



Bournemouth University



National Centre of Computer Animation

## Crowd Simulation based on Emergent Behaviours

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MSc Computer Animation and Visual Effects

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# Crowd in Films



# Crowd in Films

## Contributions

- Visually stunning
- Catches public's attention
- Enriches story
- The story may just need it

# Crowd in Films

## Contributions

- Visually stunning
- Catches public's attention
- Enriches story
- The story may just need it

## Issues

- Requires either real extra cast
- or more animators.
- Requires more time and money

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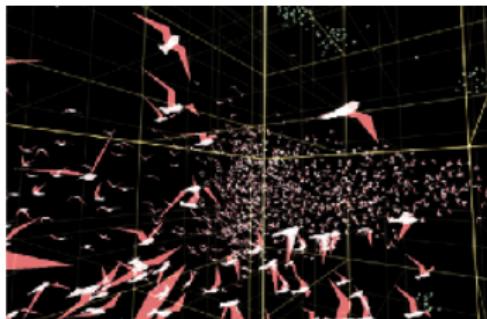
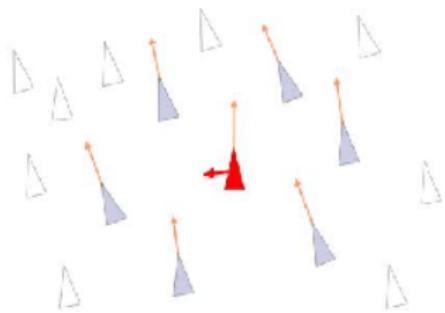
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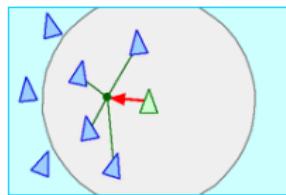
# Motion Planning for Crowd



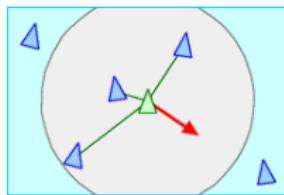
# Crowd Motion Simulation



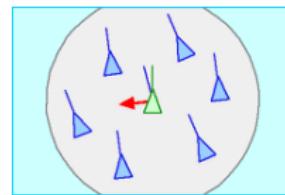
# C. Reynolds' Flocking Model



Cohesion



Separation



Alignment

# Concept of Emerge

“A system which is designed and defined by certain rules or mathematical equations may configure itself in a way that could not be anticipated” (Kleinrock, 2010)

# MASSIVE Software



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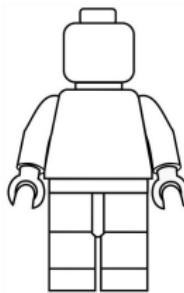
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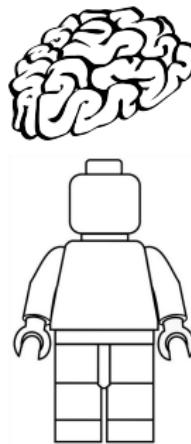
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# Agent



# Agent



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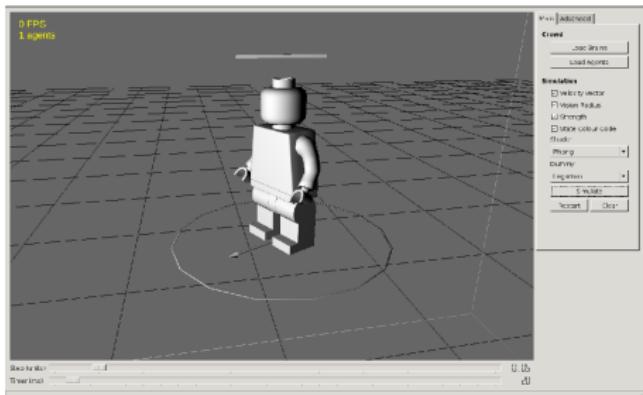
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# Agent Body

## Physical Properties

- Mass
  - Strength
  - Maximum Strength
  - Velocity
  - Maximum Speed
  - Vision Radius



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# Agent Brain

## Behaviour

The brain receives information about the agent body, the environment and the interactions with other agents. After processing, it determines which actions the agent must perform.



