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PED: Pedestrian Environment Designer

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The Challenge

- Pedestrian simulations during development of pedestrian areas
  - Building design, evacuation planning
- Heavily dependent on environmetal interaction
- Environment creation is a difficult

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Aims

- How can we produce environments
  - Easily
  - Quickly
  - Minimal technical knowledge
- Can we provide interactive, iterative development?

1. **Environment Design Interface**
2. FLAME GPU simulation
3. Connection between UI & FLAME GPU

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Background

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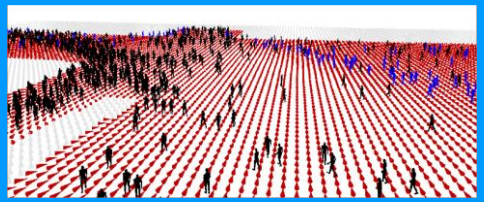
Pedestrian Simulation

- Microscopic simulation via Agent Based Modelling (ABM)
  - Simulate individuals in the system
  - Local Interaction
  - Natural method to describe microscopic models [1]
- Used to evaluate performance of an environment [2]
- ABM are computationally expensive [3]
  - GPU acceleration provides performance but adds complexity



[1] Bernhardt, K. "Agent-based modeling in transportation." Artificial Intelligence in Transportation 72 (2007).
[2] Teknomo, Kardi. "Application of microscopic pedestrian simulation model."Transportation Research Part F: Traffic Psychology and Behaviour 9.1 (2006)
[3] Algers, Staffan, et al. "Review of micro-simulation models." Review Report of the SMARTEST project (1997).

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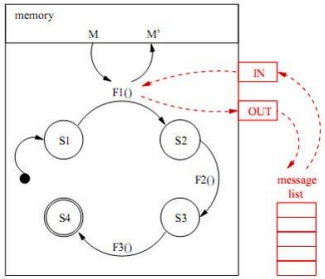
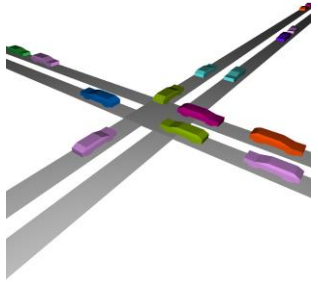
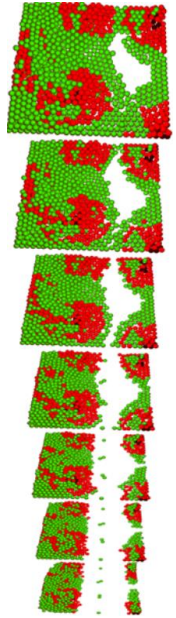
Flexible Large-Scale Agent Modelling Environment for GPUs

- "Template based simulation environment" for agent based simulation on GPUs [1]
- High level interface for describing agents abstracts complexities of GPU [2]
- State-based agent representation
- Message-based communication

FLAME GPU







[1] Richmond, P. "FLAME GPU technical report and user guide." Department of Computer Science Technical Report CS-11-03 (2011).

[2] Richmond, Paul. "Resolving conflicts between multiple competing agents in parallel simulations." European Conference on Parallel Processing. Springer International Publishing, 2014.

http://flamegpu.com

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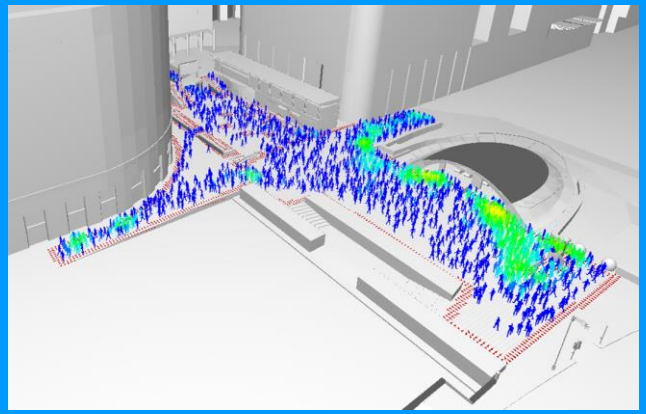
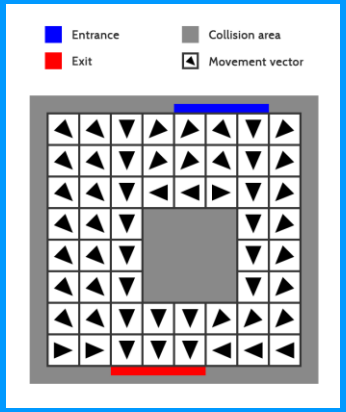
Simulation Model

