The Quest for Real-Time Virtual Human Control

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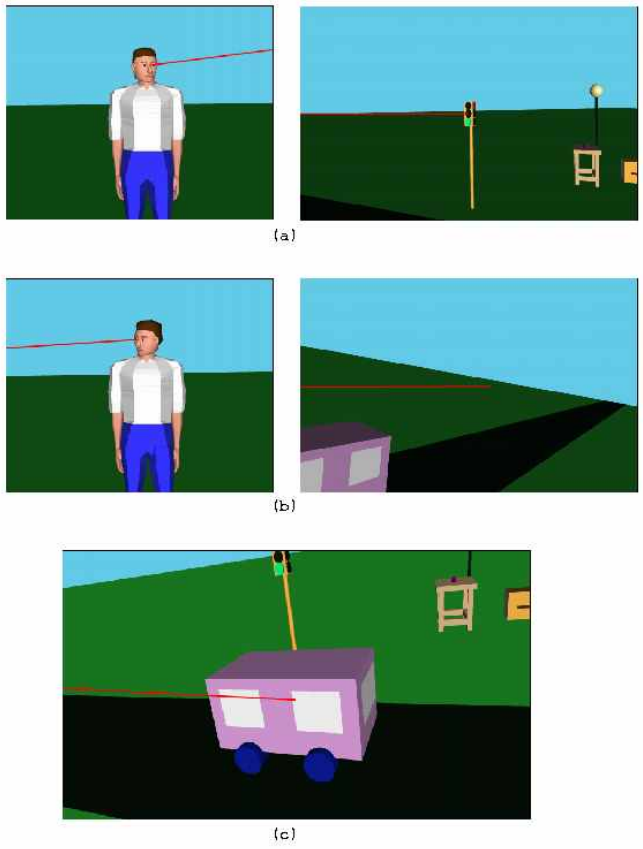
Center for Human Modeling and Simulation (HMS)

- 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

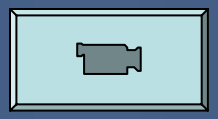


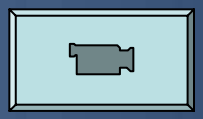
Functionality

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

Locomotion

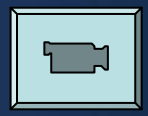
- Evolving model based on a combination of kinematic simulation of leg motions plus motion capture data on pelvis motion.
- Combined for procedural locomotion on uneven or moving terrain.
- Can combine with carrying and pushing.





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:

Space: Indirect ---------- Direct
Weight: Light ---------- Strong
Time: Sustained ---------- Sudden
Flow: Free ---------- Bound

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.

