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Tangible Virtual Humans: Meet your New Role-players

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Tangible Virtual Humans: Meet Your New Role-players

Amela Sadagic, Ph.D.
MOVES Research Associate Professor
Larger ONR Project Team
(Project: “3D Display and Capture of Humans for Live-Virtual Training”)

- **University of Central Florida (IST & CS)**
  - Dr. Greg Welch (Project PI)
  - Dr. Charlie Hughes (Co-PI)
  - Dr. Nagendran, Dr. Tappen, Dr. Pattanaik, students

- **Naval Postgraduate School (MOVES)**
  - Dr. Amela Sadagic (Co-PI)
  - MOVES Visualization team
  - Charles Kinzer, Noah Lloyd-Edelman, student interns

- **University of North Carolina at Chapel Hill (CS)**
  - Dr. Henry Fuchs (Co-PI)
  - (Dr. Greg Welch, PI)
  - Dr. Ilie, Andrei State, students
Outline

- Why Do We Need Virtual Humans?
- Different Display Technologies
- Research Questions
- Past and Current Studies
- Student Thesis Opportunities
- Upcoming Studies
- Q & A
A Quest for More
Realistic Virtual Humans

MASSIVE, early & mid 1990s

DIVE, late 1990s

National Tele-immersion Initiative, 1997-2000

BASE-IT, 2008-2011

Tangible Virtual Humans, 2010 - 2012
Projective Displays: Rear Projection Head

Performing ophthalmic exam on a Physical-Virtual Patient

UCF: Greg Welch (PI) and Juan Cendan
UF: Benjamin Lok and Diego Rivera-Gutierrez
UNC-Chapel Hill: M. Whitton Dr. D. A. Chesnutt, Prof. H. Fuchs, P. Lincoln, R. Skarbez
Projective Displays: Shader-Lamp Approach

In these demonstrations, the inhabiter is encumbered only by a head tracker.
Animatronic Characters
2D ‘Flat’ Projections In Military Training
A Problem Domain

• **Trends observed in IIT:**
  - Physical world has a priority. ‘Images’ on the wall get less attention
  - Extremely difficult to recognizing where a virtual human projected on the wall is looking

• **Research Questions:**
  - Is 3D virtual human more effective than 2D virtual human?
  - Are 3D virtual humans (physical-virtual) acceptable replacement for the real humans?
Static & Dynamic Events

Specific issues:
• Determine ability of human visual perceptual system in evaluating eye-gaze direction for all conditions
• Subjective responses: how realistic, confortable, easy to guess, task accord, feeling ‘together’ with vir. hum.

Study of Static Events:
• Single 5 sec long eye-gaze event

Study of Dynamic Events:
• A simple eye-gazing scenario with 2 or 3 ‘connected’ static events (the eye transitions smoothly from one direction to the other one)
Front & Back View

25 visual targets

3 observer's positions
Experimental Design

- # of subjects (within-subjects design): 42
- # of conditions: 3 (2D, 3D shared-lamp, human - HA)
- # of positions for each condition: 3
- # of gaze estimates from one position: 15 (12 + 3 replications)
- # of real targets & simulated positions: 22
- # of target decoys: 3
- # of visual targets evaluated in each condition in Static Events: 1890
- # of visual targets evaluated in each condition in Dynamic Events: 588
## Static Events: Number of Exact Matches

<table>
<thead>
<tr>
<th>Condition:</th>
<th>2D</th>
<th>3D</th>
<th>HA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Observations&lt;sup&gt;1&lt;/sup&gt;</td>
<td>1890</td>
<td>1890</td>
<td>1890</td>
</tr>
<tr>
<td>Number Exact Matches, 1&lt;sup&gt;st&lt;/sup&gt; Guess Only</td>
<td>176</td>
<td>446</td>
<td>944</td>
</tr>
<tr>
<td>Percent Exact Matches, 1&lt;sup&gt;st&lt;/sup&gt; Guess Only</td>
<td>9.3%</td>
<td>23.6%</td>
<td>49.9%</td>
</tr>
<tr>
<td>Ratio</td>
<td>1</td>
<td>2.5</td>
<td>5.4</td>
</tr>
<tr>
<td>Number Exact Matches, 2&lt;sup&gt;nd&lt;/sup&gt; Guess Only</td>
<td>20</td>
<td>62</td>
<td>44</td>
</tr>
<tr>
<td>Percent Exact Matches, 2&lt;sup&gt;nd&lt;/sup&gt; Guess Only</td>
<td>1.1%</td>
<td>3.3%</td>
<td>2.3%</td>
</tr>
<tr>
<td>Number Exact Matches, 1&lt;sup&gt;st&lt;/sup&gt; or 2&lt;sup&gt;nd&lt;/sup&gt; Guess</td>
<td>196</td>
<td>508</td>
<td>988</td>
</tr>
<tr>
<td>Percent Exact Matches, 1&lt;sup&gt;st&lt;/sup&gt; or 2&lt;sup&gt;nd&lt;/sup&gt; Guess</td>
<td>10.4%</td>
<td>25.4%</td>
<td>52.3%</td>
</tr>
<tr>
<td>Ratio</td>
<td>1</td>
<td>2.6</td>
<td>5</td>
</tr>
</tbody>
</table>