# Agent Brain

## Behaviour

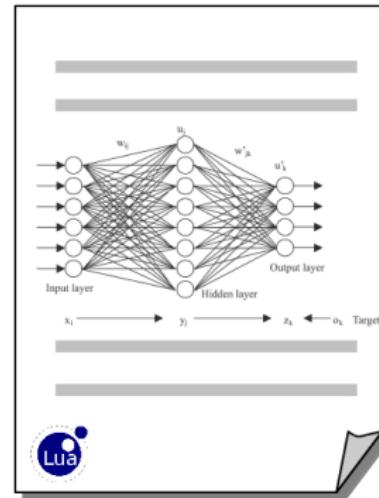
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# Agent Brain

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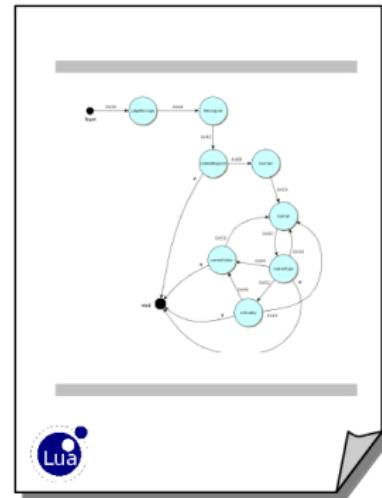
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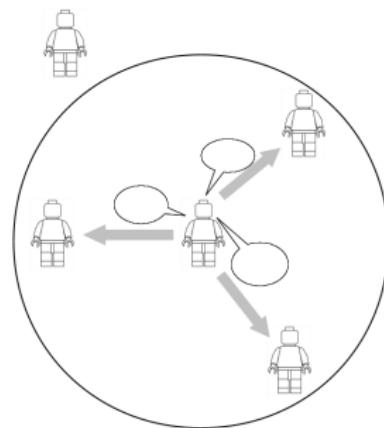
# Interconnections

“The complexity does not reside in the individuals, but on the way they are interconnected and they interact to each other”  
(Kleinrock, 2010)

# Interactions Among Agents

## Message

- Agent Identification
- Label
- Position
- Strength



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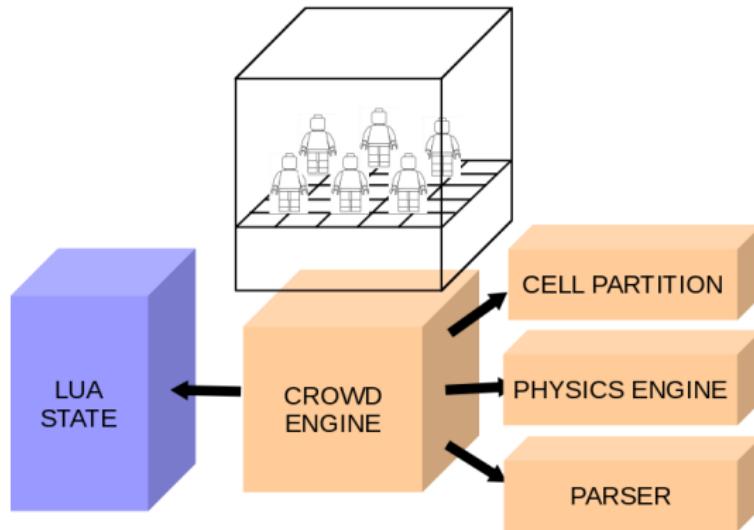
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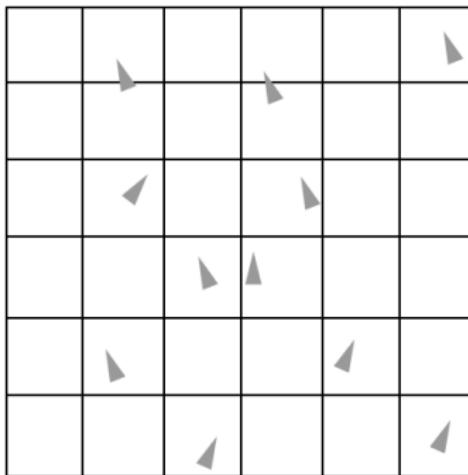
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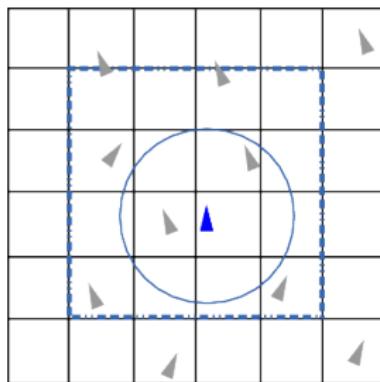
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# 2D Grid Cell Partition



