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DH2323 DGI16

INTRODUCTION TO COMPUTER GRAPHICS AND INTERACTION

IVAs AND CROWDS

An introduction

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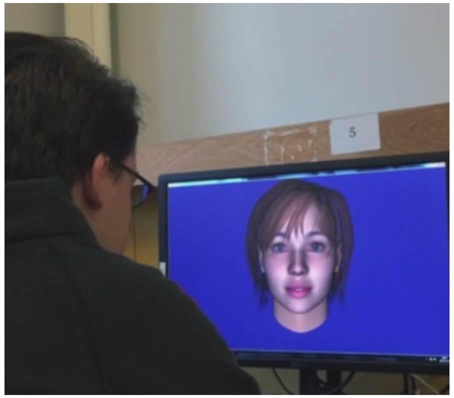
In This Lecture


- Real and artificial behaviour
- Virtual agents
- Interactive computer graphics and animation
  - Computer game technologies
- Behavioural animation
- Introduction to simulating:
  - Individuals, groups, crowds
- Human perception

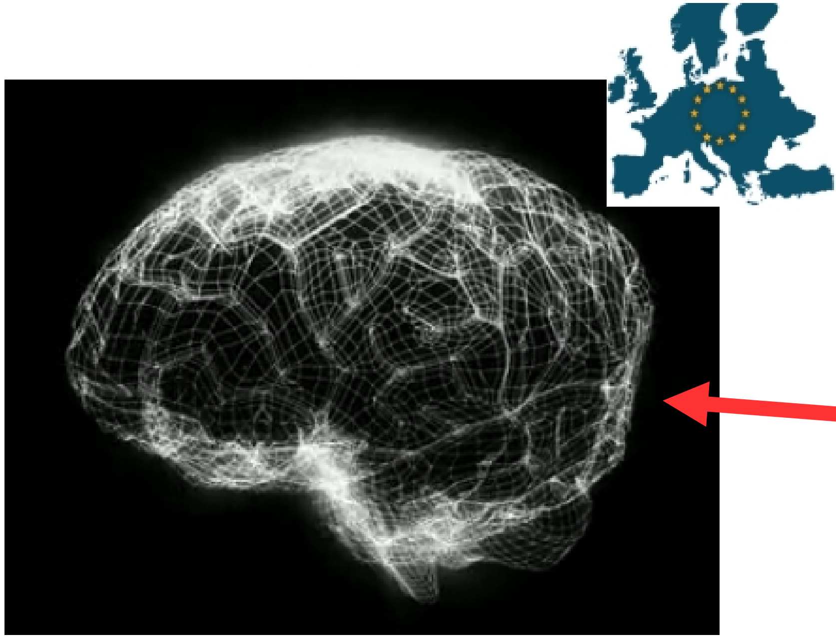
(Real) Behaviour

Starlings, Film by Liberty Smith and Sophie Windsor Clive

https://www.youtube.com/watch?v=iRNqhi2ka9k

(Real) Behaviour

Behaviour Simulation



The Human Brain Project, EU FET

PLEdestrians, Guy et al., UNC and Intel, 2010

Behaviour

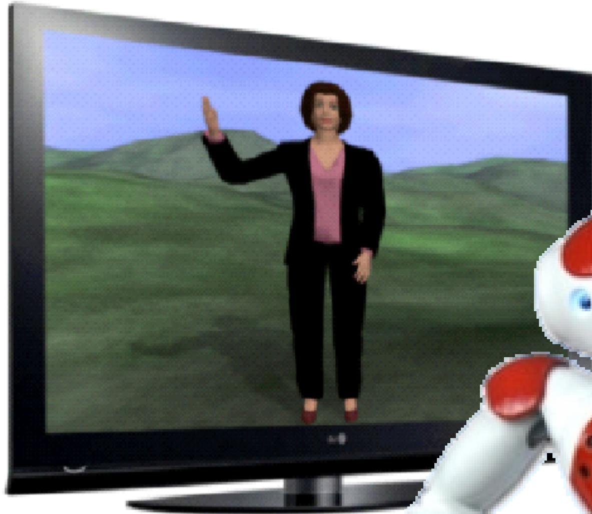
- Modelling living entities
  - Complex, evolving, (ill-)behaving, goal-directed
  - Bounded rationality
  - Irrational (e.g. classic view of feeling, emotion, affect)
- Behaviour
  - Open to interpretation, not always so open to awareness
  - Culture, subtle signals, **context**
- Humans are experts on human behaviour
  - May not know exactly *why* something looks fake

Machines

Robonaut 2, NASA

Asimo, Honda

Greta, ParisTech



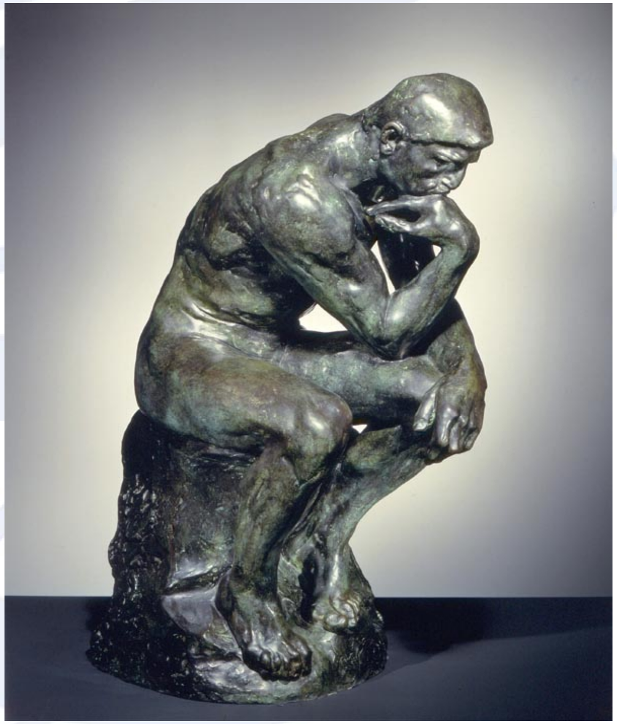
Nao, Aldebaran Robotics

Moravec’s Paradox

“…comparatively easy to make computers exhibit adult level performance on intelligence tests … difficult or impossible to give them the skills of a one-year old when it comes to perception and mobility.”

Moravec 1988

Easy *(-ish)*



- Logic
- Algebra
- Chess

Hard (!)

- Play golf
- Spot a bear in the woods
- Run (or even walk) away without falling

Advances in mobility

Functional

But scary!

Big Dog, Boston Dynamics

Social Machines

Machines that consider humans

…as more than just physical objects

Goal-directed, volitional, emotional

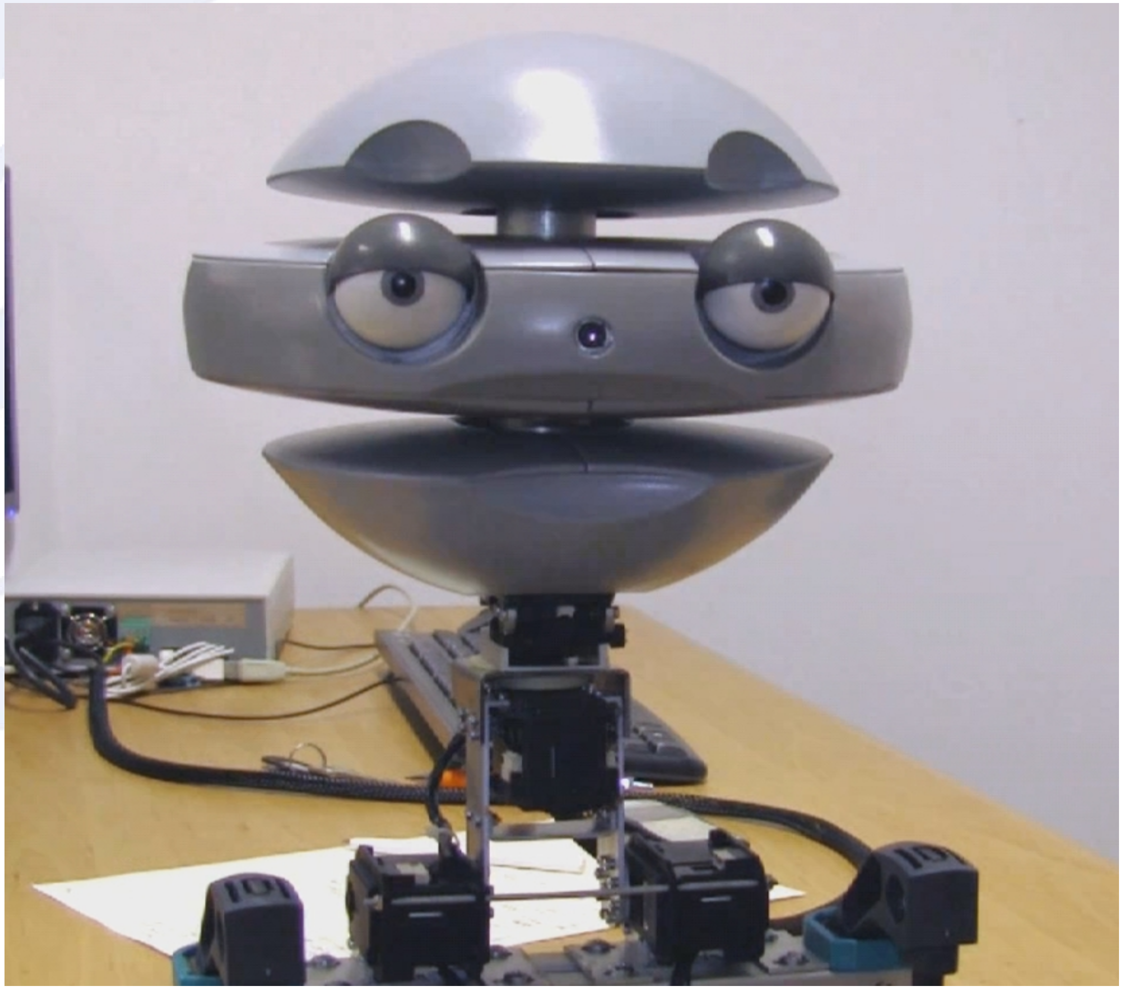
Capable of expressing themselves

Aim: Humans that consider machines as social entities

Leonardo, Robotic Life Group, MIT Media Lab

Jules, Bristol Robotics Lab

Expressive Behaviour



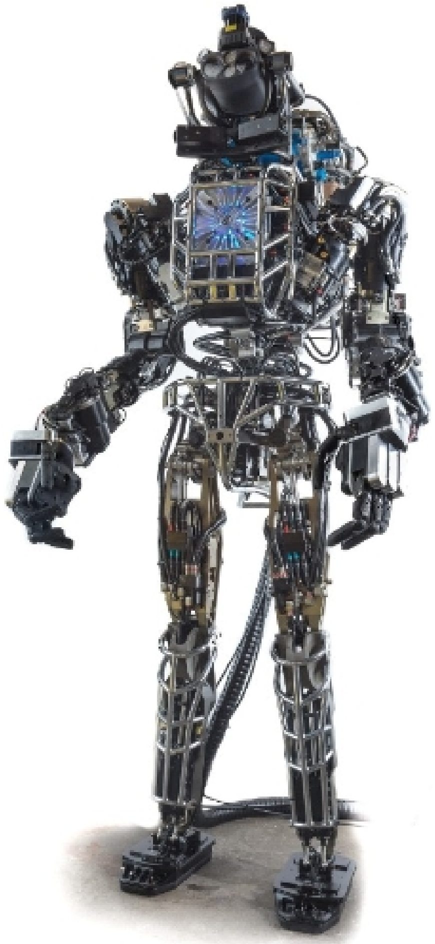
EMYS, University of Wroclaw, Poland
INESC ID, Portugal

Virtual characters

- Computer graphics and animation
- Animation → AI, ALife
- Many overlaps with social and mobile robotics
  - One to one interaction
  - Crowd/swarm simulation
- Embodiment raises many interesting issues
- Virtual models: cheap

CG Animation Primer

Many objects are composed of hierarchies
Transformations enable us to compose hierarchies



Atlas, Boston Dynamics

CG Scene composition

ARMA 3, Bohemia Interactive

A photorealistic scene (circa 2013)

