High Performance Agent-Based Simulation with FLAME for the GPU

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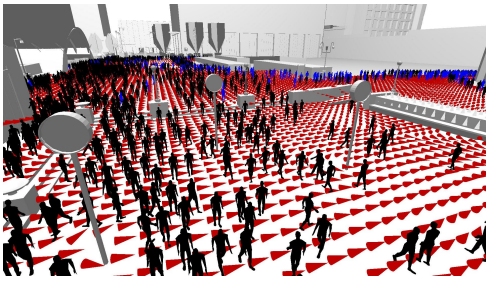
FLAME GPU

Introduction

➢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.
➢Traditional ABM toolkits such as Repast, Mason and Swarm are primarily aimed at a single CPU architecture limiting the scale and performance of models.
➢Grid based supercomputing techniques are expensive and often unavailable.

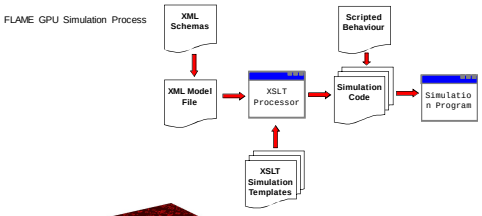
Real Time Simulation and Visualisation of 5,000 Shoaling Fish



Real Time Pedestrian Simulation using Discrete Agents for Global Navigation

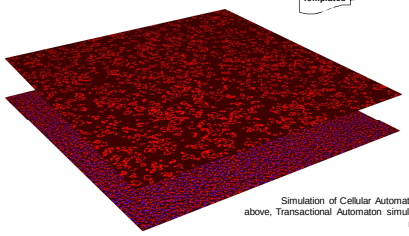
Template Driven Agent Modelling

➢Template driven simulation code generation based on the Flexible Large-scale Agent Modelling Environment (FLAME).
➢XML is used for model specification with extendible Schemas used to ensure correct model syntax and add GPU specific information.
➢XSLT Code templates generate compliable simulation code which is linked with C based agent function scripts.
➢Complexities of GPU programming are entirely abstracted from the modelling and simulation process.

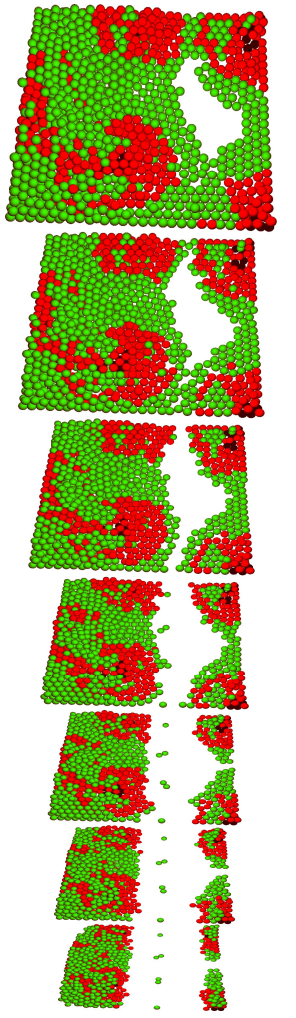


State Based Agents

➢State based agents described using a formal agent specification using the X-Machine (a form of state machine with internal memory).
➢State based functional transitions perform agent behaviour and message based communication.
➢Similar agents (in the same state) are processed in batches to allow agent heterogeneity across the population whilst minimising execution divergence.
➢State transitions may have conditions or global conditions to limit the number of agents which perform an agent function. The later can be used to perform non linear recursive simulation steps e.g. Performing accurate inter agent force resolution or to solve conflicts introduced by movement of discrete agents in parallel.



Simulation of Cellular Automaton (Game of Life above, Transactional Automaton simulating Sugarscape movement below)

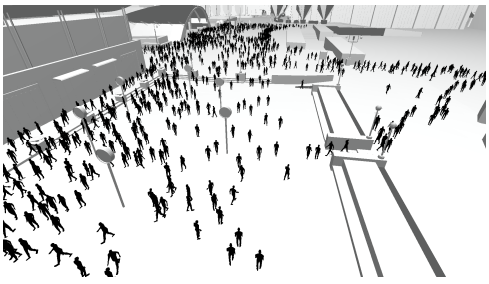


Real Time simulation of Keratinocyte Tissue Colony Formation with Parallel intercellular force resolution

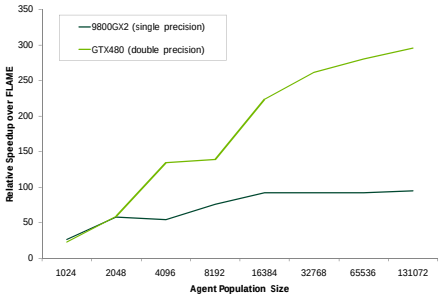
GPU Simulation

➢Efficient GPU memory access patterns ensure high performance.
➢Agent birth and death allocation is provided using a Parallel Prefix Sum and Scatter Kernel to compact sparse data.
➢Agents can communicate through either brute force, spatially partitioned or discrete space (for Cellular Automaton) messaging.
➢Function conditions can be used to provide non linear time simulation steps suitable for parallel force resolution
➢Real time visualisation and real time simulation steering.

Simulation and Visualisation of a small Flock or Birds



Real Time Pedestrian Simulation Combined with Advanced Environment Visualisation



Relative speedup of the Circles benchmarking model for brute force message iteration in both single and full precision on a NVIDIA 9800GX2 and a NVIDIA GTX480 respectively.

Results and Conclusions

➢Massive performance over non Parallel Alternatives with simulation times reduced form hours to seconds in some cases.
➢Massive performance potential demonstrated for cellular level agent based epithelial tissue modelling.
➢Future Work: Implement a multiple GPU solution for larger/multi-level simulations.

Population Size	Simulation Time (ms)
1024	0.94
4096	1.24
16384	2.45
65536	9.09
262144	33.74
1048576	136.28

Performance of Spatially partitioned message communication on the Circles Benchmarking Model

References

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