Influence of biological motion cues on collision avoidance temporal decision processing

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Skills: C#, Unity (optional)

Context

This master proposal is a joint project with a PhD work about motion perception during collision avoidance task between walkers. The methodological approach considers virtual reality as a main tool to study human behaviour. One of the main task will be to develop new experiments in the existing VR setup. In addition, the candidate will be involved in the management of the experiment as well as the data analysis and interpretation.

Related Work

Biological motion is highly dense with informative cues that perceivers can extract efficiently for processing. Such examples include the ability to identify gender from only point light displays (Kozlowski and Cutting, 1977; Stevenage, et al., 1999), requiring a minimum of 2 seconds or two steps before deciding on a gender (Cutting and Proffitt, 1981). When considering an orthogonal crossing of two walkers, both walkers will answer two fundamental questions, where and when is the crossing of paths likely to occur (Cutting et al 1995). How walkers adapt their trajectory has previously been considered (Basili et al 2013; Huber et al 2014), where Olivier and colleagues (2012;2013), developed a method to pair the interaction and observed a mutual solution between two walkers. It has been argued that biological motion is indeed important for temporal advantages, although not exclusive for successful completion (Meerhoff et al., 2014). Recently Lynch and colleagues (2017) confirmed that biological motion is indeed not necessary for successful collision avoidance. Nevertheless, they reported behavioural differences between global motion cues and local cues, local cues

being more reproducible while global motion cues, in selected appearances required longer observational periods and others producing over adaptation in avoidance behaviour.
An advancement from this latter study by Lynch et al. (2017) would be to consider, as Cutting and Proffitt (1981), whether visual appearance manipulation has an effect on decision processing. This work aims to further develop the understanding of visual cues from body motion, specifically investigating the duration of subjective observation per global and local motion cues. It is hypothesised that local cues will convey additional relevant information for successful collision avoidance than global cues alone and thus require shorter observation periods.

Method

The study should consider a similar experimental setup as Lynch et al. (2017). The visual appearance of obstacles should be consistent with the previous study of Lynch et al. (2017), that is, a full body control, trunk and legs for local cues and a cylinder or sphere as global cues (Figure 1).
The study should be then partitioned into five randomized blocks, for each visual appearance, where obstacles advance from the participant's left or right. Through controlling the distance at which the obstacle moves with constant speed and heading, at the moment the participant can see the obstacle (MPDtsee), we will control the predicted crossing distance and thus the risk of collision (Olivier et al, 2012). Two crossing distances, one [0.3m] with a predicted collision (within 0.5m) and a second distance [0.6m] that doesn't require adaptation, however an adaptation is generally seen. Furthermore, we will control the sign of MPD at MPDtsee, a positive sign indicates the participant will cross first (in front of the obstacle), and a negative sign indicates the participant will cross second (behind the obstacle). Each condition should be repeated a minimal of three times.
The experimental design is then 120 trials (5 visual appearances x 2 crossing directions (left-right), 2 MPDtsee x 2 crossing orders x 3 repetitions).