CG Scene composition

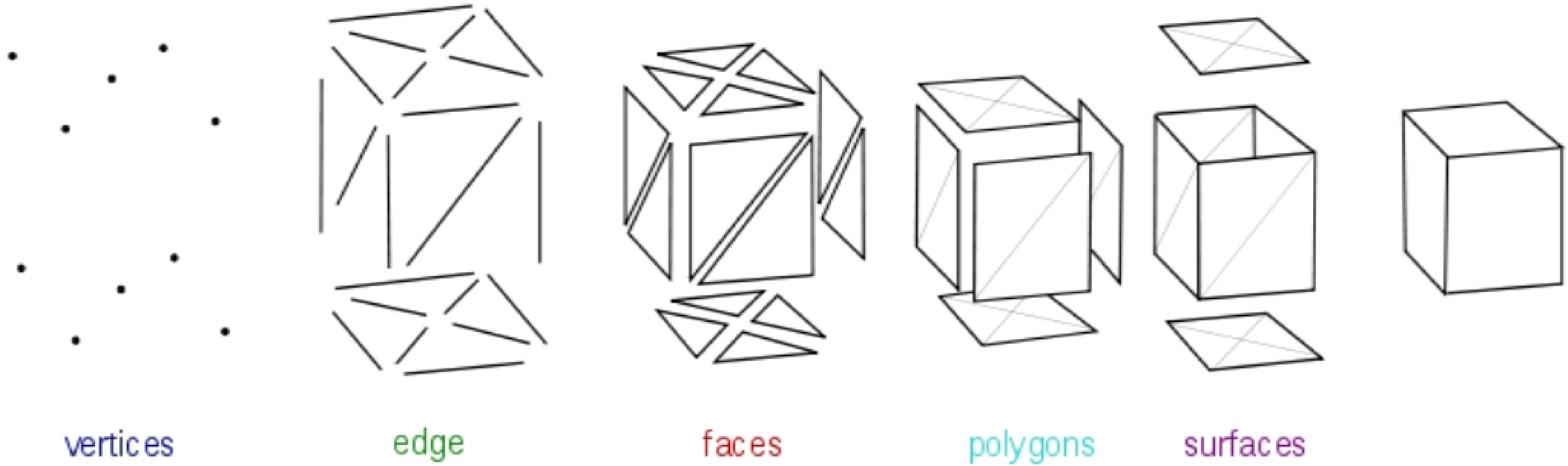
A photorealistic scene (circa 2013)

ARMA 3, Bohemia Interactive

Underlying representation (geometry: white)

Geometric primitives

(a brief introduction)



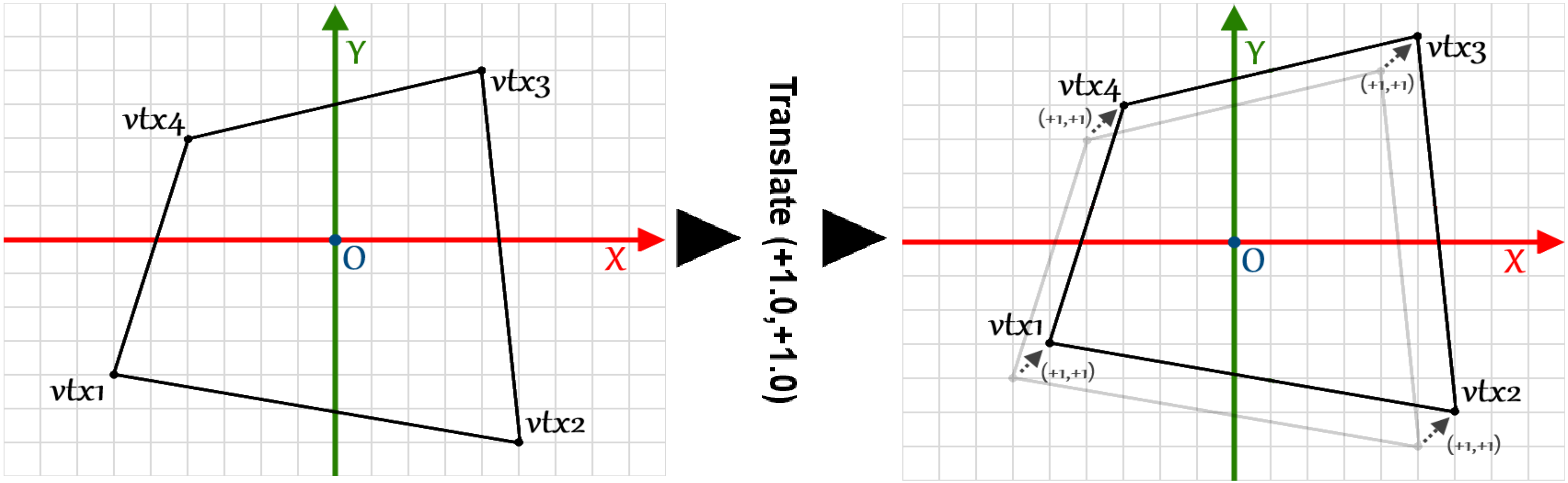
Translating an object

Translation operation takes place on a point

But a geometric object (*mesh*) is a collection of vertices

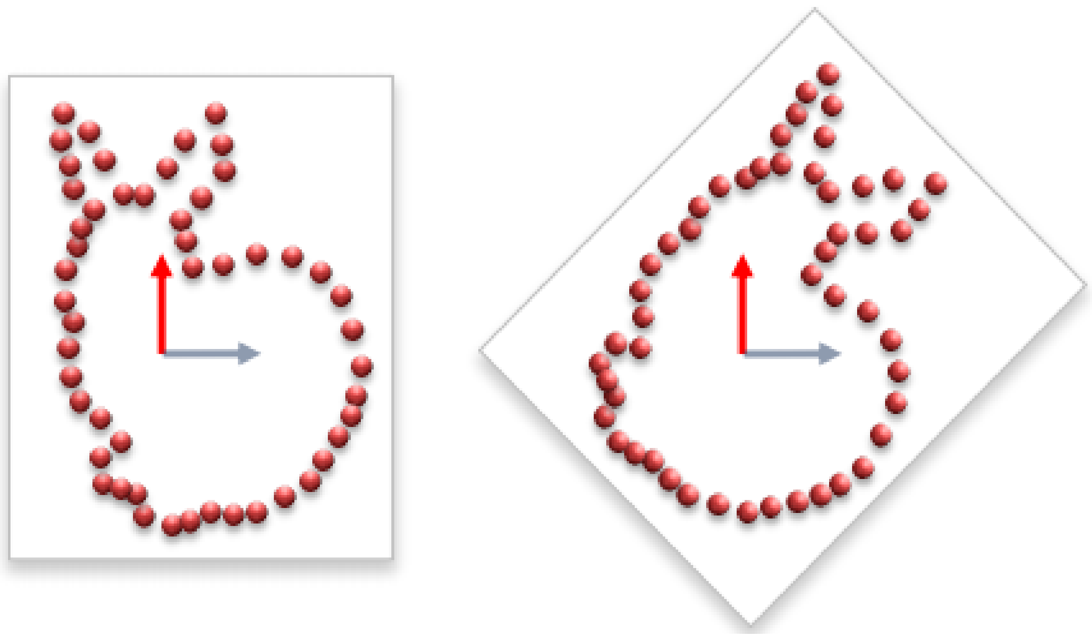
How to translate that?

Translate each of its vertices



Rotating an object

Rotation operation takes place on a point
How to rotate a object?
The same procedure applies:
Rotate each vertex that comprises the object



Representation

Transformations are represented as 4x4 *matrices*

Translation

$$\mathbf{T}(t_x,t_y,t_z)=\begin{pmatrix}1&0&0&t_x\\0&1&0&t_y\\0&0&1&t_z\\0&0&0&1\end{pmatrix}$$

Rotation around *x*-axis

$$\mathbf{R}_x(\phi)=\begin{pmatrix}1&0&0&0\\0&\cos\phi&-\sin\phi&0\\0&\sin\phi&\cos\phi&0\\0&0&0&1\end{pmatrix}$$

Rotation around *y*-axis

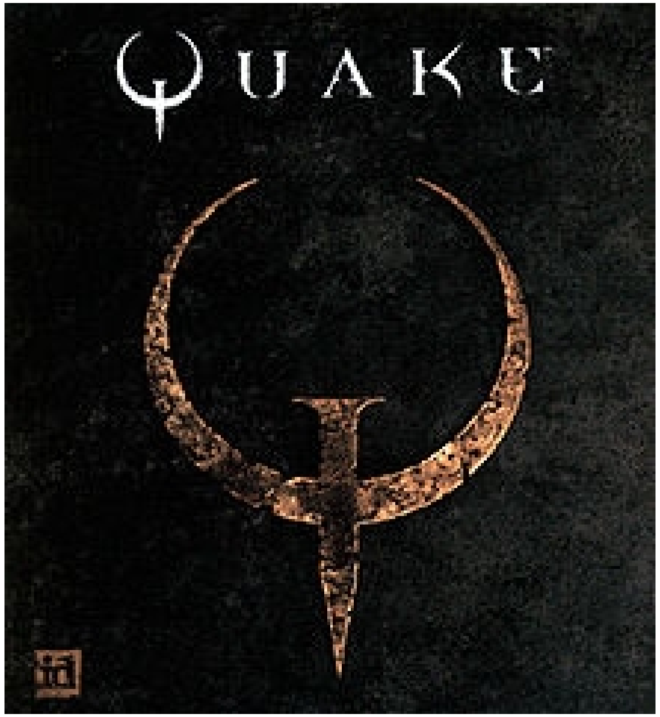
$$\mathbf{R}_y(\phi)=\begin{pmatrix}\cos\phi&0&\sin\phi&0\\0&1&0&0\\-\sin\phi&0&\cos\phi&0\\0&0&0&1\end{pmatrix}$$

Rotation around *z*-axis

$$\mathbf{R}_z(\phi)=\begin{pmatrix}\cos\phi&-\sin\phi&0&0\\\sin\phi&\cos\phi&0&0\\0&0&1&0\\0&0&0&1\end{pmatrix}$$

$$\mathbf{M}\cdot\mathbf{x}=\begin{pmatrix}m_{11}&m_{12}&m_{13}&m_{14}\\m_{21}&m_{22}&m_{23}&m_{24}\\m_{31}&m_{32}&m_{33}&m_{34}\\m_{41}&m_{42}&m_{43}&m_{44}\end{pmatrix}\begin{pmatrix}x\\y\\z\\1\end{pmatrix}=\begin{pmatrix}x'\\y'\\z'\\w'\end{pmatrix}$$

Game Technologies



Game Complexity: 2004++

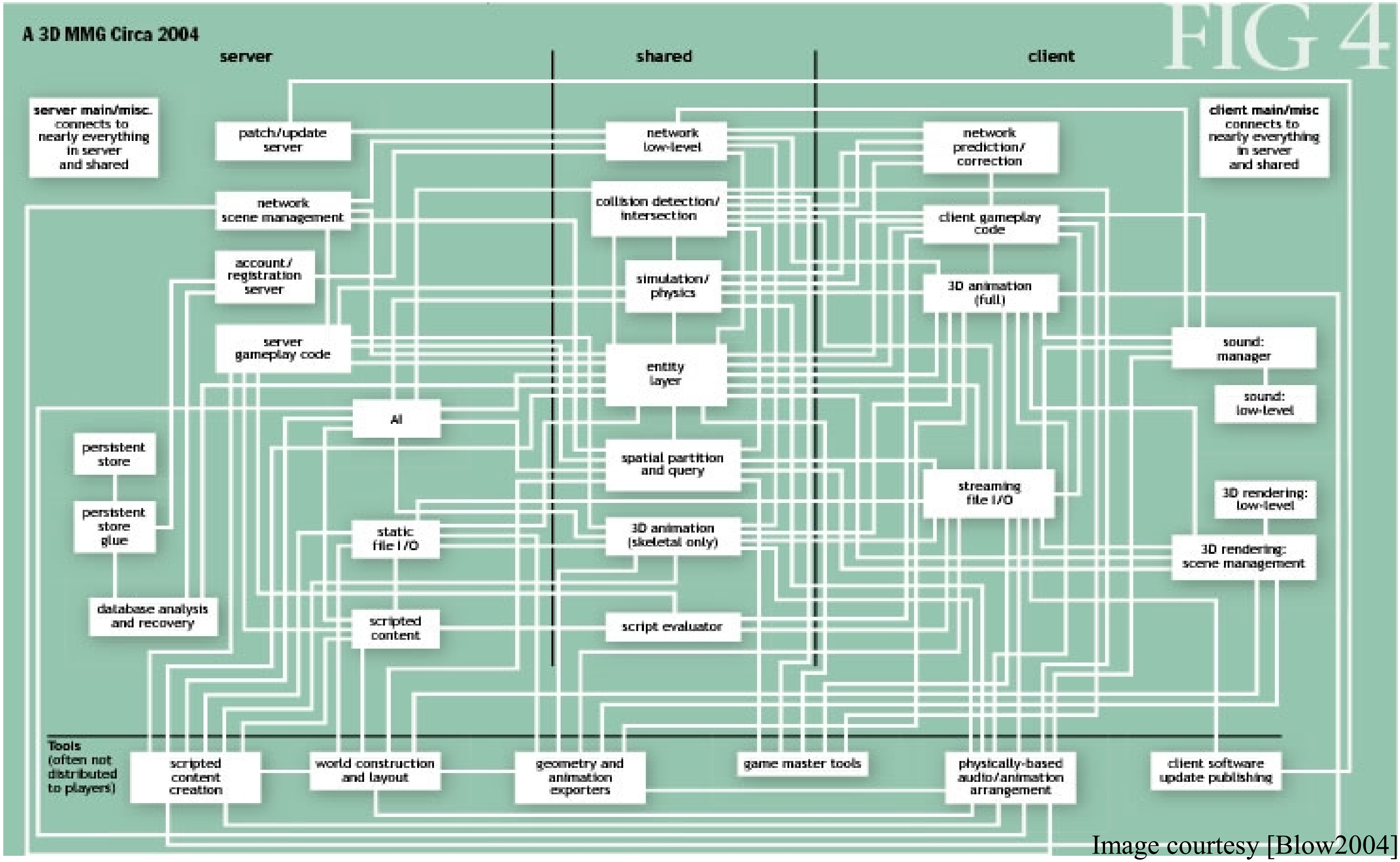


Image courtesy [Blow2004]

