Chapter 11

Behavioural Animation
Behavioral Animation

Knowing the environment

Aggregate behavior

Primitive behavior

Intelligent behavior

Crowd management
Behavioral Animation

- Cognitive
- Behavioral
- Physical
- Kinematic
- Geometric
Knowing the environment

Vision – what do you know about the present

Memory – what is recorded about the environment

More about AI than graphics
Vision

Geometric issue – what’s in sight?
OR
Can I see X?

Computation v. accuracy

Perceptual issue – what do you see?

Cognitive modeling – necessary? At what level?
Omniscience

Everything in database is ‘known’
FOV Vision

Use surrogate bounding volumes, or sample points
Occluded Vision

ray casting
sample environment

z-buffer
use object IDs as color

Use surrogate bounding volumes
Target-testing vision

Can I see X?
Cast ray

Sample object

Use surrogate bounding volumes

Department of Computer Science and Engineering
Object Recognition

Cognitive modeling
How much and what part is needed?

Application need?
Not yet addressed in literature
More AI than graphics
Other senses?

- Hearing?
- Smell?

Model sensors & signal propagation

Spatial occupancy approach?

Applications?
Memory

What is recorded about the environment

Spatial occupancy

Transience of objects: time-stamps

hierarchy: short-term, long-term
Spatial Occupancy

transiency

doorway

wall
# Aggregate Behavior: E pluribus unum

Emergent Behavior

## Typical qualities

<table>
<thead>
<tr>
<th>Type</th>
<th>Elements</th>
<th>Physics Env/Others</th>
<th>Intelligence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particles</td>
<td>$10^2-10^4$</td>
<td>Much/none</td>
<td>None</td>
</tr>
<tr>
<td>Flocking</td>
<td>$10^1-10^3$</td>
<td>Some/some</td>
<td>Limited</td>
</tr>
<tr>
<td>Crowds</td>
<td>$10^1-10^2$</td>
<td>Little/much</td>
<td>Little-much</td>
</tr>
</tbody>
</table>
Primitive Behavior - Flocking

Local control – for realism, the flock member only reacts to locally accessible information

Perception – FOV vision – angle can change with speed

Interacting with other members – stay with friends, avoid bumping into each other

Interacting with the environment – collision avoidance is primary
Primitive Behavior - Flocking

Original work by Craig Reynolds

Global control – need control of flock
script flock leader
global migratory urge

Negotiating the motion

Collision avoidance – steer to avoid

Splitting and rejoining – difficult to tune parameters

Modeling flight – e.g., banking into turns
Negotiating the Motion

Forces
Or
“Reasoning”
(e.g. rule-based)
Navigating Obstacles

Problems with repulsive forces
Navigating using bounding sphere
Navigating

Testing for being on a collision path with (bounding) sphere

Given: P, V, C, r

\[ k = (C - P) \cdot \frac{V}{|V|} \]
\[ s = |C - P| \]
\[ t = \sqrt{s^2 - k^2} \]
\[ t < r \]
Finding closest non-colliding point

Calculate $s, t$

$$k = \sqrt{|C - P|^2 - r^2}$$
$$r^2 = s^2 + t^2$$
$$k^2 = s^2 + (|C - P| - t)^2$$
$$k^2 = r^2 - t^2 + |C - P|^2 - 2|C - P|t + t^2$$
$$t = \frac{k^2 - r^2 - |C - P|^2}{-2|C - P|}$$
$$s = \sqrt{r^2 - t^2}$$

$$U = \frac{C - P}{|C - P|}$$
$$W = \frac{(U \times V) \times U}{|(U \times V) \times U|}$$
$$B = P + (|C - P| - t)U + sW$$
Navigating - finding a pass

To avoid collision: find closest point on edge to pass object

Vision Options:
Render in z-buffer
Sample environments with rays
Modeling Flight - common in flocking
Modeling Flight

- Lift
- Thrust
- Gravity
- Drag
Modeling Flight

Relative wind \rightarrow \text{Angle of attack} \rightarrow \text{Lift} \rightarrow \text{Drag}
Modeling Flight

Lift

Gravity

Vertical lift

Horizontal lift

Gravity

Lift
Primitive Behavior - Prey-Predator

unbalanced abilities
  vision - distance, movement, fov
  maximum velocity
  maximum acceleration
  maximum angular velocity
  maximum angular acceleration
Prey-Predator - vision
Prey-Predator

agility: speed and turning
Prey-Predator - hidden by forces

Using pure forces
May not prevent object penetration
Prey can be ‘hidden’ by environmental repulsive forces
Intelligent Behavior

Autonomous behavior
   ‘Self-animated’ characters
   Perception & reasoning about environment
   Personality, emotions, dispositions

Manifestations of Individuality
   Body Expressions and Gestures
   Facial expressions
   Speech
Internal State

Models what the agent needs to do

Suggested precedence classes of internal state variables

Imperatives
Desires
Suggestions
Levels of Behavior

Hooks for the animator to impose control

Arbitration among competing intentions
Expressions and Gestures

ToBI – Tones and Break Indices
LMA – Laban Movement Analysis

BEAT
EMOTE
RUTH
Greta
EMOTE

N. Badler at U.Penn

Expressive MOTion Engine (EMOTE)

Speech driven movement and gestures
Torso & arms
Laban Movement Analysis
  Effort
  Shape
J. Cassell at M.I.T.