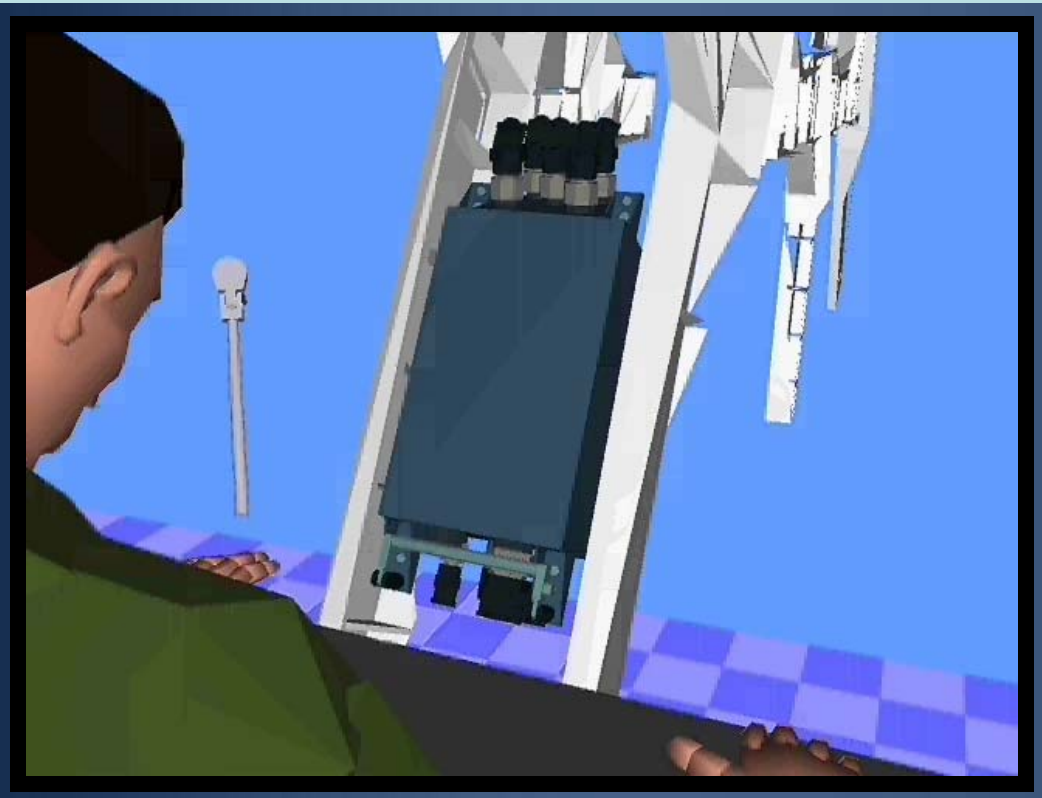
Autonomy: Scripting for Complex Tasks

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



Eye view (Note attention Control)

Actual instructions translated into PARs, which then control actions.

Some movements may greatly increase realism, but shouldn't require explicit controls.