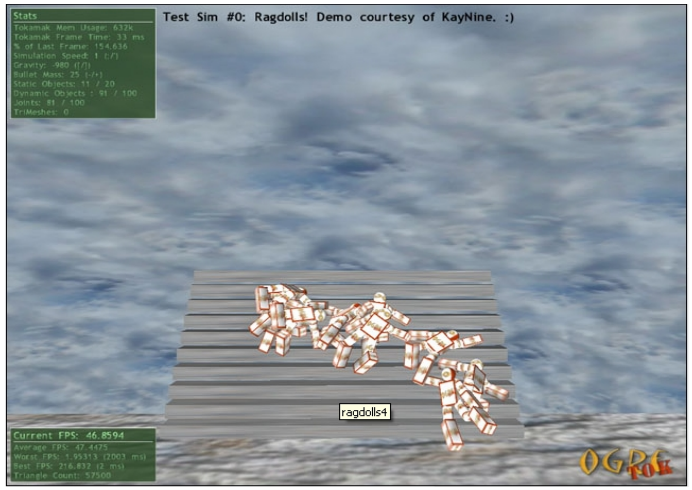
Libraries: Graphics

Object-oriented Graphics Rendering Engine (OGRE)

OGRE is primarily a **graphics engine**

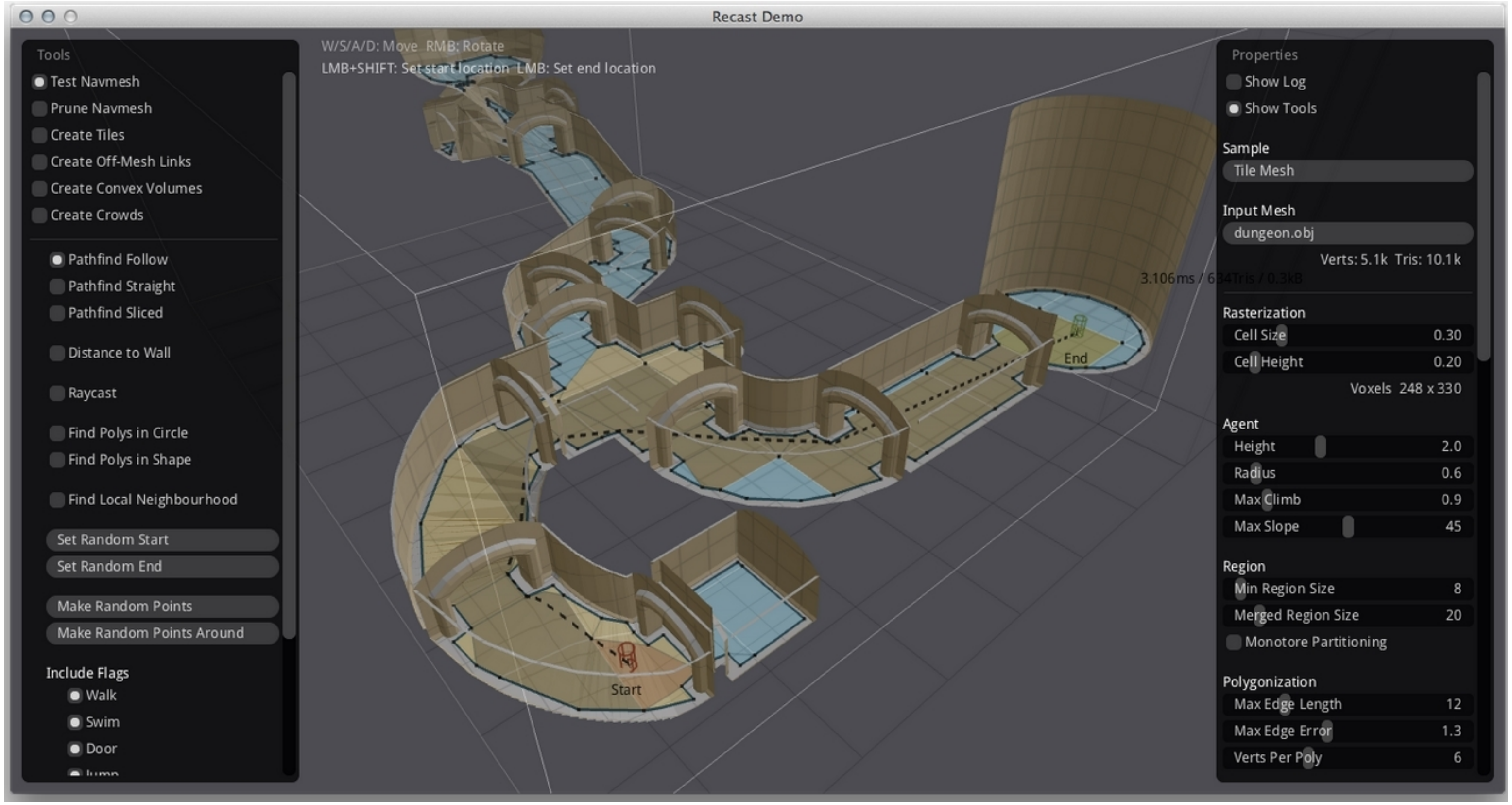
C++

http://www.ogre3d.org/



Libraries: Navigation

Recast (nav meshes), Detour (pathfinding and spatial reasoning), MIT license



https://www.youtube.com/watch?v=XyfLSocd9ec

Libraries: Physics

Mainly rigid-body and cloth simulation

Havok

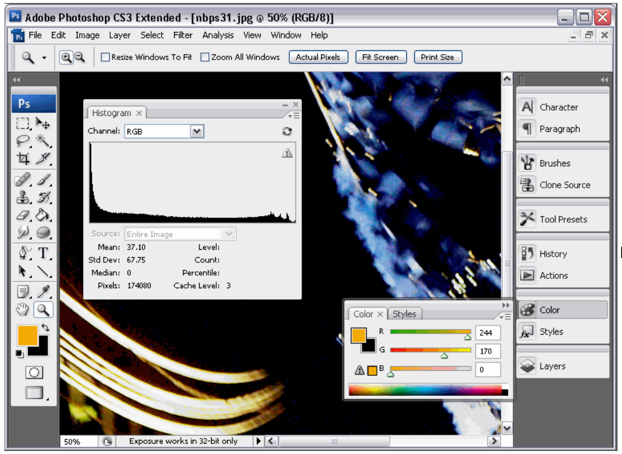
Bullet

ODE

Game Technologies

Suitable for (motivated) beginners! See examples here:
https://www.kth.se/social/course/DH2323/page/blogs-2/
http://www.csc.kth.se/~chpeters/projects.html

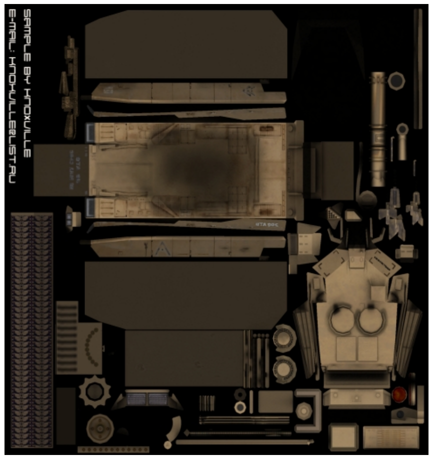
Game Technology Chain



2D paint package

3D modelling package

Real-time engine



2D textures

3D models and animations

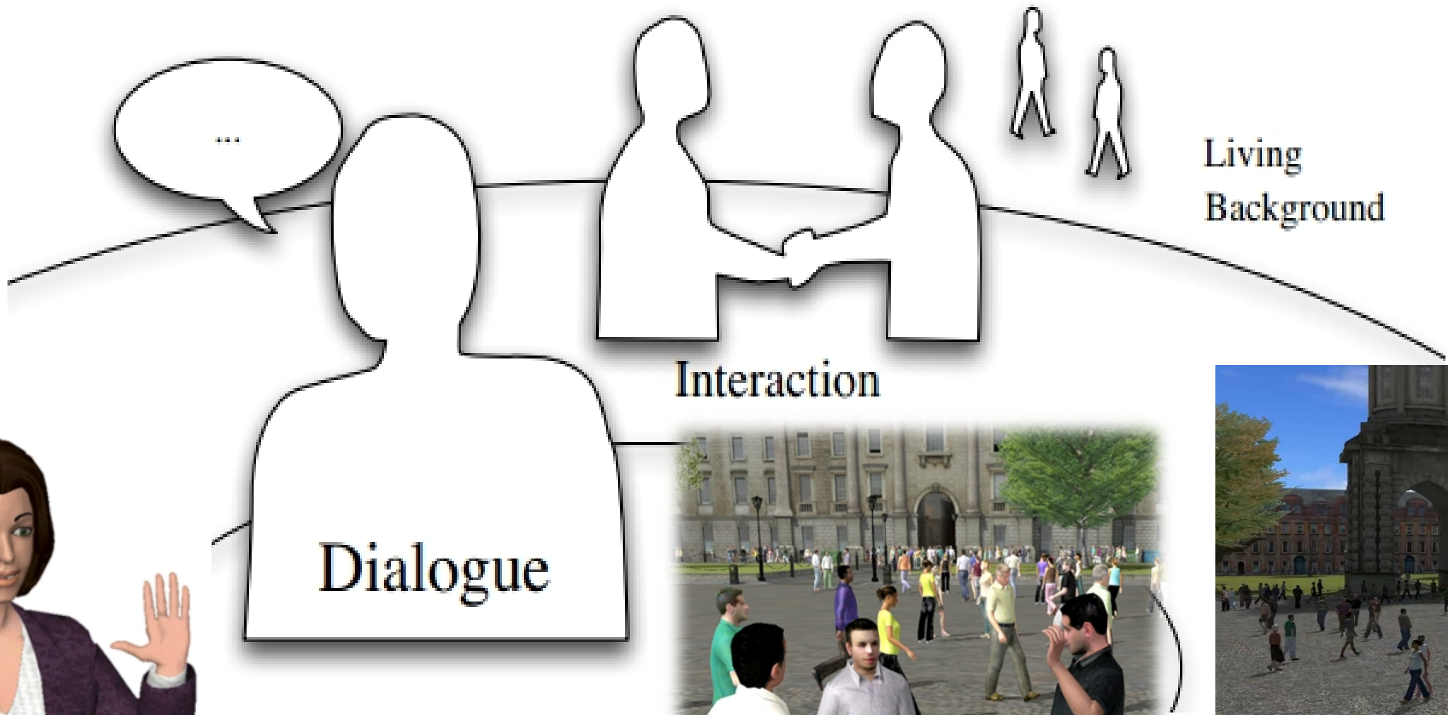
Real-time rendering, animation and interaction