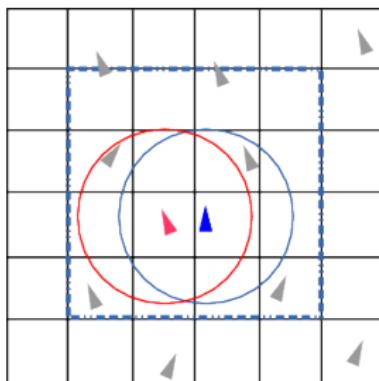
# Searching Neighbours in Vision Radius Algorithm



## Two procedures

- Find the agents in the cells which include the vision radius
- Find the neighbours from those agents

# Searching Neighbours in Vision Radius Algorithm



## Heuristic

“Two agents that are spatially close may share many common neighbours” (Lee, 2010)

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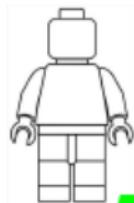
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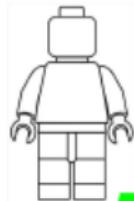
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# Forces



**Prime Mover Force**  
Determined by the brain

# Forces



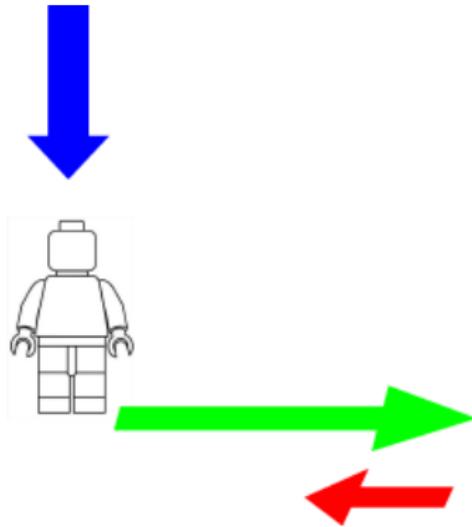
**Prime Mover Force**

Determined by the brain

**Gravity**

Vertical towards the ground

# Forces



**Prime Mover Force**

Determined by the brain

**Gravity**

Vertical towards the ground

**Friction**

Opposite to the movement

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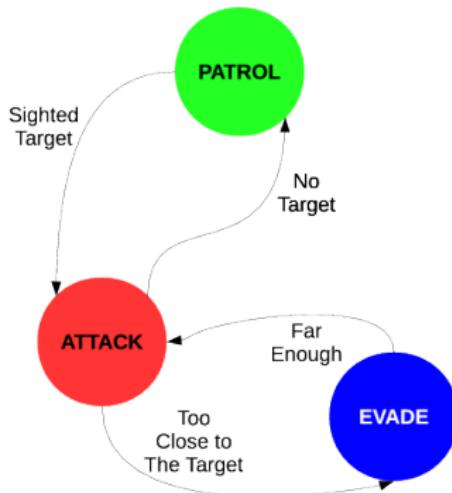
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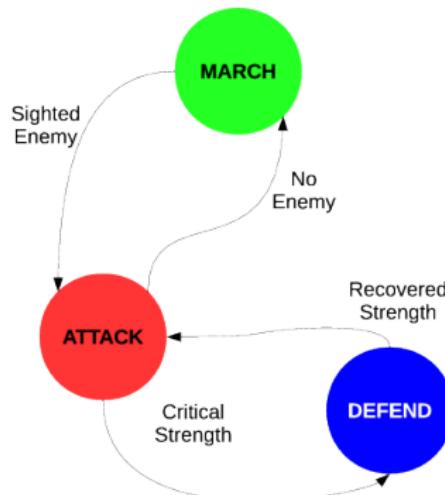
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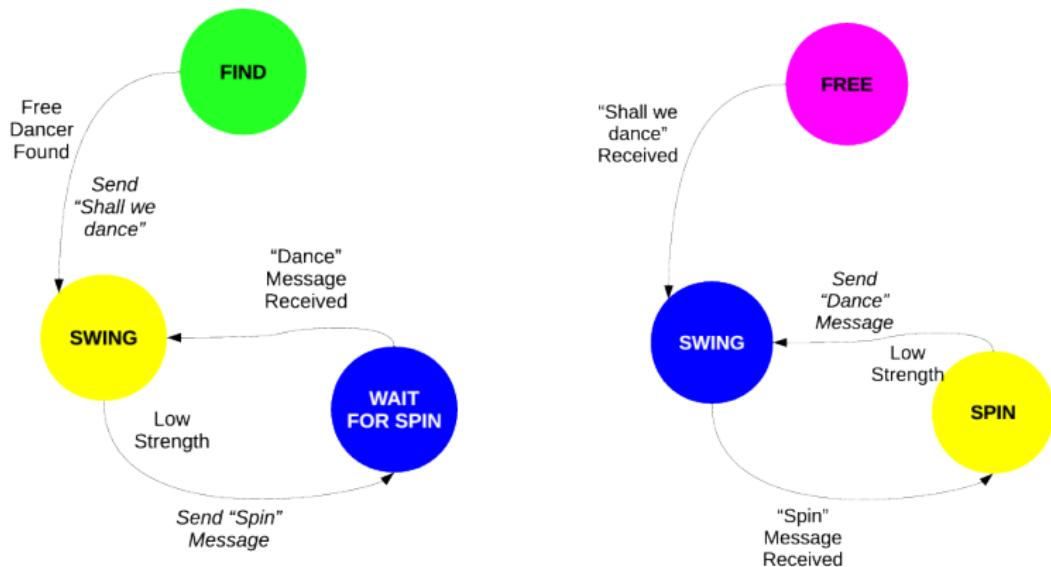
# Shooter Droid FSM