- Pedestrians enter simulated region at entrance
- Travel towards target exit
- Force Vector Fields (FVFs)
  - Grid of force vectors
  - Global navigation to target exit
  - Obstacle avoidance (solid objects)
- Social-Force Model
  - Local Collision avoidance
  - Based on implementation by Karmakharm [1]
- GUI is primarily tool to create Force Vector Fields



Pedestrian Simulation of London area



Example FVF

[1] Karmakharm T., Richmond P., Romano D. M.: Agentbased large scale simulation of pedestrians with adaptive realistic navigation vector fields. TPCG 10 (2010), 67–74. 3

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Solution

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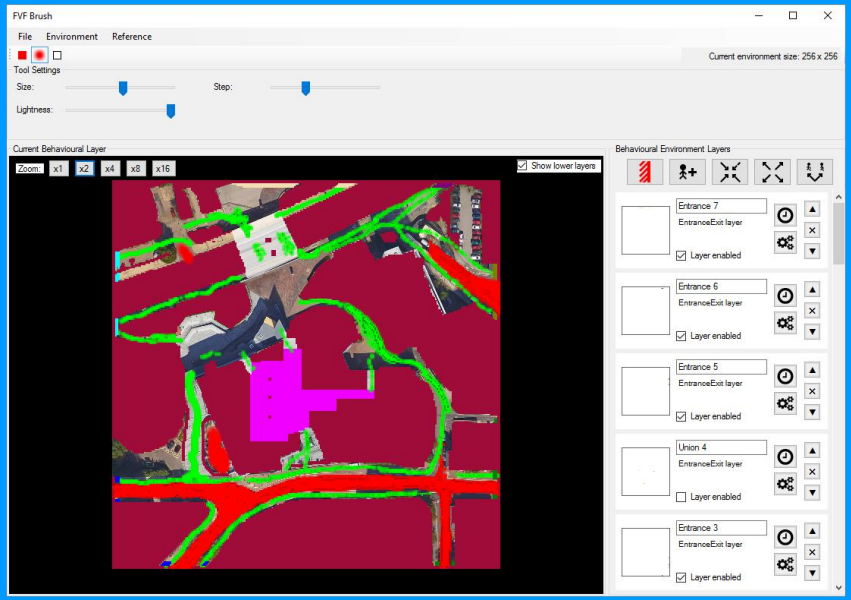
Pedestrian Environment Designer

1. **Layer-centric GUI for Environment Creation**
   Inspired by graphic tools such as Adobe Photoshop, GIMP etc

2. **Environment Compilation**
   Layers converted to Force Vector Fields and combined

3. **FLAME GPU Simulation**
   High Performance GPU accelerated simulation

4. **Real-time Environment Update**
   Update the environment during runtime for immediate feedback



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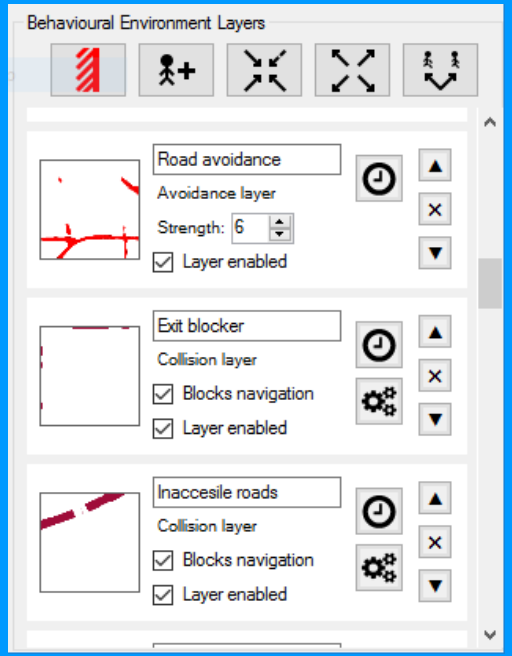
Layer-centric Editor

- Environment discretised as 2D grid (ie. Bitmap)
- Layers map to specific behaviour
- Many layers combine for full environment
  - Entrance/Exit, Collison, Attraction, Avoidance, Interest, Reference
- Bitmap tools: Rectangle, Brush …
- Settings: Emission Rates, disable layers …