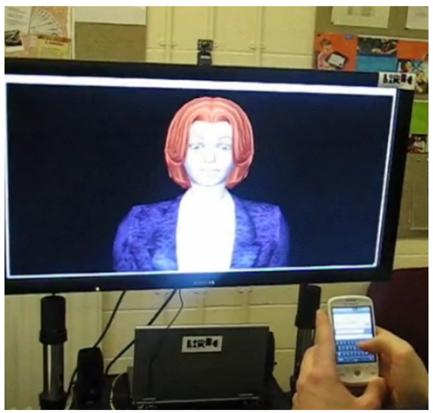
chpeters@kth.se

Character Behaviour

Assassin's Creed, Ubisoft Entertainment

Levels of Interaction





Individuals

Groups

Crowds

Computational Models

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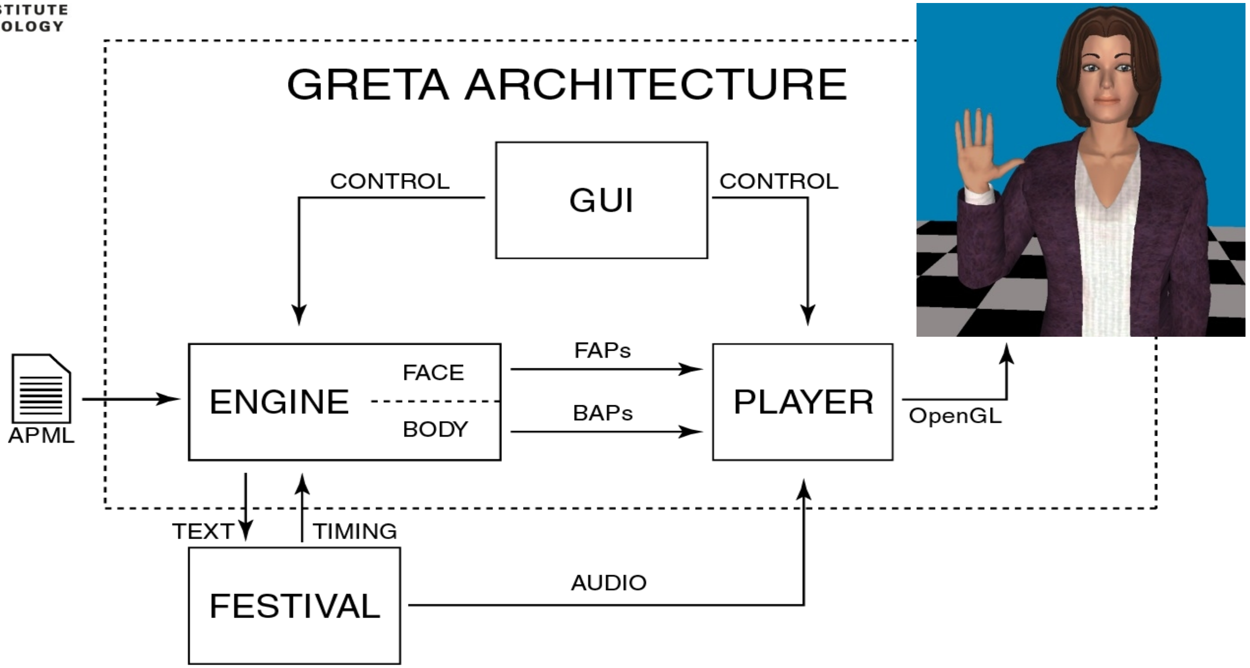


See: **Pelachaud, et al**

ParisTECH, France

Example: Superposition of Sadness and Joy

Joy

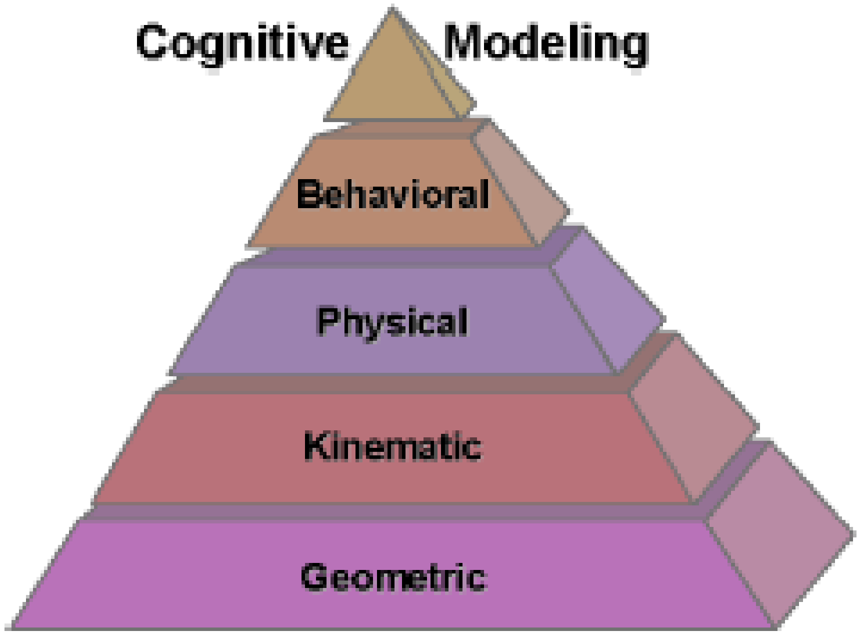
Sadness

Original video

Sadness and Joy

CG Modelling Methods

- Geometric
  - Transform vertices, edges, faces (ugh!)
- Kinematic
  - Forward, Inverse Kinematics
- Physically-based
  - Particles, rigid body dynamics, mass-spring systems, hair, cloth
- Behavioural
  - Self-animating characters, reactive, 'senses'
- Cognitive
  - In-depth knowledge representation, reasoning and planning



The CG Modelling Hierarchy

© Funge et al., 1999

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Behavioural Animation

- Important Factors:
  - **Degree of Autonomy**
    - Agent has selection of potential actions it can make in certain situations and decides *itself* (according to its program) which to select given the current situation
    - Decisions may take place at multiple different control levels
  - **Reactive Behaviour**
    - Decision-making mechanisms are often lightweight …
    - …although term ‘behavioural animation’ sometimes used as umbrella concept encapsulating agents that are cognitive to different degrees, capable of more sophisticated reasoning
  - **Sensing**
    - Agent capable of sensing the external environment
    - Varying degrees of sensor sophistication
      - E.g. Ray casting → synthetic vision

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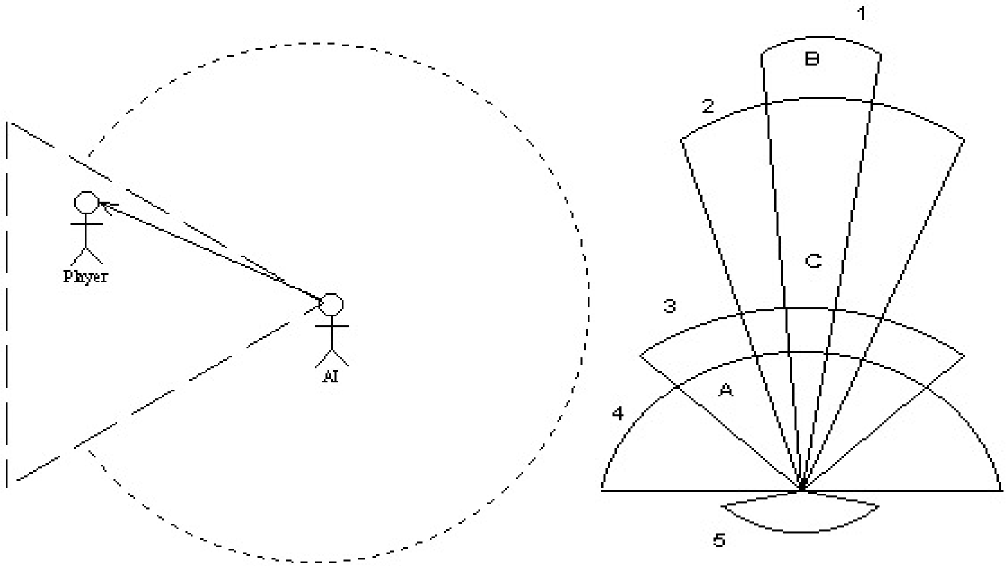
Issues

- Advantages:
  - Emergent behaviour
    - Simple set of rules can lead to the *appearance* of complex behaviours
  - Useful for animating large crowds
    - Do not have to manually adjust the animation of each agent individually…
    - …but important to provide differentiation in the behaviour of agents so they do not all act in the exact same way
- Disadvantages:
  - Hard to achieve specific desired effects
    - Agents animated only through indirect means
    - Reacting to each other and to environment
    - Many variables to consider so outcomes can be hard to predict

Sensing

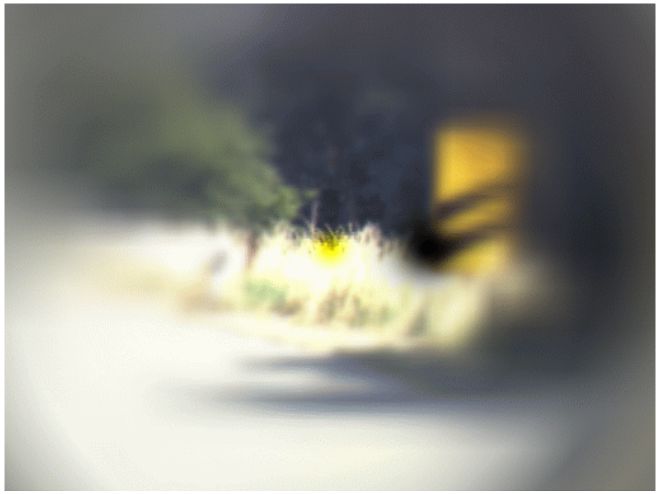
Why add sensing?

- –Environment database contains all objects and their states
- –Agents can have *unrestricted* access to this data
  - •Agents may be perceived to have unrealistic abilities
- –Provide agents with simplified senses
- –Examples:
  - **Volume tests** –anything falling within the volume is 'sensed'
  - **Ray-casting** – shoot one or more rays out and check for collisions
  - **Synthetic vision** – render the scene from perspective of agent
  - •None attempt to tackle machine vision problem



Example: Gaze Generation

- Gaze
  - Mobile orientable sensor
  - e.g. Pan-tilt camera, eyes and head
  - Active vision (robotics)
- Sends signals into the environment
  - May help others to infer one's intentions
  - Perception of the attentive behaviours of others



Ilab, University of Southern California

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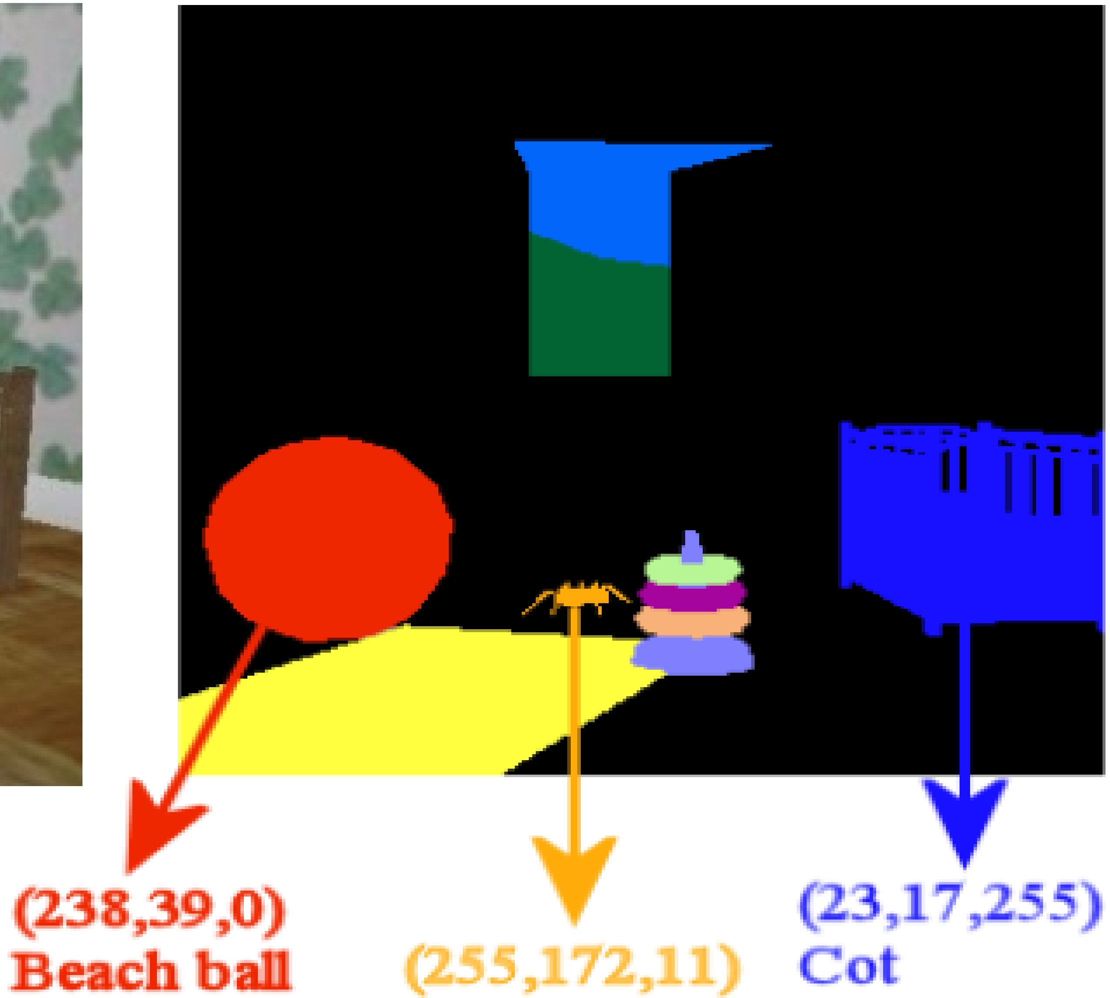
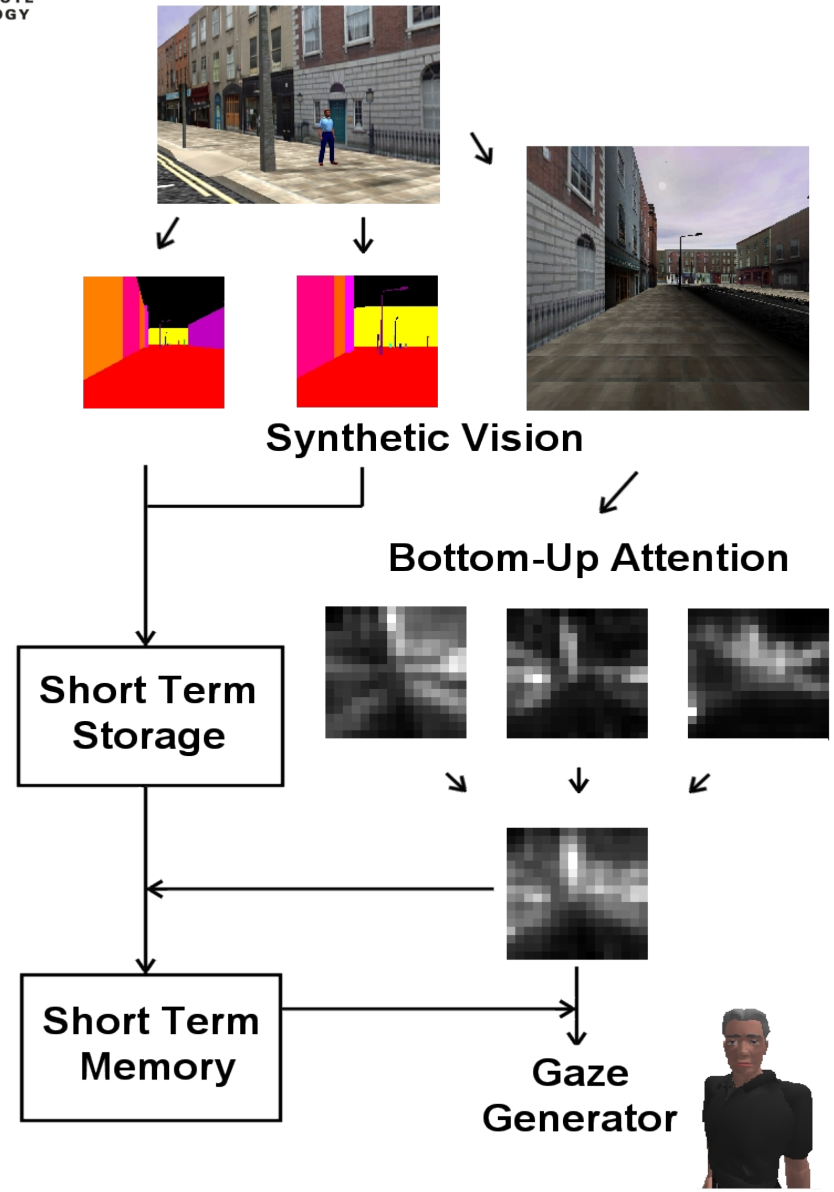
Synthetic Vision: False-colouring



