Perceptual Evaluation of Human Animation Timewarping

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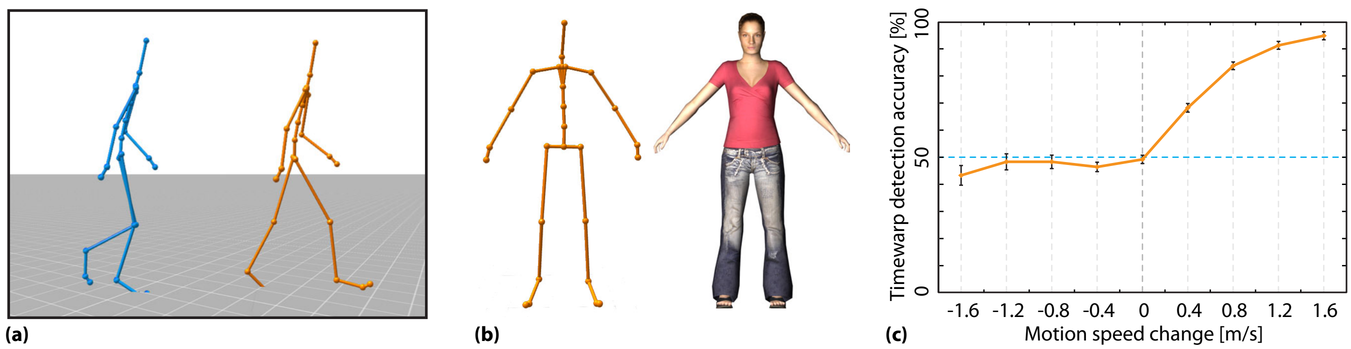

Figure 1: *(a) screenshot from running experiment (side view, stick figure); (b) stick figure and geometrical model used in the study; (c) experiment results in absolute differences in speed of the locomotion, showing that speeding up the motion produces severe perceptual artifacts while event significant slow down is perceptually acceptable.*

Abstract

Understanding the perception of humanoid character motion can provide insights that will enable realism, accuracy, computational cost and data storage space to be optimally balanced. In this sketch we describe a preliminary perceptual evaluation of human motion timewarping, a common editing method for motion capture data. During the experiment, participants were shown pairs of walking motion clips, both timewarped and at their original speed, and asked to identify the real animation. We found a statistically significant difference between speeding up and slowing down, which shows that displaying clips at higher speeds produces obvious artifacts, whereas even significant reductions in speed were perceptually acceptable.

1 Computer Animation and Perception

Computer animation and motion perception are closely related fields, as the result of motion synthesis is always presented to a live observer. In this study, we focus on motion timewarping, a method used in both parametric models and state machines for matching and transitioning between clips of the same type with different timing or speed. Timewarping, and particularly dynamic timewarping, originates in speech recognition and was succesfully used, alongside other signal processing techniques, on animation data (e.g., Bruderlin and Williams [1995]). However the perceptual implications of such manipulations have not been extensively studied and are hard to predict. Our evaluation approach is closely related to the work of Reitsma and Pollard [2003], but we focus on human locomotions rather than generic ballistic motion.

2 Experiment Design

Five motion captured clips of a walking animation served as the stimuli for our experiment. These five animation speeds covered a normal range of human walking, ranging from 0.8 m/s to 2.4 m/s with 0.4 m/s increments. For each clip, we created 4 other versions using timewarping to match the speed of the other clips, leading to a total of 25 clips (e.g., the 1.2 m/s motion was slowed down to 0.8 m/s and speeded up to 1.6, 2.0 and 2.4 m/s). We hypothesised that timewarping would be less noticeable if the timewarped speed is close to the original speed of the clip.

The experiment consisted of sequences depicting two animated characters side-by-side (Figure 1). Both characters (Figure 1b) were either stick figures or geometric models (the model's realism was found to affect perceptual sensitivity to errors in motion [Hodgins et al. 1998]), facing forward or sideways (to test if motion error sensitivity is affected by viewpoint), with each simultaneously displayed pair using the same setup. One character's animation consisted of the original motion, randomly placed on the left or right side of the screen, while the other was timewarped to match its speed. We also tested the real animation against itself as a control case.

