The Quest for Real-Time Virtual Human Control

Jan M. Allbeck
Norman I. Badler
Center for Human Modeling and Simulation (HMS)

- University of Pennsylvania
- Becoming SIG Center for Computer Graphics
- Director is Norman I. Badler
- Associate Director is Jan M. Allbeck
- Claim to fame is Jack.
### Comparative Virtual Humans

| **Appearance** | 2D drawings > 3D wireframe > 3D polyhedra > curved surfaces > freeform deformations > accurate surfaces > muscles, fat > biomechanics > clothing, equipment > physiological effects (perspiration, irritation, injury) |
| **Function**   | cartoon > jointed skeleton > joint limits > strength limits > fatigue > hazards > injury > skills > effects of loads and stressors > psychological models > cognitive models > roles > teaming |
| **Time**       | off-line animation > interactive manipulation > real-time motion playback > parameterized motion synthesis > multiple agents > crowds > coordinated teams (time to create movement at the next frame) |
| **Autonomy**   | drawing > scripting > interacting > reacting > making decisions > communicating > intending > taking initiative > leading |
| **Individuality** | generic character > hand-crafted character > cultural distinctions > sex and age > personality > psychological-physiological profiles > specific individual |
Appearance
Functionality

- Robust walking and reaching are required by a lot of scenarios.
- Expressivity builds life.
Locomotion

• Evolving model based on a combination of kinematic simulation of leg motions plus motion capture data on pelvis motion.
• Combined for procedural locomotion on uneven or moving terrain.
• Can combine with carrying and pushing.
Real-Time Upper Torso & Arm Reach (Zhao et al., SAE 2005)

- Interactive wrist reach goal.
- Real-time collision avoidance
- Use available strength to mediate arm poses.
- Multi-joint dependencies.
- Torso motion from empirical data (Delleman/TNO).
- Benefits from spatial subdivision and guidance.
Better Movements: Motion Qualities “Orthogonal” to Gesture Choice

- A “lively / reluctant” wave
- A “warm / cool” welcome [handshake]
- A “threatening / friendly” gesture
- Pick up the broken glass “carefully”
- A “smashing” blow

Need to construct an intermediate representation between motion and “meaningful” states.
EMOTE Motion Quality Model (Chi et al., SIGGRAPH 2000)

• EMOTE: A real-time motion quality model.
• Based on Effort and Shape components of Laban Movement Analysis.
• Defines movement qualities with 8 parameters.
• Controls numerous lower level parameters of an articulated figure.
• May be used to promote individuality.
Effort Motion Factors

Four factors range from an *indulging* extreme to a *fighting* extreme:

<table>
<thead>
<tr>
<th>Factor</th>
<th>Indulging (Indirect)</th>
<th>Fighting (Direct)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Space</td>
<td>Indirect</td>
<td>Direct</td>
</tr>
<tr>
<td>Weight</td>
<td>Light</td>
<td>Strong</td>
</tr>
<tr>
<td>Time</td>
<td>Sustained</td>
<td>Sudden</td>
</tr>
<tr>
<td>Flow</td>
<td>Free</td>
<td>Bound</td>
</tr>
</tbody>
</table>
Manner Variants (adverbs): HIT

Hit the ball

... softly.

... forcefully.
Autonomy

• What base functionality can be built on?
• Makes virtual humans easier to instruct.
• Trade off between autonomy and control.
Autonomy: Scripting for Complex Tasks

WalkFromSit, SitFromWalk, Reach, Carry2Hands, push, attach (camera), ...
Following Instructions: A human capability

1. Rotate the handle at the base of the unit.
2. Disconnect the 4 bottom electric connectors.
3. Disconnect the 5 top electric connectors.
4. Disconnect the 2 coolant lines.
5. Unbolt the 8 bolts retaining the power supply to the airframe and support it accordingly, and remove it.
Executing Maintenance Instructions

Actual instructions translated into PARs, which then control actions.

Eye view (Note attention Control)
Some movements may greatly increase realism, but shouldn’t require explicit controls.
Eye Movements Modeled from Human Performance Data

Source

Eyes fixed ahead

Eyes moved by statistical model

Full MPEG-4 face
Visual Attention Model (Gu et al., IVA ’06)

- Model multiple influences:
  - imperfect cognition
  - interaction behaviors
  - internal agent state
  - engagement level
  - social context
  - environmental distractions
Gaze and Gesture Application

- American Sign Language synthesis
- “Classifier Predicates”: Basically gestural movements that relate to a virtual space around the signer situating the participants in the discourse, or show the actual movement path of a verb by spatial analogy.
And then there were many...
Crowds

Mobs

- Aggressive
  - Lynchings
  - Bourbon
  - Proletariat

- Terrorizations

- Escape

- Acquisitive
  - Panics in unorganized crowds

- Espressive
  - Panics in organized crowds

Audiences

- Casual
- Intentional

- Recreational
- Information-seeking

Brown (1954)
Mass Phenomena
## Comparative Virtual Crowds

<table>
<thead>
<tr>
<th>Appearance</th>
<th>Variety</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Function</strong></td>
<td>Variety of behaviors and movements</td>
</tr>
<tr>
<td><strong>Time</strong></td>
<td>How many characters can be simulated</td>
</tr>
<tr>
<td><strong>Autonomy</strong></td>
<td>Coordination, cooperation, and competition</td>
</tr>
<tr>
<td><strong>Individuality</strong></td>
<td>Individuals, groups, and mass phenomena that evolves</td>
</tr>
</tbody>
</table>
Multi-Agent Communication for Evacuation Simulation (MACES)

- **Wayfinding** to explore unfamiliar building to find exits.
- Inter-agent **communication** to share partial mental maps.
- Roles for individual agents:
  - **Trained leaders**: complete knowledge of the structure.
  - **Untrained leaders**: sparse knowledge. Help others and search the environment to construct their mental maps.
  - **Untrained followers**: dependent people who cannot make own decisions; when they see some other agent they follow it.
MACES: Results (Pelechano, IEEE CG&A 2006)

- Significant improvements in evacuation rates with inter-agent communication.

- Only a small percentage (~10%) of trained (knowledgeable) leaders yield evacuation rates comparable to the case where everyone is trained.
High Density Crowd Simulation (HiDAC); (Pelechano et al., SCA 2007)

- Simulate individual and group psychosocial parameters.
Durupinar, et al. Crowds with Personality (AAMAS 2008)

- Openness
- Conscientiousness
- Extroversion
- Agreeable
- Neuroticism
Conclusions?

• Greater minimum investment
• Higher expectations
• Adding cognition to animation still implies animation
• Control vs. Autonomy
• Application focused
• Ease of creation and modification (adaptability)
• Mass Phenomena
• Data driven
Thank you!
http://hms.upenn.edu

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