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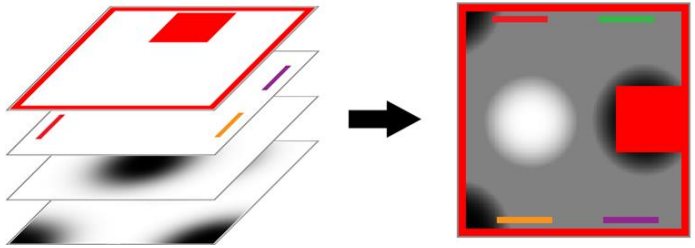
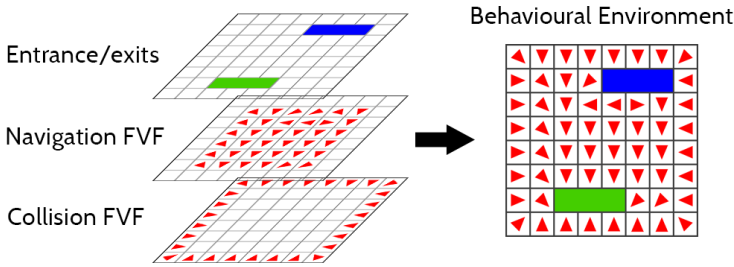
Environment Compilation

- Converts bitmap layers to FLAME GPU compatable files
- Collision layers combined to single FVF
- Navigation FVF created per exit
  - Iterative Dijkstra Floodfill
- FVFs smoothed
  - Avoid diagonal convergence
  - Nearest neighbour average





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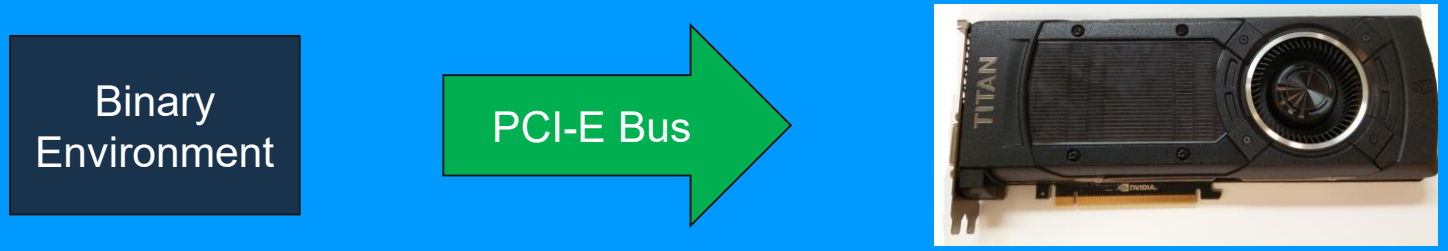
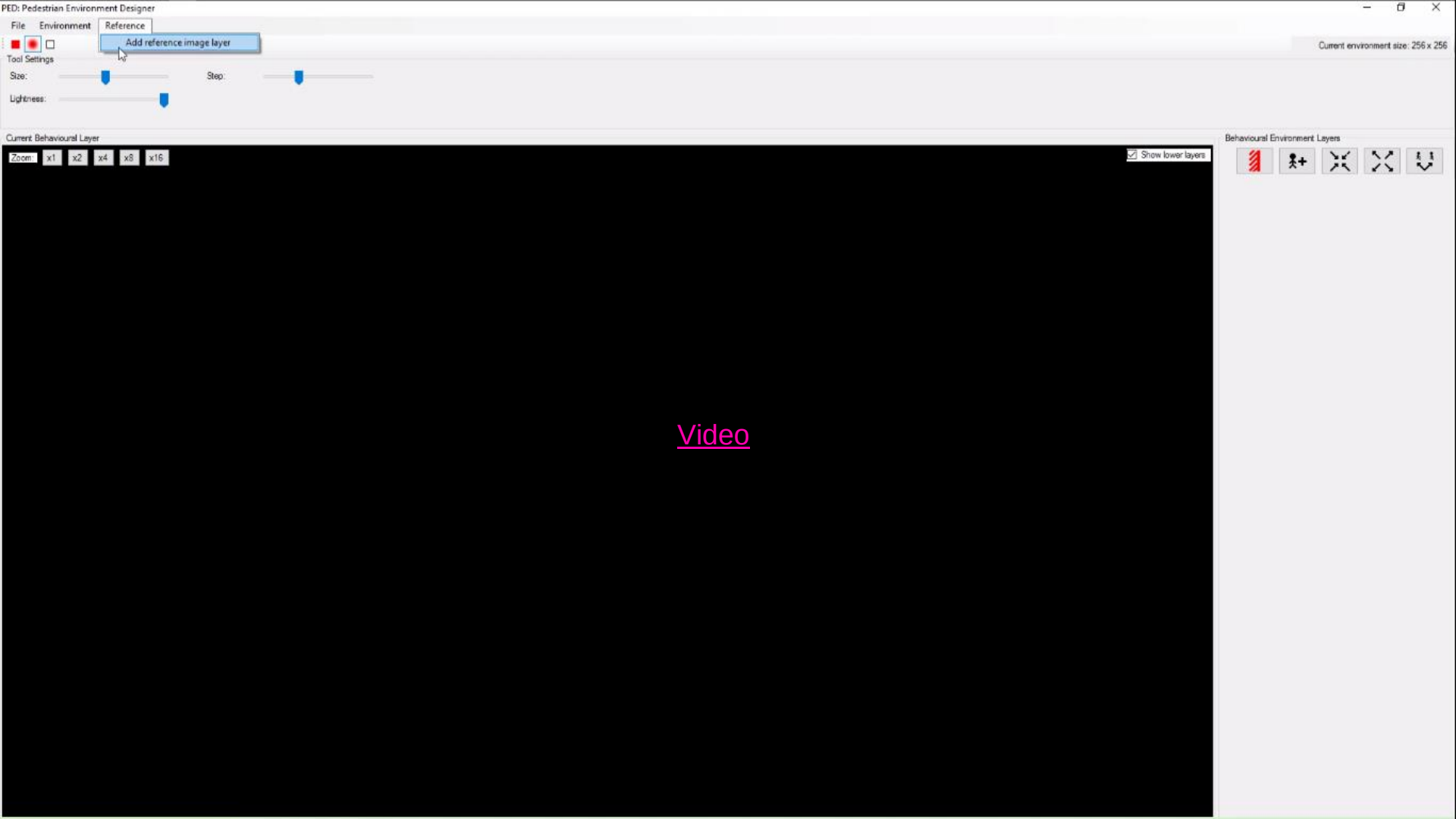
Simulation