Eye Movements Modeled from Human Performance Data

Source

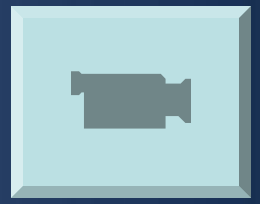
Eyes fixed ahead

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



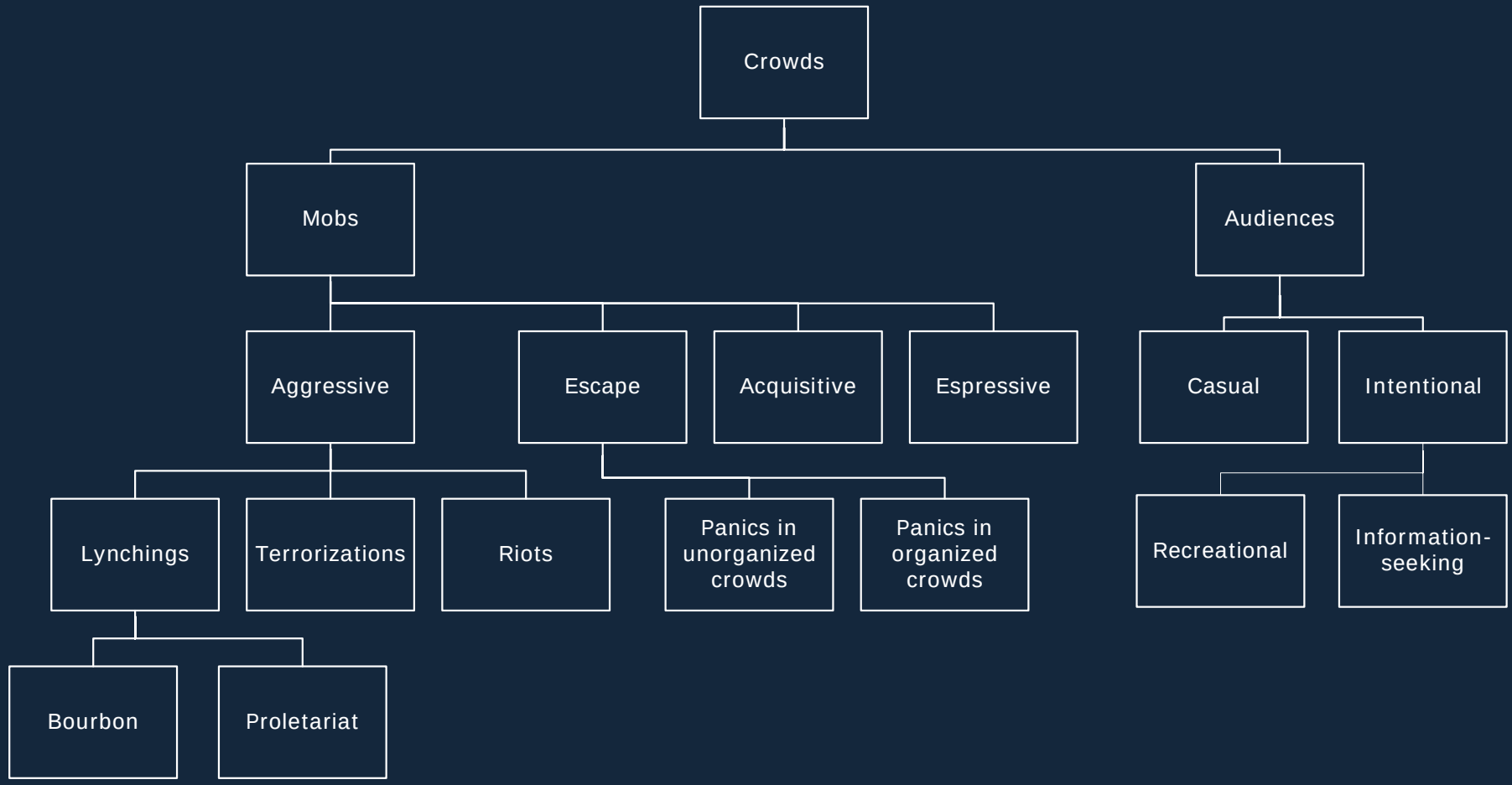
Reactivity

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.

Time

And then there were many…



Brown (1954)
Mass Phenomena

Comparative Virtual Crowds

Appearance	Variety
Function	Variety of behaviors and movements
Time	*How many characters can be simulated*
Autonomy	*Coordination, cooperation, and competition*
Individuality	*Individuals, groups, and mass phenomena that evolves*

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.

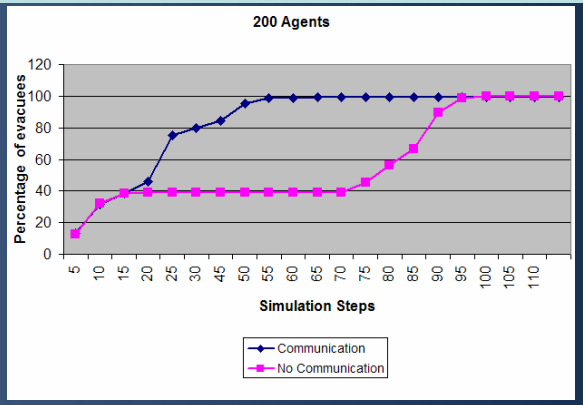
 ***100% Untrained followers***

 ***100% Untrained leaders***

 ***10% Trained leaders***

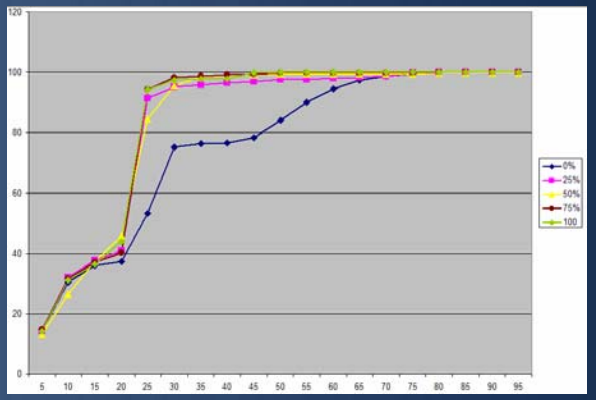
MACES: Results (Pelechano, IEEE CG&A 2006)

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



Evacuation time for 200 agents with and without communication.

- Only a small percentage (~10%) of trained (knowledgeable) leaders yield evacuation rates comparable to the case where everyone is trained.



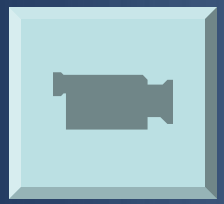
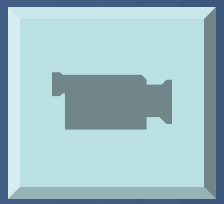
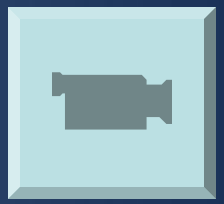
Evacuation time for 0, 25, 50, 75 and 100% leadership.

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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