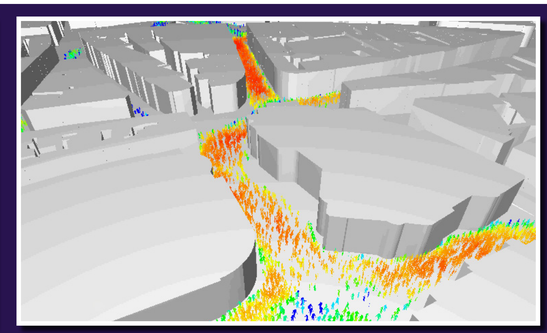
• Simulation of 160,000 pedestrians at ~20 frames per second without visualisation when running 8 simultaneous simulation of 256^2 grid size across 2 Nvidia GTX 590 GPUs.

• Uses low-cost hardware and networking components.

• Future work: Further optimization of the simulation framework, incorporating more complex navigation system and bringing the software to commercialisation.







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[2] D. Helbing, I. Farkas, and T. Vicsek. Simulating dynamical features of escape panic. Nature, 407(6803):487{490, Sept. 2000.

[3] T. Karmakharm, P. Richmond, and D. Romano. Agent-based Large Scale Simulation of Pedestrians With Adaptive Realistic Navigation Vector Fields. In Theory and Practice of Computer Graphics (TPCG) 2010, pages 67{74, 2010.

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[5] FLAME GPU Website, http://www.flamegpu.com

[6] P. Richmond and D. Romano. Agent Based GPU, a Real-time 3D Simulation and Interactive Visualisation Framework for Massive Agent Based Modelling on the GPU. The rst International Workshop on Super Visualization (IWSV08), 2008.1

[7] P. Richmond and D. Romano. Template-Driven Agent-Based Modeling and Simulation with CUDA. In W.-m. W. Hwu, editor, GPU Computing Gems Emerald Edition, Applications of GPU Computing Series, chapter 21, pages 313-324. Morgan Kaufmann, 1st edition, Feb. 2011.