Overview

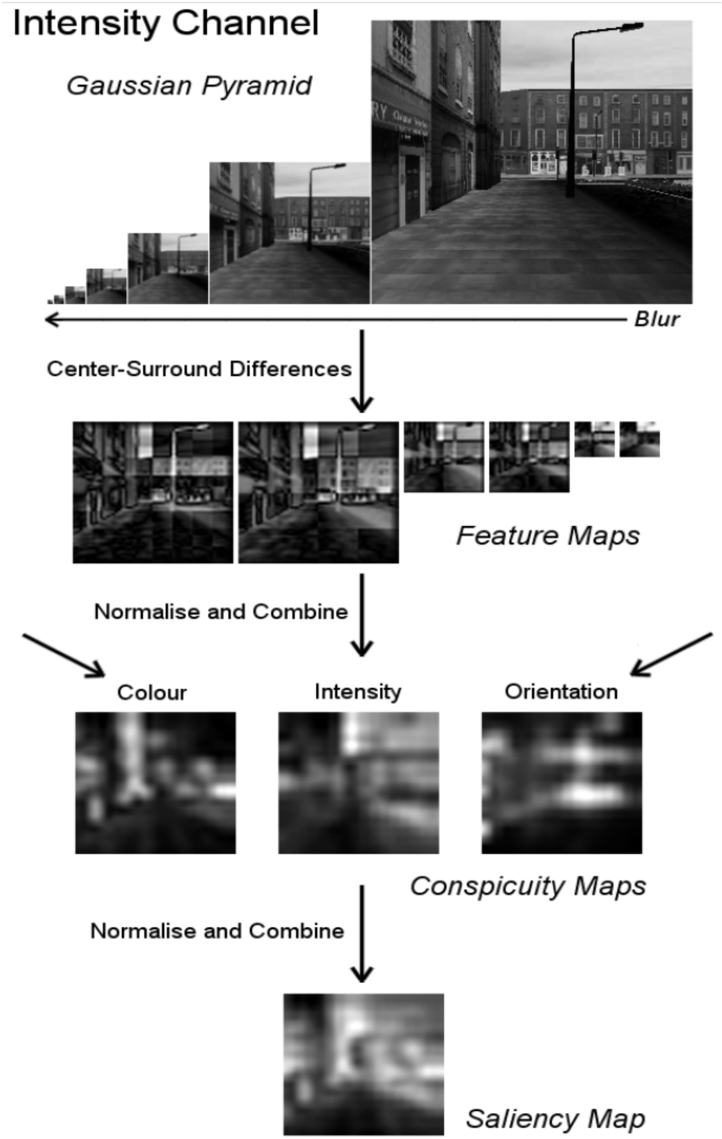


Input environment through synthetic vision component

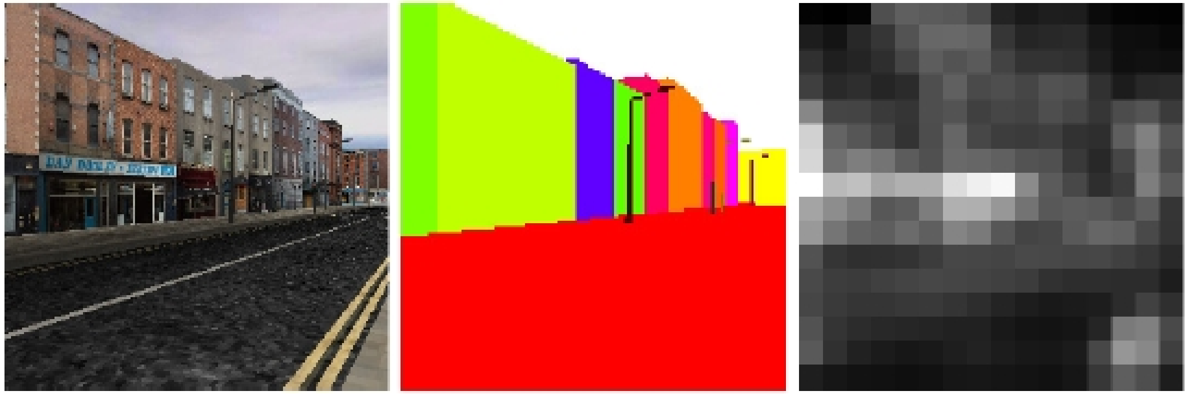
1. Process visual field using spatial attention model
2. Modulate attended *object* details using memory component
3. Generate gaze behaviours towards target locations

Bottom-up Attention

- Model
  - Cognitive engineering
  - Itti et al. 2000
    - http:// ilab.usc.edu/bu/
  - Biologically inspired
  - Inputs an image, outputs encoding of attention allocation



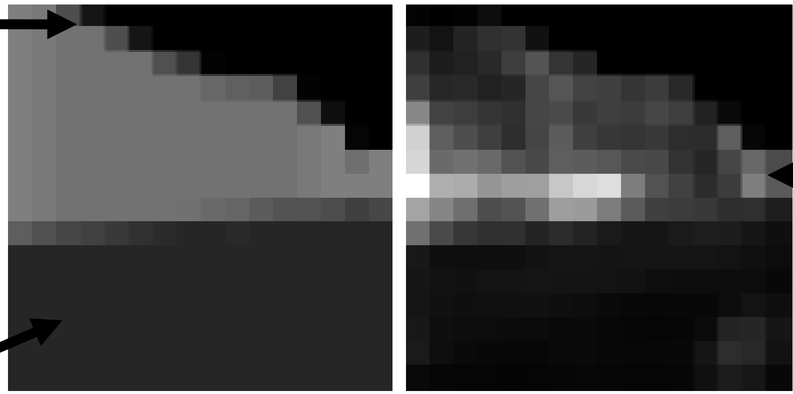
Overall



Original False-colour Saliency (visual attention)

Sky ‘object’ looked at previously

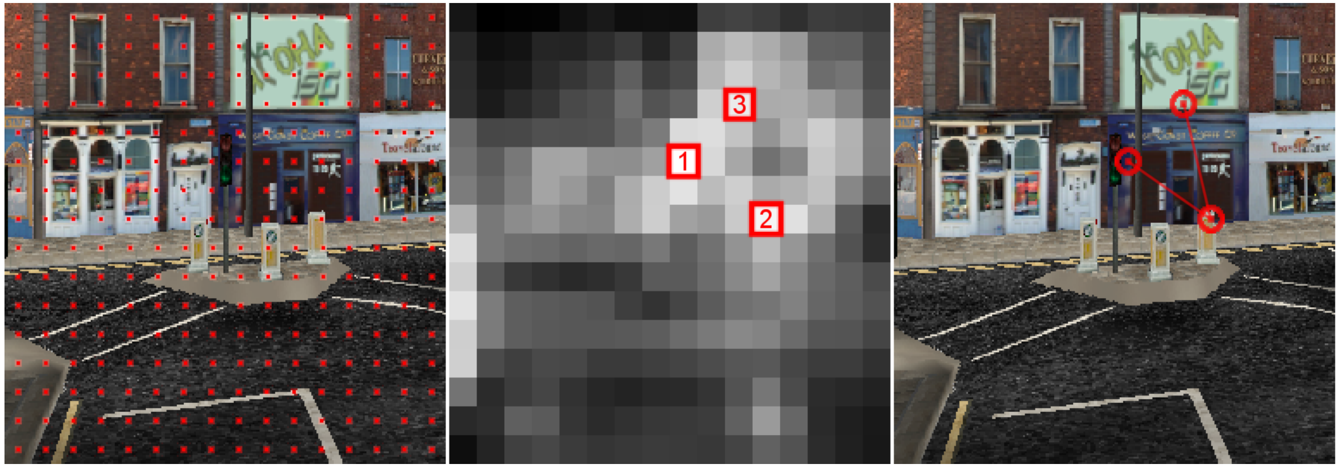
Road ‘object’ looked at previously

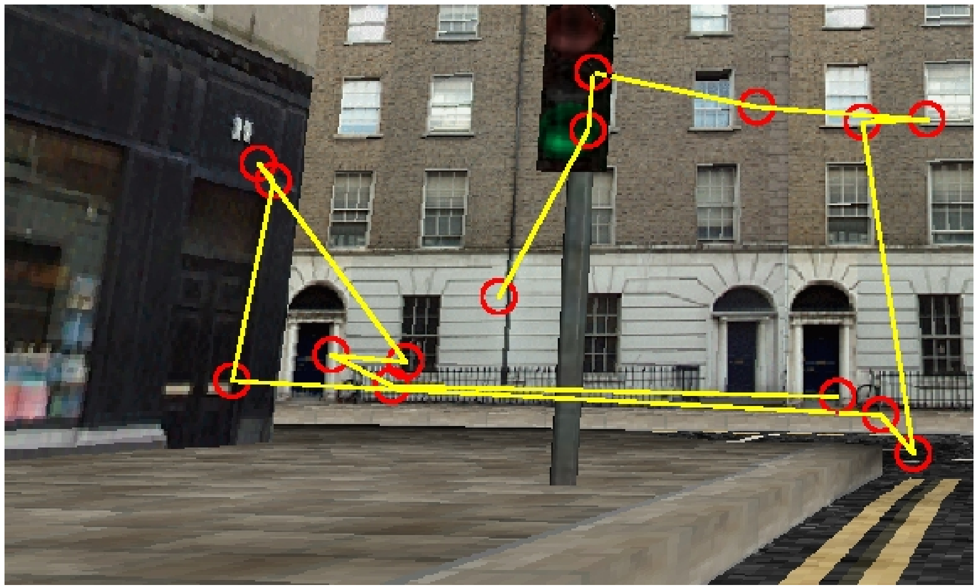


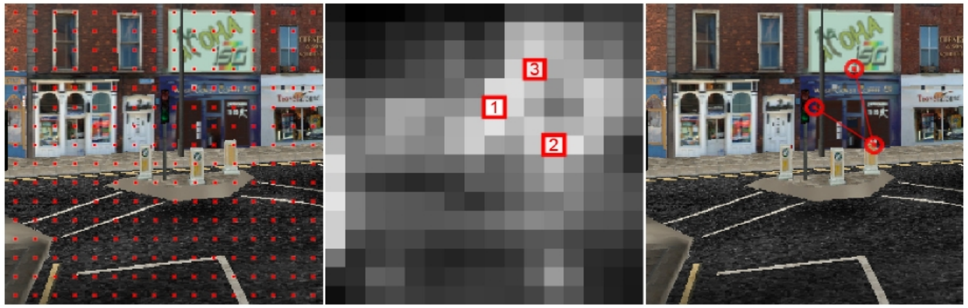
'Buildings' area receives enchanced attention

