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► **To cite this version:**

Benjamin Niay, Anne-Hélène Olivier, Julien Pettré, Ludovic Hoyet. The Influence of Step Length to Step Frequency Ratio on the Perception of Virtual Walking Motions. ACM SIGGRAPH Symposium on Applied Perception, Sep 2019, Barcelone, Spain. hal-02395303

HAL Id: hal-02395303

<https://hal.science/hal-02395303>

Submitted on 5 Dec 2019

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The Influence of Step Length to Step Frequency Ratio on the Perception of Virtual Walking Motions

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Motivations

- More realistic virtual motions are needed in entertaining applications.
- Walk Ratio (WR) = natural and invariant ratio between step length (SL) and step frequency (SF) of an individual.

Objectives

- Investigate the ability of viewers to recognize this natural ratio on virtual characters.
- **Main Hypothesis:** Viewers are able to identify the natural walk ratio of an individual.



Walk Ratio = SL / SF

Left, smaller steps, lower walk ratio.
Right, longer steps, higher walk ratio.



Background

- Humans walk with different speeds and styles [1].
- Biomechanical parameters such as the Walk Ratio [2] associated with walking seldom taken into account in walking animations.
- Walk ratio: constant at different walking speeds, but inter-individual differences exist (e.g. gender differences) [2].

Conclusions

- Viewers are able to identify self-selected step length to step frequency ratio of actors.
- Differences regarding actors' gender seem to exist.
- New insights in the creation of personalized and more realistic walking motions.

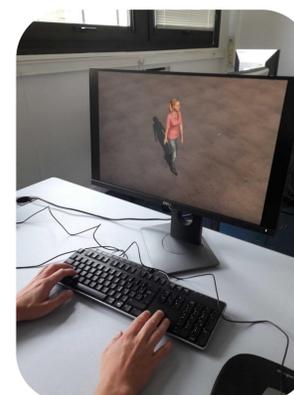
Methods

Stimuli Generation:

- Motion capture (Xsens System)
 - 2 Female actors (1.78 and 1.65m, 26 and 22 years old).
 - 2 Male actors (1.80 and 1.78m, 24 and 20 years old).
- 5 free walks at different speeds captured to compute natural walk ratio.
- 5 walking speeds at 5 different cadences captured (from 80Hz to 120Hz, by 10Hz steps). We blended these motions to generate walking motions at different given speeds and step frequencies.

Perceptual Study:

- 15 Participants (11 Male 4 Female between 18 and 30 years old).
- **Task:** Participants adjusted the step frequency of virtual humans (using the keyboard) until they considered the motion to be the most natural.
- **Factors:** 4 Actors, 3 Speeds (0.8, 1.0, 1.2 m/s), 2 Initializations (min 80, max 120), 4 repetitions. Step frequency was bounded between 80 and 120 steps per min.
- **Data Collected:** Step frequency and Walk Ratio responses.



Results

Actor effect on the estimated walk ratio

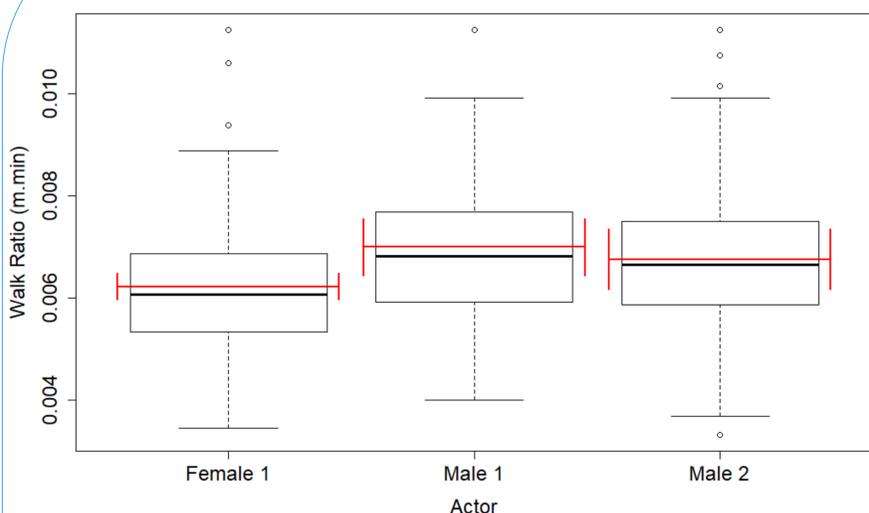
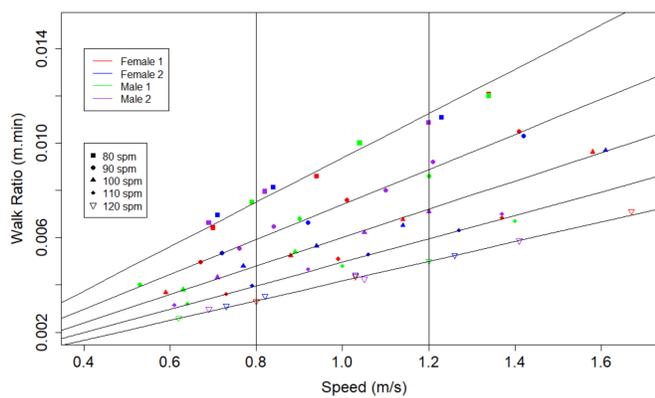


Figure 1: Estimated walk ratio for the different actors. Red plot correspond to the natural captured walk ratios and their corresponding standard deviation.

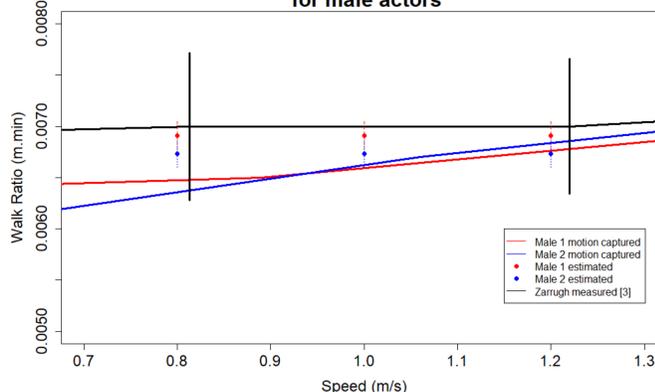
Walk ratios estimated by the participants are not significantly different from the captured walk ratios except for Female 2

Actor	Female 1	Male 1	Male 2
WR Actor	0,00623	0,007	0,00676
WR Estimated	0,00619	0,00691	0,00673
p value	0,5718	0,2209	0,7225
Significantly difference	No	No	No

Stimuli Generation



Speed effect on motion captured and estimated walk ratios for male actors



- Validation of the stimuli presented to the participant in the perceptual experiment.

- For male actors, walk ratios computed from the motion capture (red and blue lines) are in agreement with Zarrugh's findings [3].

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. *ACM TOG* 32 (2008), 204:1-204:11.
- [2] Noburo Sekiya, Hiroshi Nagasaki, Hajime Itoh and Taketo Furuna. 1996. The invariant relationship between step length and step rate during free walking. *Journal of Human Movement Studies* 30 (1996), 241-257
- [3] M.Y. Zarrugh, F.N. Todd and H.J. Ralston. 1974. Optimization of Energy Expenditure during Level Walking. *Europ. J. appl. Physiol.* 33 (1974), 293-206

Acknowledgements

We wish to thank all the participants in our experiments.

This work was funded by the French ANR, as part of the JCJC Per² project ANR-18-CE33-0013.