<sup>1</sup>Observers x Targets x Observer Positions = 378 x 15 x 3 = 1890
Static Events:
Average Yaw Angle by Condition

- All measures are in degrees

<table>
<thead>
<tr>
<th>Condition:</th>
<th>2D</th>
<th>3D</th>
<th>HA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Observations(^1)</td>
<td>1890</td>
<td>1890</td>
<td>1890</td>
</tr>
<tr>
<td>Average Yaw Error 1(^{st}) Guess Only</td>
<td>12.77</td>
<td>7.52</td>
<td>3.52</td>
</tr>
<tr>
<td>Ratio</td>
<td>3.6</td>
<td>2.1</td>
<td>1</td>
</tr>
<tr>
<td>StDev Yaw Error 1(^{st}) Guess Only</td>
<td>4.80</td>
<td>4.45</td>
<td>2.21</td>
</tr>
<tr>
<td>Average Yaw Error 2(^{nd}) Guess Only</td>
<td>8.32</td>
<td>5.47</td>
<td>6.16</td>
</tr>
<tr>
<td>StDev Yaw Error 2(^{nd}) Guess Only</td>
<td>5.21</td>
<td>3.65</td>
<td>5.88</td>
</tr>
<tr>
<td>Average Yaw Error 1(^{st}) and 2(^{nd}) Guess</td>
<td>12.67</td>
<td>7.47</td>
<td>3.63</td>
</tr>
<tr>
<td>StDev Yaw Error 1(^{st}) and 2(^{nd}) Guess</td>
<td>4.76</td>
<td>4.44</td>
<td>2.28</td>
</tr>
</tbody>
</table>

Second guess (which occurs 10% of the time) has negligible effect on Yaw error estimates.
Static Events:
Average Pitch Angle by Condition

- All measures are in degrees

<table>
<thead>
<tr>
<th>Condition:</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Total Observations(^1)</td>
<td>1890</td>
<td>1890</td>
<td>1890</td>
</tr>
<tr>
<td>Average Pitch Error 1(^{st}) Guess Only</td>
<td>9.84</td>
<td>6.54</td>
<td>2.82</td>
</tr>
<tr>
<td>Ratio</td>
<td>3.5</td>
<td>2.3</td>
<td>1</td>
</tr>
<tr>
<td>StDev Pitch Error 1(^{st}) Guess Only</td>
<td>4.07</td>
<td>3.32</td>
<td>2.09</td>
</tr>
<tr>
<td>Average Pitch Error 2(^{nd}) Guess Only</td>
<td>6.39</td>
<td>4.60</td>
<td>3.90</td>
</tr>
<tr>
<td>StDev Pitch Error 2(^{nd}) Guess Only</td>
<td>4.91</td>
<td>3.91</td>
<td>5.14</td>
</tr>
<tr>
<td>Average Pitch Error 1(^{st}) and 2(^{nd}) Guess</td>
<td>9.78</td>
<td>6.50</td>
<td>2.84</td>
</tr>
<tr>
<td>StDev Pitch Error 1(^{st}) and 2(^{nd}) Guess</td>
<td>4.11</td>
<td>3.39</td>
<td>2.06</td>
</tr>
</tbody>
</table>
### Static Events: Subjective Data