- High Performance Simulation via FLAME GPU
- Efficient Visualisation via GPU Instancing

Interactive Update

- Recompiling environment during simulation causes immediate update
- Environment encoded in binary to reduce run-time parsing
- File change causes copy of new environment onto GPU




PED: Pedestrian Environment Designer
File
Environment
Reference
Add reference image layer
Current environment size: 256 x 256
Tool Settings
Size:
Step:
Lightness:
Current Behavioural Layer
Zoom
x1
x2
x4
x8
x16
Show lower layers
Behavioural Environment Layers
Video

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Example: Sheffield Station

Video

Avoidance

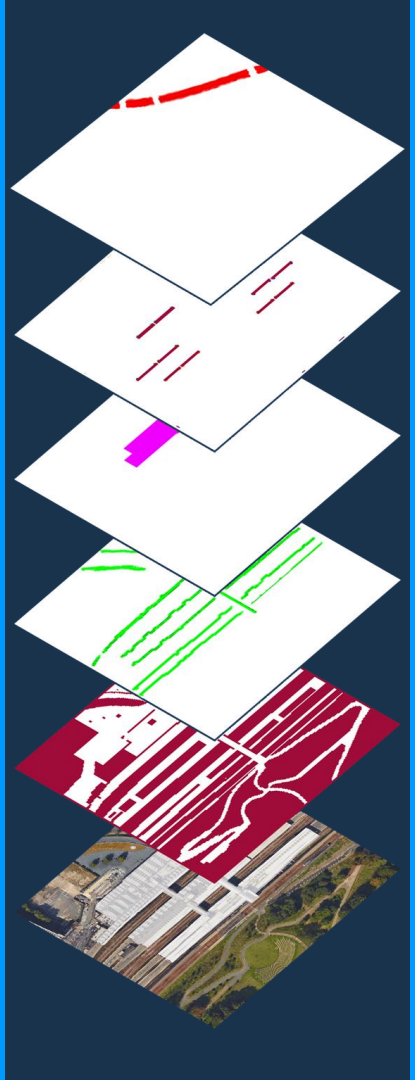
Trains + Entrance/Exit

Interest

Attraction

Collision

Reference



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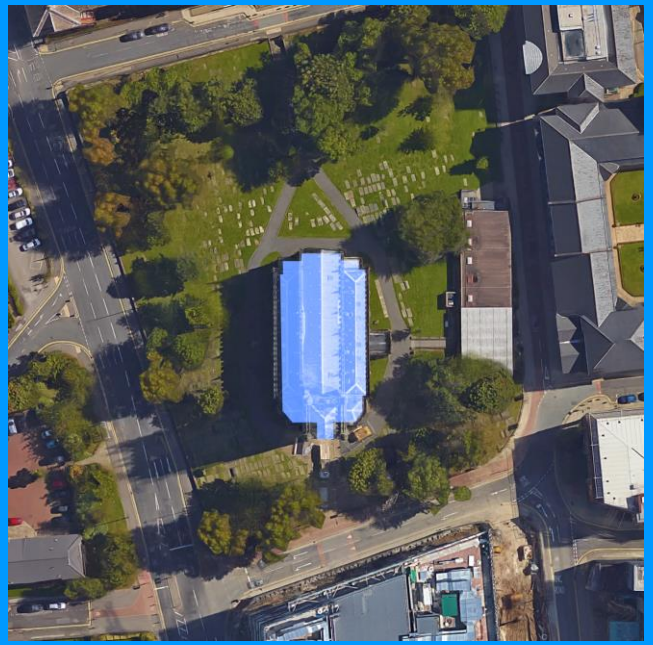
User Testing

- Evaluate UI usability for non-technical authors
- Written instructions to create sample model
- Asked to create a local environment
  - St George's Church, Sheffield
  - Familiar to the users