Memory Final

Scan-path Generation






1
2
3


H
M
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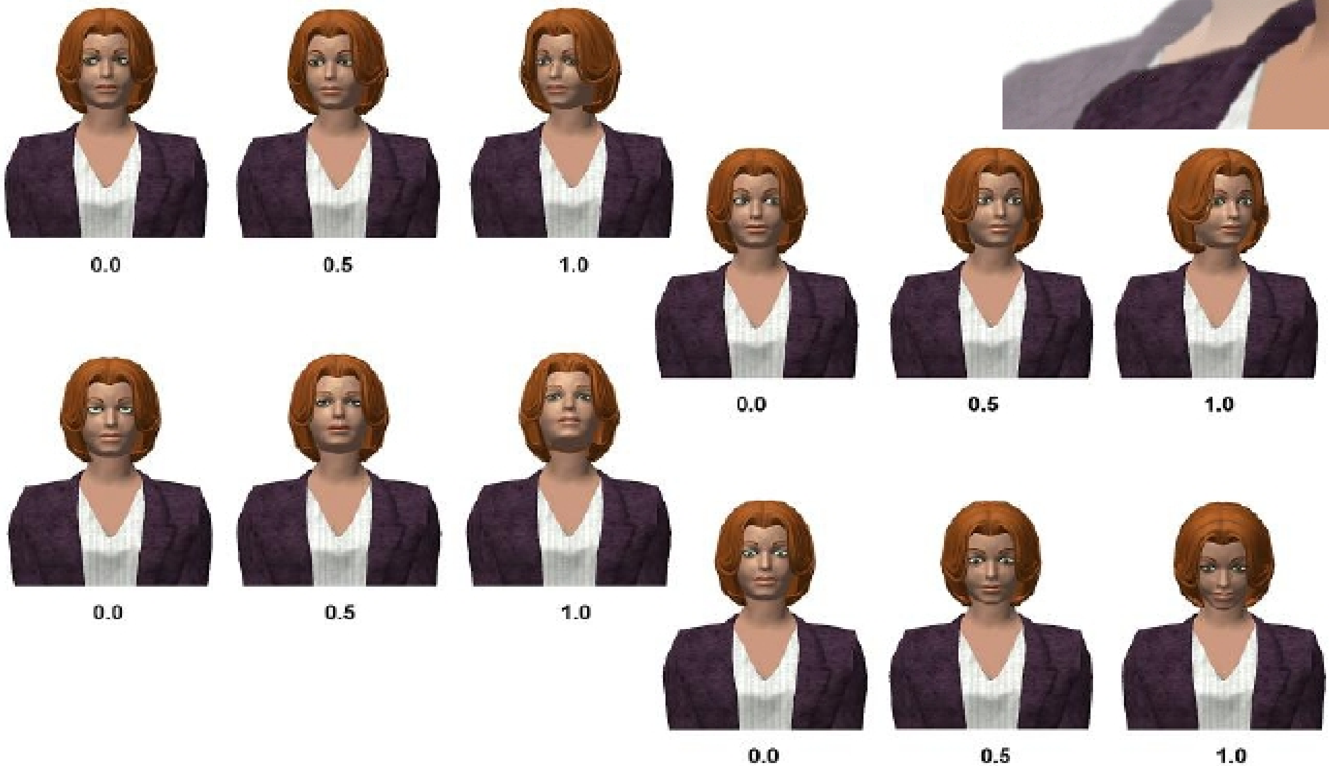
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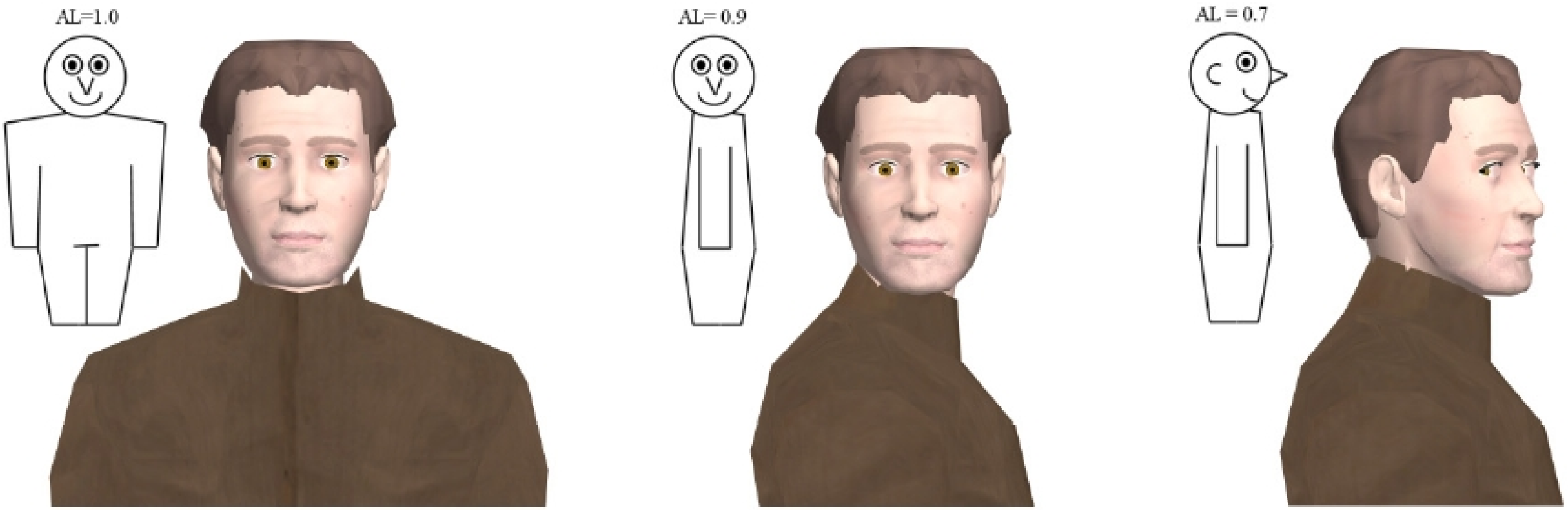
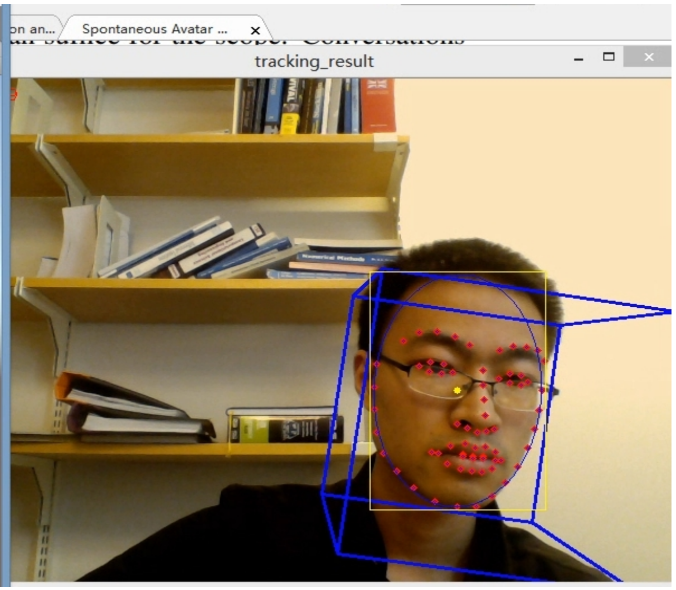
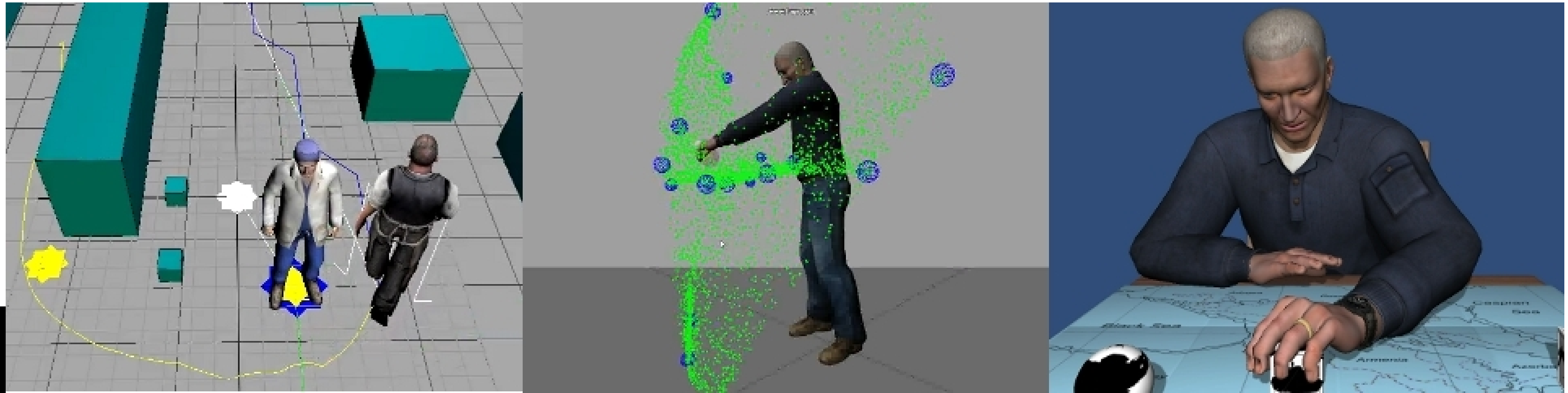
Blinking and Eye-head Ratio



Gaze-based Interaction



Facial Animation and IVAs



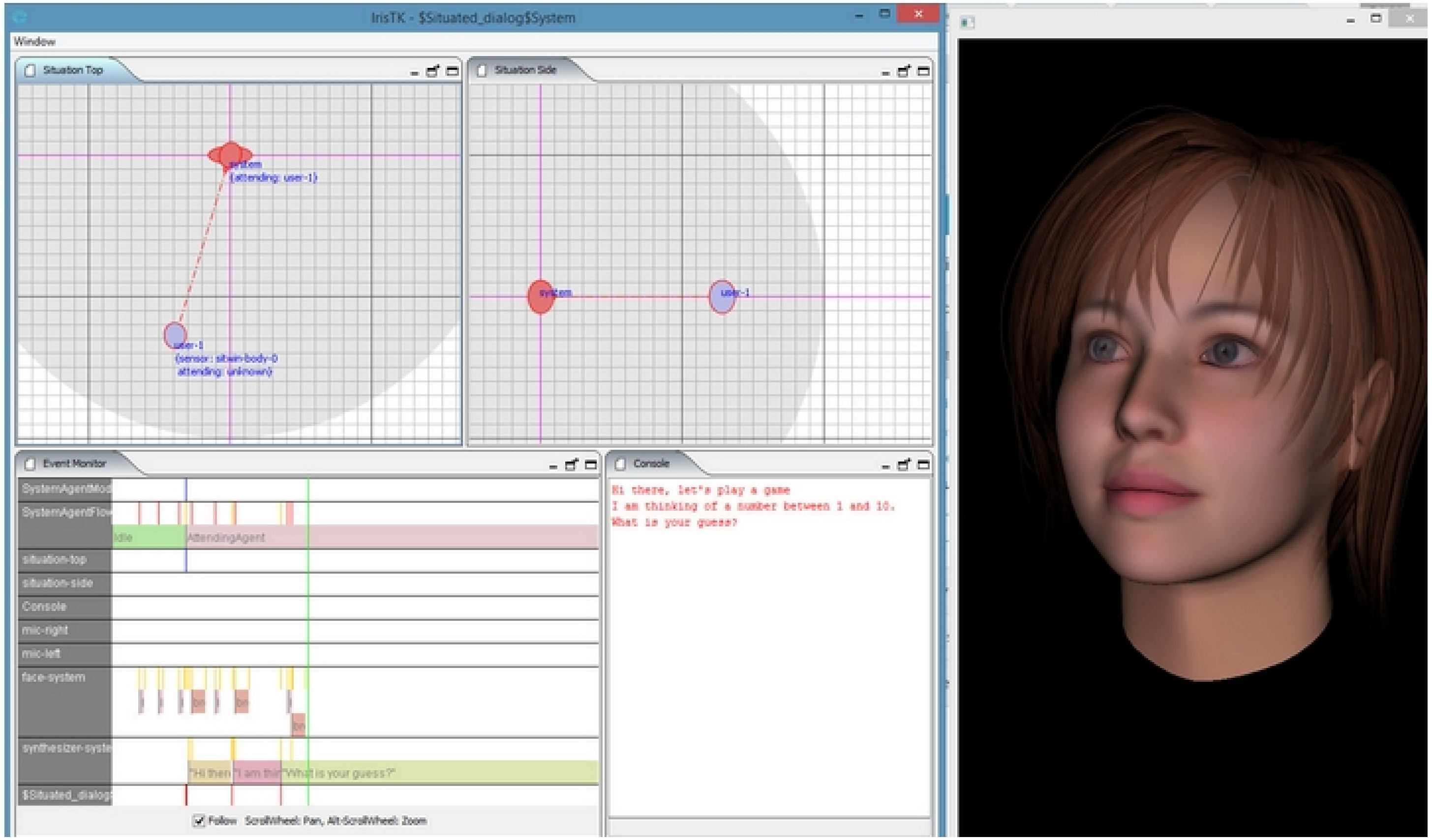
Smartbody

LGPL license

http://smartbody.ict.usc.edu/video

http://www.facefx.com/content/english-un-declaration-human-rights

Want to try it for yourselves?



