Computer Animation
Algorithms and Techniques

Behavioral Animation:
Knowing the environment
Flocking
Behavioral Animation

Knowing the environment

Aggregate behavior

Primitive behavior

Intelligent behavior

Crowd management
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

Use surrogate bounding volumes

Z-buffer
use object IDs as color

Rick Parent

Computer Animation
Target-testing vision

Can I see X?
Cast ray

Sample object

Use surrogate bounding volumes

Rick Parent

Computer Animation
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

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

Attempt at parallel movement:

Attempt to fly directly toward a surface

Attempt at finding a passageway
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

Vision Options:
Render in z-buffer
Sample environments with rays

Rick Parent
Modeling Flight – common in flocking
Modeling Flight
Modeling Flight

Relative wind → Angle of attack → Lift → Drag
Modeling Flight

Lift

Gravity

Vertical lift

Lift

Horizontal lift

Gravity
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