- Maximum of 1 hour to produce visually-convincing pedestrian simulation



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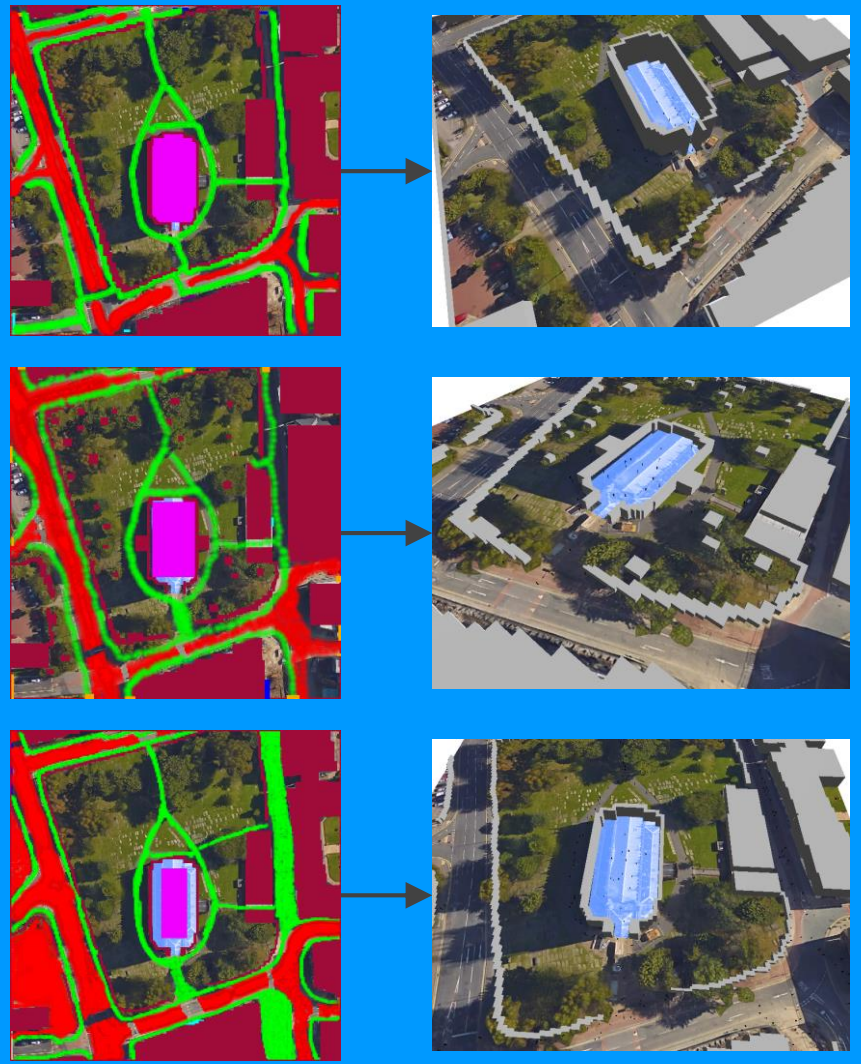
User Testing Results

- Participants all felt
  - Intuitive
  - Easy to use
  - Created realistic looking models
  - Valued dynamic updates

- 44 minutes average time taken
- 14 to 23 layers used
- 90 to 210 pedestrians

- User models not validated



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Conclusion

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Conclusions

- Suitable for complex environments
- Usable by non-technical authors with minimal training
- Dynamic update offers immediate feedback & iterative development

Future Work

- Vector tools for creating environments
- Multiple levels (i.e. stairs, bridges)
- Improved pedestrian simulation
  - Guidance Fields, Continuum dynamics

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Thank you

shef.ac.uk/dcs/research/groups/visual-computing

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