IrisTK: http://www.iristk.net/

Video: http://www.iristk.net/examples.html

Furhat ROBOTICS

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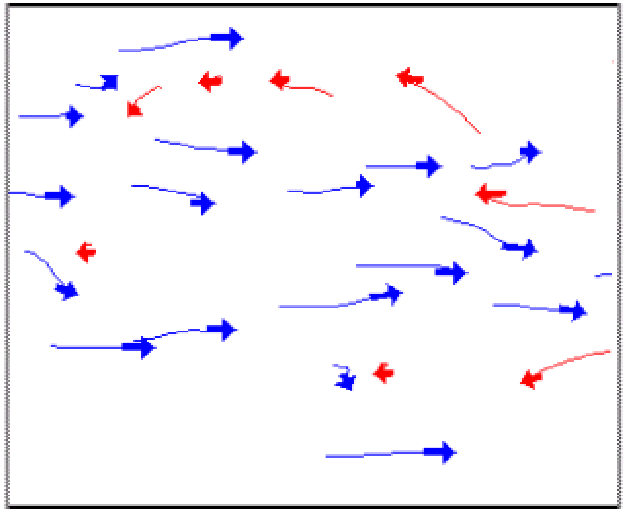
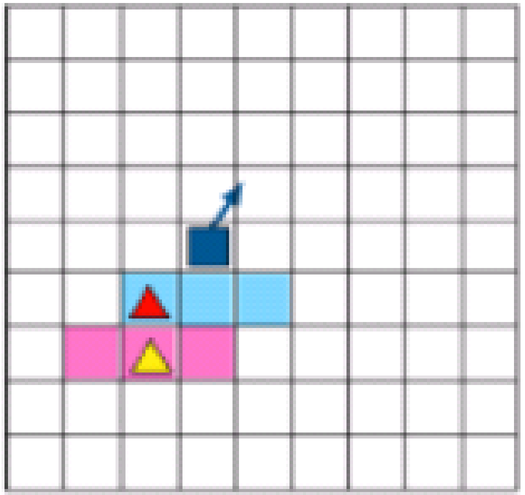
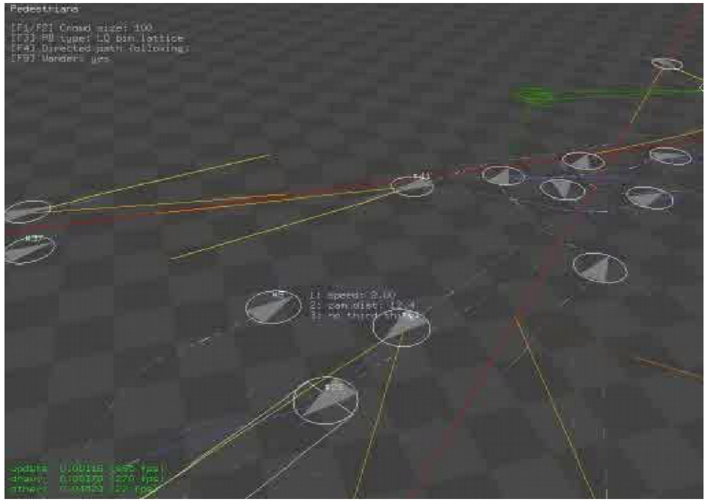
Behaviour Approaches







Social forces

- \+ Realistic pushing behaviour, lane formation
- \- Behaviour more like particles than humans
- E.g. Helbing and Molinar

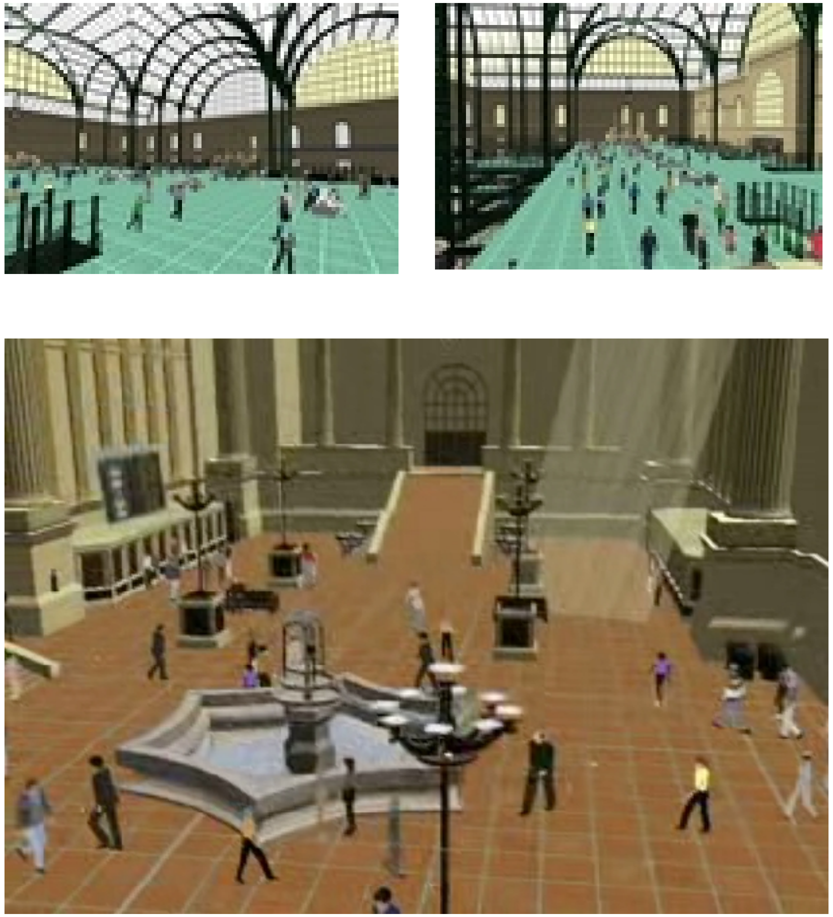
Cellular automata

- \+ Fast, easy to implement
- \- Underlying checkerboard pattern
- E.g. Loscos et al.

Rule-based

- \+ Realistic for low and medium densities
- \- Collision detection and repulsion not considered
- E.g. Reynolds

Autonomous Pedestrians



Shao and Terzopoulos 2005

- Shao and Terzopoulos
  - Model individuals
  - Cognitive modelling
  - Deliberative as well as reactive behaviours
  - Virtual environment represented by hierarchical collection of maps
    - Topological – high level links
    - Perception
    - Path – long range and short range path planning

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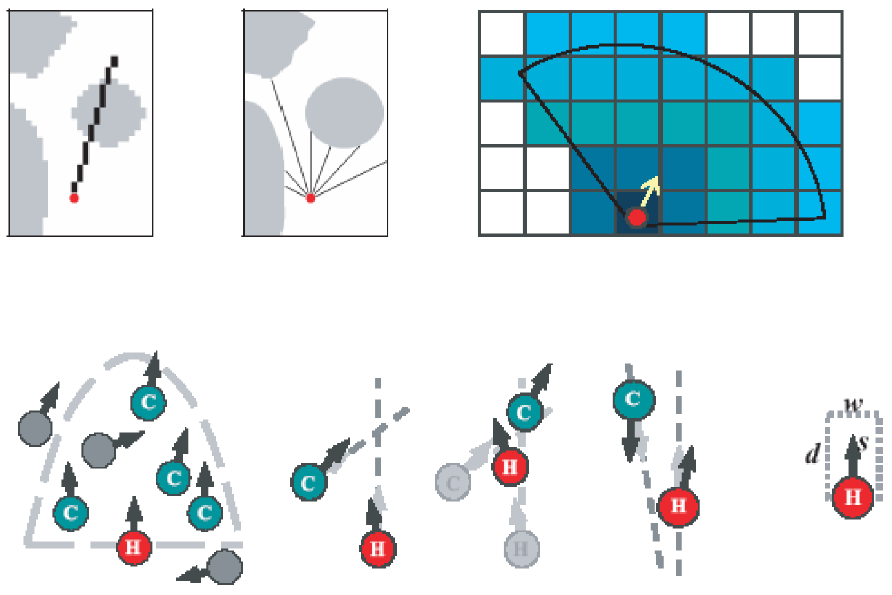
Autonomous Pedestrians



Shao and Terzopoulos 2005

- Perception
  - Stationary *(left, middle)* and mobile objects *(right)*
- Behavioural control
  - Primitive reactive behaviours
  - Building blocks to support more complex behaviours
  - Controlled by action selection mechanism
- Cognitive control
  - Global path planning
  - Goal stack

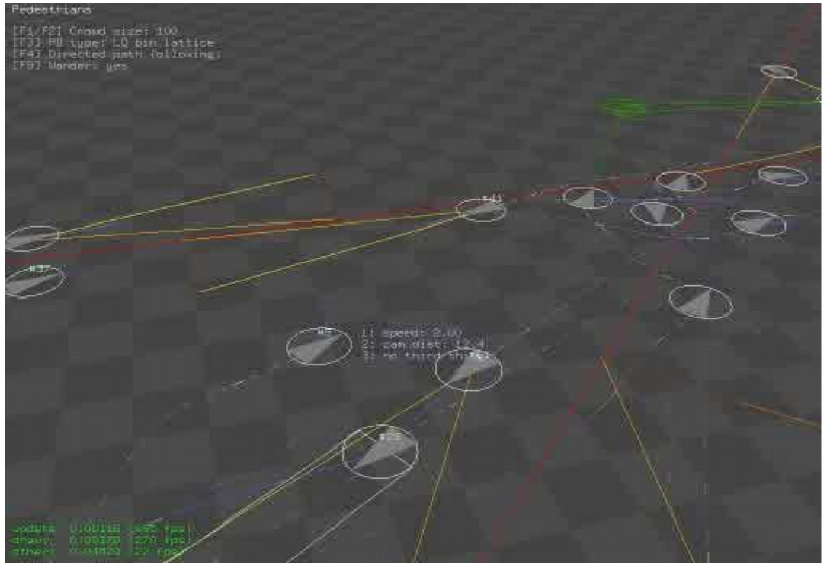
Video: https://www.youtube.com/watch?v=8-uqYSWLqpQ

chpeters@kth.se

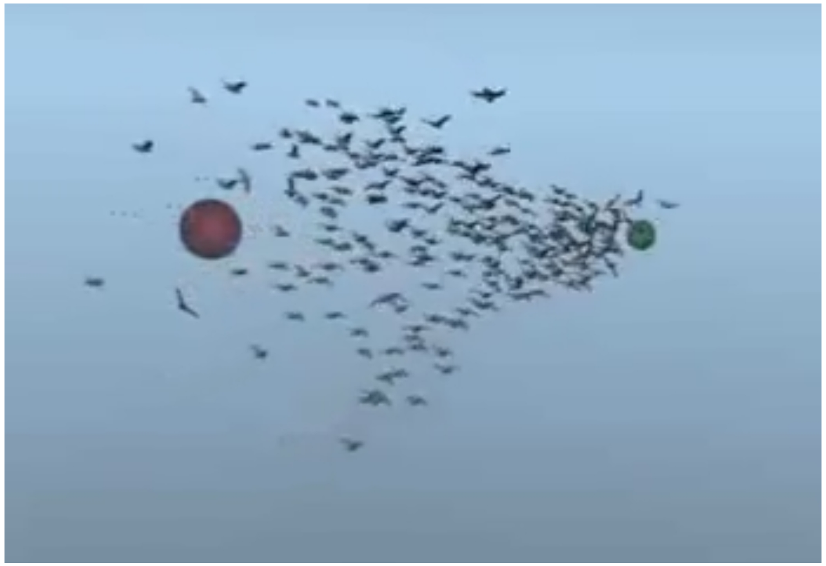
Try it yourselves: “Boids”

- Three *steering* behaviours:
  - Separation
  - Cohesion
  - Alignment
- Great for fish, insects, etc
- Basic version not so good for humans
- *Steering behaviours* can be augmented
  - See OpenSteer pedestrian plug-in:

    http://opensteer.sourceforge.net/



Reynolds, 1999



Video: https://www.youtube.com/watch?v=GUkjC-69vaw

From *Boids* to Zombie Hordes

The Walking Dead

World War Z

https://www.youtube.com/watch?v=ZpJoMuuE3Eg
1:13

Technical research areas:

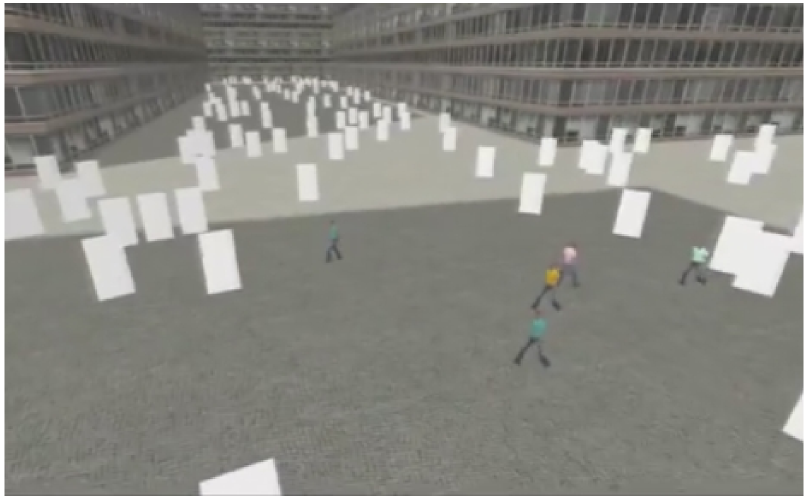
Crowd generation, rendering, behaviour simulation and perception

Zombie Hordes

Rendering challenges

Real-time operation -> Imposters

Representation and variety of appearance



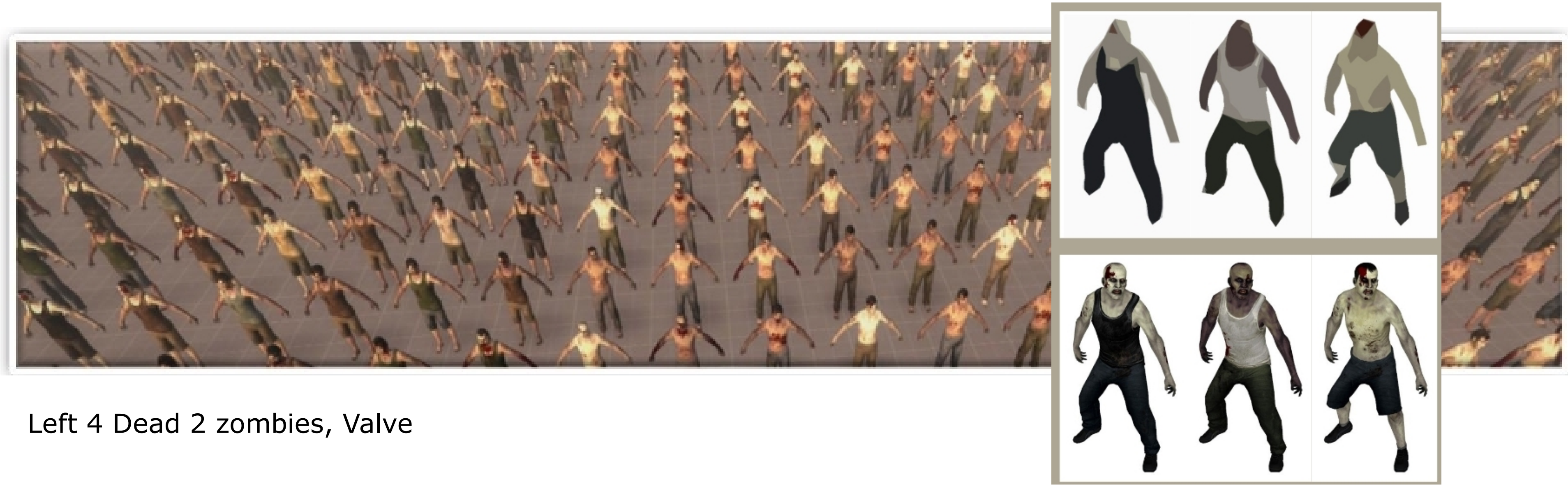
Eye-posters and *perceptually varied crowd* projects, Ludwig Axelsson, Håkan Eriksson, Tim Lindeberg, Martin Schön; Måns Odstam, Andreas Stjerndal

Blog: https://tribestar.wordpress.com/category/perceptually-varied-crowd/

Zombie Hordes

Rendering challenges

- Real-time operation -> Imposters
- Representation and variety of appearance -> Generation



Left 4 Dead 2 zombies, Valve

Zombie Hordes

Rendering challenges

Real-time operation -> Imposters

Representation and variety of appearance -> Simulation

High density crowds via unilaterally incompressible fluid simulation, Richard Ristic and Johan Berglund

Paper available for download from www.csc.kth.se/~chpeters/projects.html

Video: https://kth.box.com/s/0t3w4nln7h436hctbf7kqkmh6pi59q28

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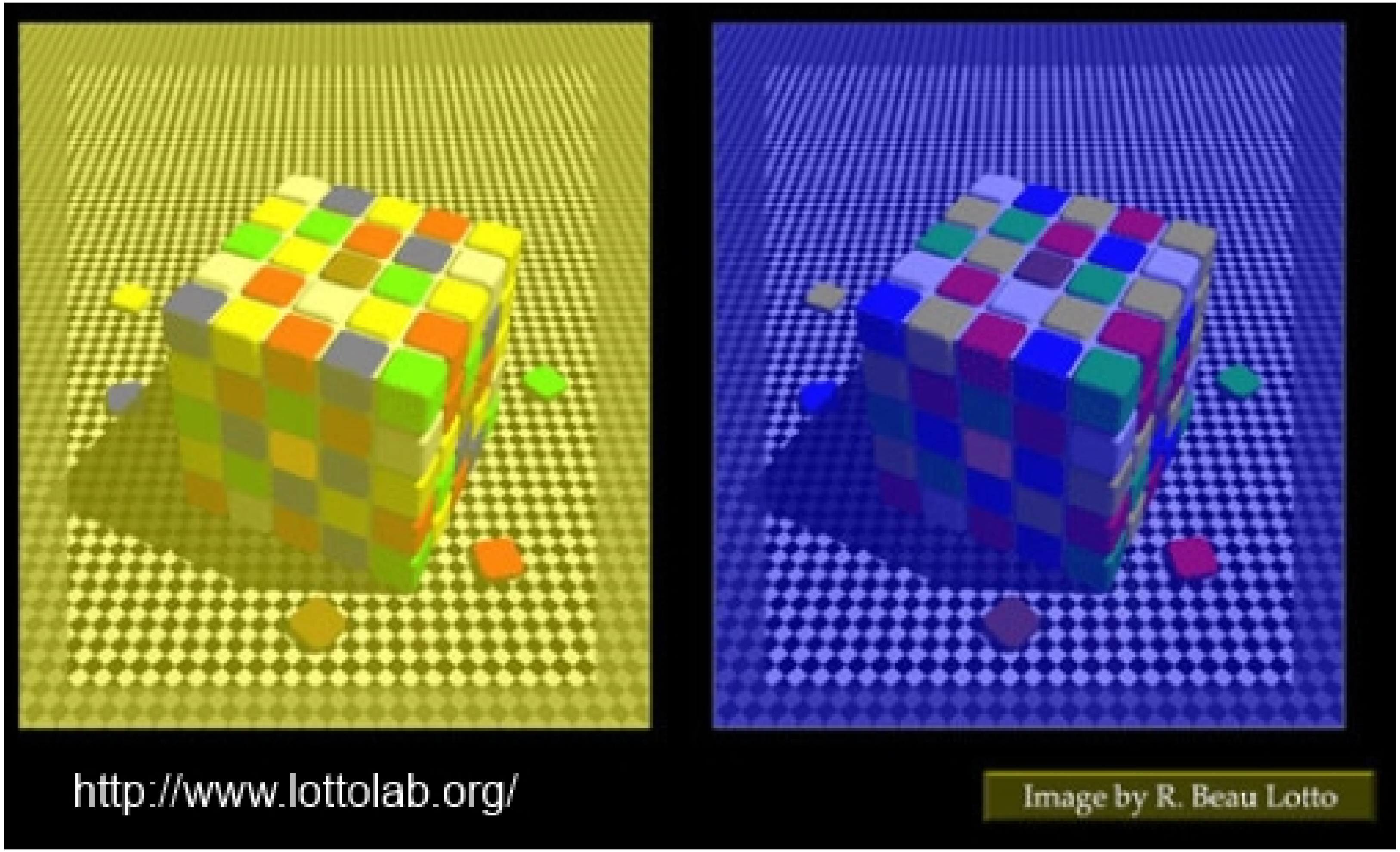
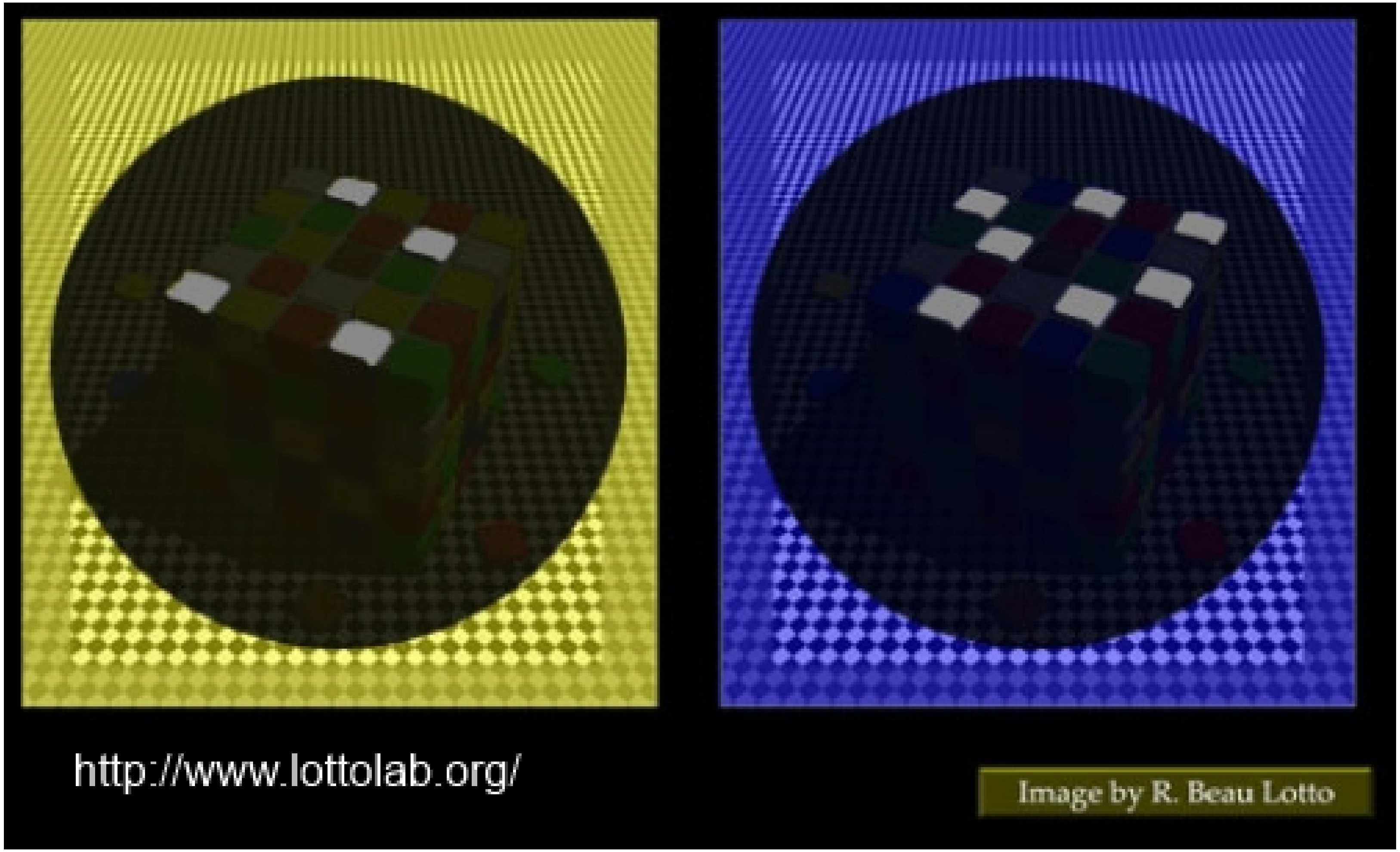
Embodiment

Trustworthy?
Natural?
Uncanny?

Human Perception



Human Perception



Perception and Zombie Hordes

Representation and variety of appearance

-> Perception studies

Clone Attack! Perception of Crowd Variety, McDonnell, et al., ACM Transactions on Graphics (SIGGRAPH 2008), 2008

Evaluating the perception of group emotion from full body movements in the context of virtual crowds, Carretero, et al., ACM Symposium on Applied Perception, 2014

ROYAL INSTITUTE OF TECHNOLOGY

Reminders

Lab work

- Submission was May 20th
- Bilda will reopen soon

Lab session(s)

- Tuesday 24th, 12:00-13:00 (VIC)
- Friday 27th, 08:30-10:00 (VIC)

SUDOA