# Warrior FSM



# DanceLeader and Dancer FSM's



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# Summary

## Crowd Simulation based in Emergent Behaviours

- Complexity is born from simplicity
- Flexible and scalable approach due to script-based behaviors
- Robust and solid physically-based virtual world
- Scalable application design
- Easy and quickly testing of AI behaviours due to brain independence
- Adaptable to any sort of simulation

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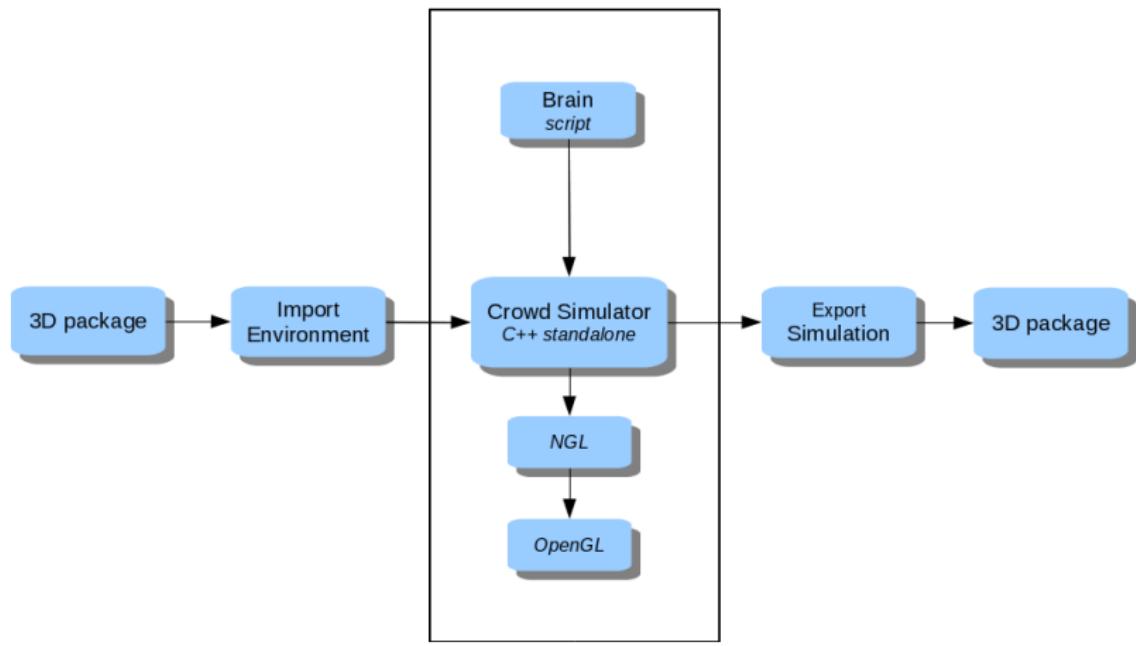
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# Summary

- The emergent crowd behaviour is hard to anticipate
- Simulations remain empirical
- Many tests required
- This thesis presents a part of a whole process, there is no finished product to present.

# Possible Pipeline



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# Future work

- Import environment, such as terrain, from 3D package
- Export the simulation. Associate animations to the states
- Include a robust physics engine
- Integrate it in a real pipeline
- Or write a plugin

Thank you for your attention