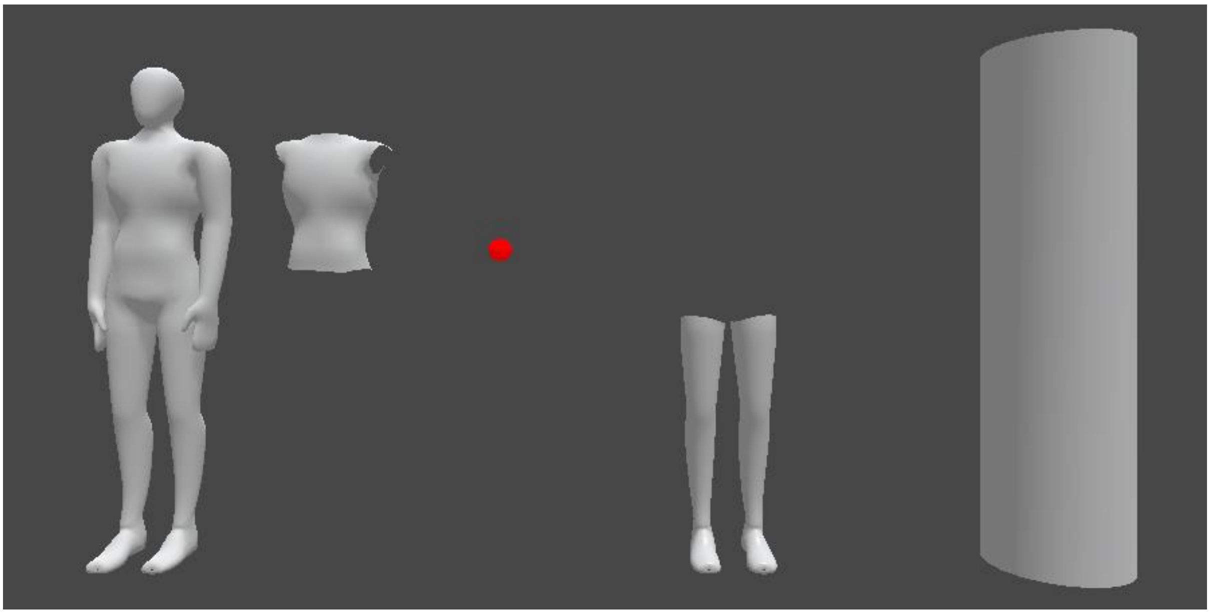

Figure 1: Visual representations, as used by Lynch et al. (2017); from left to right, full body, torso, centre of gravity (sphere), legs, cylinder.

We have chosen 0.3 and 0.6m as the crossing distances due to their previously reported behavioural responses, distances within 0.6m whilst interacting with a robot see changes to original crossing order (Vassallo et al., 2017), whereas distances within virtual reality see this phenomenon more frequently at distances below 0.3m. An alternative experimental set up would use a single crossing distance [0.4m/0.5m] where a collision is reported however changes of crossing order should not be influenced. A single MPD will allow an increment in the number of repetitions.

Task

Participants shall be immersed in a virtual environment, standing at a designated location. During interaction, participants will navigate, in first person perspective, through the virtual environment using a joystick towards a goal (green cylinder). Participants will be informed to avoid collisions with any obstacles that appear on their path, additionally participants will be requested to press a button to indicate when they no longer require to see the virtual obstacle to solve the task. With the button press, the virtual obstacle will disappear and the participant will continue to navigate towards the goal. Participants will be informed that they should continue to avoid any predicted collisions with the virtual walker as if the virtual obstacle was still visible.

The aim of this work will be to determine subjective temporal differences between visual appearances to solve a collision avoidance task. Thereafter, the ability to successfully complete a collision avoidance task with minimal visual cues will be evaluated.

Analysis

Captured data from the experimental set up will include time, user's head orientation and trajectory and virtual obstacle's trajectory, and subjective occlusion cut off indication. Post-processing of the interaction period (from the time the user can see the obstacle to the time when the crossing distance is minimum) will consist of extracting user and obstacle position and velocity data from their respective trajectory, which is further used to calculate a minimal crossing distance, inversions (change of MPD sign) of crossing order, and any collisions. An effect of visual appearance on the dependent variables (crossing distance, inversion rate, collision rate, and occlusion cut off) should be evaluated.

*Note, it can be good practise to indicate the side of approach, the aim is not related with the distribution of side. When participants know the side of approach they can concentrate further on visual cues and the time required for decision making.
*There should include catch trials of a button press by the participant (this data can still be recorded for reaction times).
*Finally, it may be necessary to introduce a limit of observation, where subjects may decide not to press the button for temporal occlusion, thus a limit with automatic occlusion will give an occluded behavioural response.

Alternative hypotheses

In lieu of subjective temporal occlusion or as a benefactor alongside alternative hypotheses that could be considered:

1. The current paradigm is fixed at an orthogonal 90° interaction, dependency of biological motion cues may vary according the angle of approach and thus the

temporal duration of observation can likewise vary. The aim of this work would be to conduct several angles of approach with subjective temporal occlusion functionality.

2. Alternatively, presentation of incongruent motion may be an area of consideration. Presenting biological motion that is imbalanced can indicate an order of processing. For example, a virtual walker with extravagant features such as an increased stride rate while global displacement and arm swing are consistent. Where it may be hypothesised that articulation rate alone is used for prediction, or limb specific information is used, alternatively, limbs and articulation rate are not used and global motion alone is used for prediction.
3. We are aware that global motion alone can be sufficient for effective collision avoidance, however which form of global motion is most representative of biological motion remains unclear. The understanding of the form which global motion takes in daily interactions is a key determinant for larger and future predictive crowd models. For this we propose a study concerning the shape of global motion appearance. In lieu of the preceding study we propose to use elliptical shapes that coincide with stride length and should width. We propose to include a condition of an ellipse to the size of stride length, as stride length covers a large area of while mediolateral width may not be essential. Alternatively, the larger mediolateral width and smaller anterior-posterior stride as per biological form may be more representative of control trials. Additionally, due to its geometric form the elliptical shape can be included to the first study of angle of interaction, the elliptical form presents an ability to perceive variations of orientation.

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