<table>
<thead>
<tr>
<th>Condition</th>
<th>2D</th>
<th>3D</th>
<th>HA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feeling comfortable during the session</td>
<td>5.857</td>
<td>5.714</td>
<td>6.095</td>
</tr>
<tr>
<td>Realism of the representation</td>
<td>4.381</td>
<td>5.262</td>
<td>n/a</td>
</tr>
<tr>
<td>How easy was to guess visual targets?</td>
<td>3.381</td>
<td>3.786</td>
<td>4.786</td>
</tr>
<tr>
<td>How successful they thought they were?</td>
<td>3.405</td>
<td>3.738</td>
<td>4.714</td>
</tr>
<tr>
<td>Feeling as if individual is together with them?</td>
<td>2.976</td>
<td>3.810</td>
<td>5.5</td>
</tr>
<tr>
<td>Feeling as those were computer generated images or a real person</td>
<td>3.452</td>
<td>4.262</td>
<td>6.4</td>
</tr>
<tr>
<td>Feeling as if observed</td>
<td>2.667</td>
<td>3.762</td>
<td>4.452</td>
</tr>
</tbody>
</table>

All average values, Linkert scale 1-7 (1 = lowest, 7 = highest)

Social Avoidance and Distress (SAD test): found no correlation with the results
Static Events: Conclusions

• Highly **significant improvement** in observer judgment regarding eye gaze direction for the **3D condition over the 2D condition** and for the HA condition over the 3D condition.

• A rough rule of thumb: **2x** improvement of 3D over 2D, and a **2x** improvement of HA over 3D.

• Except for issues regarding the spatial distribution of targets, there does not appear to be any significant biases in the experiment.

• None of the demographic factors (e.g. sex, eye height, age, eye glass usage) and observer positions showed any significant effects on observer performance.
Static Events:
“Mona Lisa is Always Looking at You”
Static Events:
“Mona Lisa is Always Looking at You”

If the iris is in or around the center of the eyes, the observer has impression as if 2D virtual human looks at him/her regardless of the position from which the image is observed.

⇒ 1st time it has been proven and quantified in an empirical study!

Box Plot of Delta Yaw of First Choice and Actual Target grouped by Observer (Subject) Position
User Study Data STACKED 03-29-2011 CK Gold 43v*5671c
Include condition: v14=9 OR v14=10 OR v14=5 OR v14=13

Delta Yaw of First Choice and Actual Target: F(2,1244) = 314.3869, p = 0.0000
Connecting Results with Realistic Training Scenario

Room clearing scenario + ‘flat’ virtual humans

= Asking the Marines to conduct an impossible task (as far as the capabilities of human visual perceptual system are concerned)
Great painters did not have a special technique when they made the portraits whose eyes always ‘followed’ you – they simply (perhaps unknowingly) exploited inability of human visual perceptual system to discern eye-gaze direction from the ‘flat’ images.

Apologies to all big portrait artists… but your work is still remarkable!

Possible cause of phenomena: A lack of binocular depth cues
Dynamic Events: Number of Exact Matches

<table>
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<th>HA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Observations Reported</td>
<td>559</td>
<td>566</td>
<td>573</td>
</tr>
<tr>
<td>Number of Exact Matches</td>
<td>101</td>
<td>124</td>
<td>279</td>
</tr>
<tr>
<td>Percent of Exact Matches</td>
<td>18.1%</td>
<td>21.9%</td>
<td>48.7%</td>
</tr>
<tr>
<td><strong>Ratio</strong></td>
<td>1</td>
<td>1.2</td>
<td>2.7</td>
</tr>
</tbody>
</table>

Comparison with results in Static Events

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Dynamic Events: Conclusions

• Dynamic tests show exact match results which are very similar to static tests except 2D dynamic is considerably better than 2D static
  • One hypothesis: connected events (a scenario = better context) may have positively influenced subjects’ performance.

• When portion reported OUT is used as metric 3D performance over 2D was almost a factor of 2
  • Shows a significant performance gain of 3D over 2D in the dynamic experiments.
Upcoming Studies

- Studies that introduce audio, animation of human face with micro-shifts of the head musculature (multi-posture mannequin)
Upcoming Studies

- Multi-posture virtual humans (mannequins)
- Work with Ryan Schubert (Sadagic a member of his PhD committee)
  - Optimal surface determination for multiple postures and synthetic animatronics
New Conditions and Situations to Be Studied

- **Stereoscopic Displays**: Add an additional condition – 3D active stereo – to test if a binocular depth cue is a ‘crucial’ ingredient for correct eye-gaze estimation.
- **More complex behaviors**
- **Groups of Avatars**: 2D/’flat’, 3D (stereoscopic) & 3D physical-virtual
Opportunity for Student Thesis: Perceptions, Bias and Acceptance

- Studies on perception, bias, and acceptance: Male vs female virtual humans (2D and 3D), civilian vs military uniform clothing, skin tones.
Tomorrow’s Demo Night

Come & see us in WA-275/285 and 212A Lab
With out Summer student interns Kristina, Juanita & Luana!
Q & A

Come and see our demo