Analyzing the Accuracy of Agent Representations in Crowd Simulations

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Introduction

- A crowd simulation models virtual humans (agents) in order to realistically emulate the behavior of real humans.
- They are used in many different domains from movies to emergency evacuation scenarios (Sagun et al., 2008; Pelechano & McLoone, 2009).
- For example, in emergency evacuation scenarios they attempt to predict the movements of a real crowd if an emergency were to occur (Sagun, 2008).
- Typically, simulations use disks to represent the area of exclusion of an agent.
- The two most common disk representations include:
  - Minimum Disk Representation: A disk that has a diameter equal to an average agent’s shoulder width (50 cm) (van Toll et al., 2021; Wolinski et al., 2016).
  - Maximum Disk Representation: A disk that has a diameter approximately equal to the maximum stride length of the agent (100 cm) (Wolinski, 2016; Weiss et al., 2017).

Materials & Methods

- Analysis was performed on 115 unique characters from the Microsoft Rocketbox Avatar Library (Gonzalez-Franco et al., 2020).
- In order to measure the over- and underestimates, the mesh points making up the agent were projected onto the ground plane (Fig. 3).
- Over- and underestimates were measured by taking the difference between the area of the disc and the area of the convex hull (Fig. 4 and 5).
- Three unique animations including, a slow walk, neutral walk and a run, were analyzed.

Results

- As summarized in Table 2 the greatest underestimate of 25.182cm² was found during the swing phase of the run animation with a disk radius of 25cm.
- The greatest overestimate of 61.328cm² was found during the standing phase of the walk animation with a disk radius 50cm (Table 1).
- The agents with a smaller radius had a higher rate of flow (Fig. 6).

Conclusion & Discussion

- The results confirmed the hypothesis, that disks oversimplify the space that an agent occupies at any given time-step.
- Oversimplification has drawbacks which can affect the results of a realistic simulation resulting in negative consequences.
- For example, in the flow rate analysis, it was shown that disks with a smaller radius have a faster rate of flow which is not reflective of the time it would take for humans to evacuate a building.
- In order to have better representations within simulations, agents should have a tightly bound area of exclusion, preventing them from overlapping with other agents while also allowing for tight packing (Fig. 2).
- While convex hulls present a good representation of the agent, they are costly to compute for each time-step. This prevents the simulation from scaling well.
- Future work includes analyzing other representations of agents in motion including deformable shapes and more efficient convex hulls.

Acknowledgements

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References


Table 1: cm² Difference in Area Between Convex Hull and Max Disk Representation Across Walk Cycles

<table>
<thead>
<tr>
<th>Animation Type</th>
<th>Standing (cm²)</th>
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<th>Disk Radius (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slow Walk</td>
<td>50.019</td>
<td>51.871</td>
<td>64.492</td>
<td>60.883</td>
</tr>
<tr>
<td>Run</td>
<td>49.227</td>
<td>31.739</td>
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Table 2: cm² Difference in Area Between Convex Hull and Min Disk Representation Across Walk Cycles

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<td>25.000</td>
</tr>
<tr>
<td>Run</td>
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<td>25.182</td>
<td>14.298</td>
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Figure 1: Comparison of Disk Representations

Figure 2: Agent-Agent Mesh Overlap (Min Disk Representation)

Figure 3: Illustration of the Space Coverage of A Character's Mesh by Projecting the Mesh Vertices Onto the Ground Plane to Create the Convex Hull.

Figure 4: cm² Difference in Area Between Convex Hull About Mesh Vertices and Max Disk Representation

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Figure 5: cm² Difference in Area Between Convex Hull About Mesh Vertices and Max Disk Representation

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Figure 6: Flow Rate with Left: Max and Right: Min Disk Representations

Figure 7: Flow Rate Test Scenario (Top: Min vs. Bottom: Max Disk)

Figure 8: Error Compounds with Non-Standard Meshes