Human Collision Avoidance in VR
Decoding Humans' Non-Verbal Communication While Walking

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Abstract:

It has been often stated that what makes a human crowd simulation look human is the inclusion of motivations for each individual. We know that humans walk towards goals and avoid obstacles, but how do they do it exactly? We attempt to answer that question by studying what visual signals humans give each other and what they look for when crossing paths. We hypothesize that humans will look and orient their head towards their goal and signal their intentions to others by first looking towards them, and then their goal. This is done by several experiments involving people walking in both real and virtual hallways towards goals as well as navigating around real and virtual people. The subjects' eye gaze, head rotation and body location are recorded to find how people signal their intent while walking. This will allow us to make more convincing and realistic human simulations, more immersive human-AI interactions as well as more accurately predict a human's walking path.

Introduction:

In this study we try to quantify what goes on when two humans speechlessly communicate how to pass each other without conflict. We also try to simulate this with a virtual human and gauge how effective the virtual human's signaling is.. Collision detection and avoidance has already been developed for virtual units, but this movement is not particularly human as it lacks certain visual cues and the ability to communicate with real humans through body language.

In real life humans look at their goals, obstacles and other people. They are never static and do not just look straight ahead. It would be easy to simply make simulated humans look at things randomly but problems arise when real humans must interact with these virtual ones. Immersiveness is incredibility important during virtual reality experiences and this is another opportunity to make those experiences even more life-like.

We hypothesize that humans look at each other to detect if a collision is imminent. They then make eye-contact to signal that they see one another and are ready to avoid collision. After that they will signal their intended direction movement, either left or right in our case, and proceed on that path. There is a tendency for everyone to just pass on the right, which is common culture for the people involved in our experiment, so we make sure to include obstacles and goals that force people to interact.

Related Works:

Previous studies have already shown us that humans tend to assume eye direction displays the intended walking path of another person (1). Even when a human is walking alone they will orient their eyes and head towards their goal (2). We also know that humans will look directly at each other when walking in intersecting paths; this may be to identify possible collisions or to signal to the other person that they have been seen (3).

Tools:

ST-50 HMD: Features retro-reflective balls for tracking and a removable visor so both virtual and real world experiments can be run.

Vicon Tracking System: Made up of twelve infrared cameras with multiple infrared lights as well as servers and tracking software.

AR EyeTracker: An Arrington Research infrared camera and light meant to track the transformation of a subject's pupil. The software allows for calibration and turns the visual information of the shape of the pupil into coordinates of where the subject is looking.

Retro-reflective Tracking Beret: used to track the second human participant in experiments.

Experiment Apparatus: A foam core mock hallway held together with duct tape and covered in black felt to prevent scattered infrared light from interfering with the Vicon tracking system.

Unity: The experiment and program for recording are run in Unity as well as the animation for the virtual human to walk naturally and look at human participants.

Matlab: For data analyzing.

Experiment:

The participants' heads are tracked using the Vicon tracking system. This involves making an "object" out of several retro-reflective balls in a particular signature shape. Twelve cameras shoot infrared light that the balls reflect back; the cameras together turn their two-dimensional views into three-dimensional coordinates for the "object". This object is mounted on the HMD. We then use a server and listener on another computer to feed this information into our simulation in Unity. The HMD is a Nvis ST-50 which either displays the simulation on the screens inside, or the visor is removed and the participant sees only the real world. For tracking the eye, we use an Arrington Research EyeTracker. It is made up of an infrared light and camera pointed towards the eye, and software that gives coordinates for where the eye is looking based off of the shape of the pupil. The simulation in Unity is compiled out of code from other projects, custom written code and free resources from the Unity store. The physical hallway is made to guide the participants when they are not in VR. Unity feeds the head location, rotation and eye tracking data into text files when the simulation is run, and those text files are sent to Matlab for analysis. The eye tracking data must be altered to find out where exactly the view is looking.

Peoples' eyes are calibrated 32cm away from a 64cm screen. The far right of the screen is at a 45 degree angle from their eye. The far right of the view is recorded as "1" and the center is ".5" so we subtract .5 and multiply by 2 to make the center "0", the far right "1" and the far left "-1". The tangent inverse of that is the eye gaze angle because opposite = coordinate * 32cm, adjacent = 32cm.

The Eyetracker was further calibrated to quantify error, particularly to judge if the subject is looking at the other person's face. We calculated an 8 degree "cone of confusion" around any point; if this cone overlaps the other subject's head we assume the first person is staring at the other's face.

Participants walked down the hallway in a variety of conditions; they were instructed to take a turn at the end. A person walking alone was the control while the main experiment involved two agents interacting.

Conclusion:

We replicated the results that in a one person trial, people both look towards their goal and oriented their body towards it, but also found that when another person is added, people put a significant amount of attention on this obstacle. For example, when turning right, but having another person pass them on the left, instead of spending most of their time looking right, at the goal, they spend most of their time looking left, at the obstacle. In addition we found that humans would look directly at each other for a while when far apart, but when they got significantly close they would look away from each other, possible to avoid social awkwardness.

Future Plans:

Either more work needs to be done to lower the error of the current eye tracking procedure or a better eye tracker needs to be used and a large scale experiment needs to be run. After we have deduced what signals real human make by studying them, we would animate a virtual human to mimic these actions and test the effectiveness of various items. We can “omit” some data by putting sunglasses on the model to obscure their eyes, or make them look at a cellphone to obscure both eye and head rotation.

References:

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