Input text – marked up

Generate non-verbal behavior in sync with speech

Facial expressions, head & body motions gestures
ruth

Doug DeCalro at Rutgers

http://www.cs.rutgers.edu/~village/ruth/
Facial Expression

http://expression.sourceforge.net/
Facial Expression

Ken Perlin: http://mrl.nyu.edu/~perlin/
SmartBody

https://www.youtube.com/watch?v=sD7Q777wIaQ

More videos: https://smartbody.ict.usc.edu/video
Modeling Personality

Personality – long term qualities

Emotions – short term

Mood – third level

Basic emotions: happy, sad, fear, disgust, surprise, anger
Personality Models

Biology/evolutionary approaches
  brain & anatomy
  biochemistry & personality
  genetics & personality

Psychoanalytic approach
  psychometrics
  Freud, Adler, Jung

Adaptation Theory:
  traits: passive, aggressive, withdrawn

Need theory: Freud + experiential learning

Arousal Theory: absorb & discharge energy
Type & Trait Theory

Type: individuals slotted into a type
e.g. introvert v. extrovert

Trait: lie on gradation
combination defines behavior in situation
e.g.,

Internal states: how perceptions dictate emotional experience
Trait Theory

OCEAN: openness, conscientiousness, extroversion, agreeableness, neuroticism

PEN: extraversion, neuroticism, psychoticism

OCC: how perceptions dictate emotional experience
Modeling Individuality

Improv
AlphaWolf
Dominant personality

Simulation of a pack of wolves and their behavior
Crowd Management

Emergent behavior
Statistical behavior v. believable individual behaviors
Homogeneous activity v. Internal structure

For evaluation
    Pedestrian traffic simulation
    Traffic flow
    Emergency response modeling

For entertainment
    Background crowds
Crowds

Emergent behavior:
  similar to flocking
  collision avoidance
  ‘intelligent’ paths
From a distance: statistical behavior
  nonsensical detailed motion
  reasonable visual effect
Internal structure
  limited interaction among members
  group formation
Crowd Applications

For evaluation
- Building evacuation, e.g. virtual fire drill
- Architecture evaluation, e.g. signage

For training
- Military scenarios, e.g. sniper training
- Emergency response, e.g. disaster response

For entertainment: e.g., background crowds
- games
- films, e.g., Titanic, Saving Private Ryan, Lord of the Rings
Qualities of crowd

Emergent behavior - similar to flocking, flocking system
Uniform – sameness of members
Quantity & density - average distance between members
Viewing distance – aggregate behavior, inspect individuals
Function – simple traversal, background activity, main actions

Individual processing – amount of computation per member
Physics – simulated reaction to environment
Intelligence - reasoning capability - agents
Uniformity, granularity

Background noise:
Activity without intention

Statistical behavior:
On average, intentional activity

Individuality:
Believable activity at level of individual
Execution environment

Real-time v. Off-line computation

simple computations

avoid n-squared algorithms

size limited
Spatial organization

Cellular decomposition:
- Regular 2D grid
- Adjacency accessible
- Density limited
- Cells define obstructions

Continuous space:
- Step in any direction
- Need to decipher obstructions
- Perception needed
Perception Modeling

Vision

Memory

Knowledge of environment
Navigation

Fluid flow:
  density fields, potential functions

Particle systems:
  Individual navigation

Flocking systems:
  individual perception, navigation

Rule-based

Cognitive modeling

Cellular automata
Panic & Congestion handling

Personal space

Packing people during evacuation

Stairwell traversal

Exit awareness
Motion & Navigation

Path planning

Roadmaps

Passing on pathways

Potential fields

Forming & maintaining subgroups
Structure in crowds

Homogenous – no individuality

Subgroups
Group by belief systems

A collection of Individuals – personality modeling
Other topics

Heterogeneous – pedestrians and cars

Data driven crowds – image processing

Comparison to real-world situations
Massive
http://www.massivesoftware.com/  Commercial de facto standard
Examples
Examples

A Decision Network Framework for the Behavioral Animation of Virtual Humans

Qinxin Yu
Demetri Terzopoulos
Examples