Sixty naive participants from the general public (64% male and 36% female) volunteered for this experiment. The instruction sheet indicated that one of the motions was a real captured motion and the other one was synthetically edited. The task was to indicate which of the two animations was the real motion by clicking the left or right mouse button. Each participant completed 100 trials in randomized order (25 motion clips, 2 models, 2 viewpoints).

3 Results

Using a 3-factor repeated measures ANalysis Of VAriance (ANOVA) with factors *model type* (stick or geometric), *viewpoint* (front or side), and *speed* (speed up or slow down), we found a main effect of model type ($F_{1,59} = 8.09, p < 0.007$). Post-hoc analysis using Newman-Keuls comparison of means showed that participants were more sensitive to timewarping on the geometric models than on the stick-figure. This implies that *the effect of timewarping is more noticeable on more realistic characters*, consistent with previous results [Hodgins et al. 1998]. No main effect of viewpoint was found, which implies that *side and front views did not affect sensitivity to timewarping artifacts*.

A main effect of speed was found ($F_{1,59} = 133, p < 0.000001$), where participants were able to notice speeded up motions on average 80% of the time vs. 47% of the time for slowed down animations. These results were consistent across conditions. Since we used a 2AFC (2 alternative forced choice) paradigm, this suggests that participants were simply guessing when they viewed a slowed down animation beside a real one. Therefore, consistent

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with Reitsma and Pollard [2003], *the effect of timewarping is much more noticeable when speeding up motions than when slowing them down*.

In order to investigate the speed factor further, we averaged the accuracy of participants' ratings for each timewarp level (-1.6 to +1.6 m/s with 0.4 m/s steps) and each timewarp ratio (0.33 to 3.0). A single factor repeated measures ANOVA showed a main effect of timewarp level ($F_{8,952} = 104.4, p < 0.00001$). Figure 1c shows that, as expected, performance was at chance (i.e., 50% accuracy) for the real animation compared with itself. Furthermore, for all slowed down animations, performance was also at chance, showing that participants did not prefer the real animations more than even significantly slowed down ones. However, when the animations were speeded up, participants were much more sensitive to the different levels of timewarping – up to almost 100% for a 0.8 m/s animation speeded up to 2.4 m/s. This implies that *significantly slowed down walking animations are perceived as real, whereas even small increments in speed will be noticed*.

The results of our experiments can be expressed as a more general relative timewarping ratio (see Figure 2), which also confirms the previous conclusions.

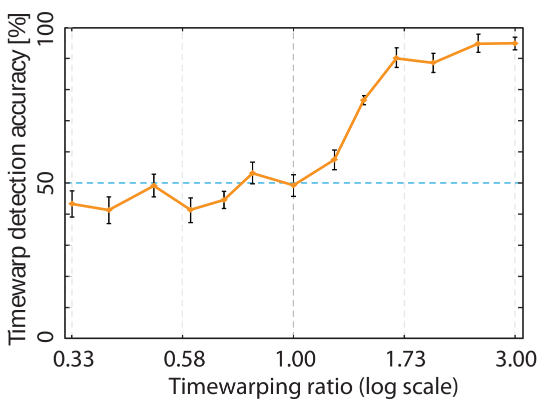

Figure 2: *Expressing the experiment results as a relative timewarping ratio. The stated conclusions, i.e., that the slowed down motions are perceptually more acceptable that speeded up clips, holds for this case as well.*

4 Conclusion

The results of our perceptual experiment have implications for both motion compression and data-driven parametrization models. They suggest that, in motion compression, the underlying databases do not have to contain densely sampled low speed locomotions, as they can be reconstructed from the higher speeds without producing perceptual artifacts. Similarly, the indications are that motion synthesis methods should avoid timewarping a source motion to create a faster movement. Rather, interpolation between slowed down locomotion clips would be preferable to the traditional combination of speeded up and slowed down animations. However, our conclusions are directly applicable to locomotion only and further studies are now needed to confirm and generalize our results.

References

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