Benjamin Niay Anne-Hélène Olivier Julien Pettré Ludovic Hoyet
Inria, Univ Rennes, CNRS, IRISA, M2S

## 1 INTRODUCTION

The realism of Virtual Humans (VH) motions, which populate virtual worlds, is an important requirement for entertaining applications. Controlling VH so that they can walk naturally is therefore particularly important. However, because of individual differences, humans walk with different speeds and styles [1], which is seldom taken into account in current virtual environments. In particular, walking is typically animated by controlling only the desired speed, which itself depends on two main parameters: step length and frequency. The ratio of theses two parameters is called the Walk Ratio [3]. While influenced by individual characteristics such as gender, morphology or age, this ratio has been shown to be an invariant parameter of walking that is naturally adopted by people and minimises energy expenditures. In this pilot study we therefore explore how the naturalness of blended animations is influenced by these two parameters.

## 2 MOTION CAPTURE

We recorded multiple walking motions from 4 actors (2F, 2M) using a Xsens MVN Link. To measure their individual Walk Ratio at different speeds, they first walked at 5 different freely chosen speeds without constraints on step length and frequency, ranging from a very slow to a very fast walk. Then, they walked using 5 different step lengths, from very small to very long steps. For each step length, they were asked to walk at 5 different step frequencies using a metronome (80, 90, 100, 110 and 120 steps per min). This provided 25 different combinations of (step length, frequency) walking motions. Using the Unity Mecanim Animation System, we constructed a 2D Blend Tree for each actor controlling both the speed and frequency of animations, which then generates new walking animations with the corresponding step length for these parameters.

## 3 EXPERIMENT

We selected 1 male and 1 female VH to display the captured motions. They were scaled according to the height of each corresponding actor, as the morphology of the VH would otherwise influence the speed and step length of the displayed motions, and therefore the corresponding Walk Ratio. To evaluate the range of frequencies producing natural walking motions for a given speed, we used an adaptive randomly interleaved staircase design, similar to [2] (step ratio: 0.871; ending condition: 8 reversals). The ascending and descending staircases were initialized at 80spm and 120spm respectively. In each trial, 7 participants were presented with 1 of the 4 VH, walking at either 0.8, 1.0 or 1.2m/s. They were then asked to answer the following question “Is the step frequency of the VH too high or too low for the displayed walk?”, using keys on the keyboard. In total, participants were presented in random interleaved order with 24 staircases: 4 Actors × 3 Walking Speeds × 2 Initializations. VH were displayed using a typical canonical viewpoint, providing as much information as possible about the studied motions (Figure 1).

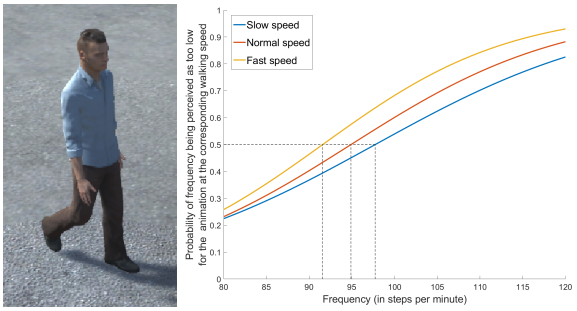


**Figure 1: (Left) Male character used in our experiment. (Right) Psychometric curves across all participant data. Blue, Orange and Yellow lines correspond to the speed of the virtual character (respectively 0.8, 1.0 and 1.2 m/s)**

## 4 RESULTS

We used the Matlab psignifit toolbox to compute the Point of Subjective Equality (PSE, point where participants are equally likely to find the frequency too high or too low), for each Speed × Actor condition and each participant and performed a 2-way Repeated Measure ANOVA (withing subject factors Speed and Actor). Our main hypothesis was that walks at lower speed would be associated with lower acceptable frequencies, as speed linearly increases with step frequency. However, our results did not support that hypothesis, as participants preferred higher step frequencies for slower than fast walks. Therefore, while this pilot study provides valuable insights about whether step length and frequency can influence the perception of virtual walking motions, we think that several aspects need to be further explored to understand their interdependence.

## REFERENCES

[1] Ludovic Hoyet, Kenneth Ryall, Katja Zibrek, Hwangpil Park, Jehee Le, Jessica Hodgins, and Carol O’Sullivan. 2008. Evaluating the Distinctiveness and Attractiveness of Human Motions on Realistic Virtual Bodies. *ACMTOG* 32 (2008), 204:1–204:11.
[2] Thomas Prazak, Ludovic Hoyet, and Carol O’Sullivan. 2011. Perceptual Evaluation of Footskate Clean Up. *ACM Symposium on Computer Animations*, 287–294.
[3] Noboru Sekiya, Hiroshi Nagasaki, Hajime Itoh, and Taketo Furuna. 1996. The invariant relationship between step length and step rate during free walking. *Journal of Human Mouvement Studies* 30 (1996), 241–257.

*ACM SAP 2019, September 19–20, 2019, Barcelona, Spain*
.