Understanding Movement Variability of Simplistic Gestures Using an Inertial Sensor

Miguel Xochicale[1], Chris Baber[1] and Mourad Oussalah[2]; [map479@bham.ac.uk]
[1] School of Electronic, Electrical and Systems Engineering, University of Birmingham, UK
[2] Center for Ubiquitous Computing, University of Oulu, Finland

Problem

Variability is an inherent characteristic of human movement [1]. Generally, humans perform the same action slightly differently trial by trial. For these reasons we are interested in studying methods that can give insight into the variability between individuals and between repetitions of the same movement. Movement variability is presented when users interact with displays [2]. However, we consider that inertial sensors offer both comfortable and unconstrained interaction with displays in order to understand movement variability.

We believe that this preliminary study might provide useful information for activity recognition, e.g. in terms of detecting changes of user's behaviour (enthusiasm, boredom, tiredness or confusion) in the way in which activities are performed over the course of training, practice or rehabilitation.

Materials and Methods

Raw time-series data is collected from a triaxial accelerometer (a_x, a_y, a_z) and a triaxial gyroscope (g_x, g_y, g_z). Then, a N samples length time-series, e.g. a_x, is used to obtain the time-delay embedded matrix, $E\{a_x\}$, with $m = 20$ and $\tau = 6$ [3, 4]. Finally, PCA is applied to $E\{a_x\}$ to compute the percentage of cumulative energy [5]. The method is applied to six simple movements which were performed by six participants wearing an intertial sensor on their right wrist, each movement were continuously repeated for 20 seconds.

Conclusion and Outlook

Although the time-delay embedding technique is subject to different values of embedded parameters (m and τ) according to the length and complexity of the time-series [4], the framework is useful for statistically presenting the inherent features of variability of simplistic gestures. Appreciating variability in human activity can not only provide useful diagnostic information but also offers an approach to considering the manner in which people interact with pervasive displays.

In the future, we will collect data from a wider range of individuals (gender and age) and from additional sensors. Also, different classification techniques will be explored.

References

[1] K. M. Newell. and D. M. Corcos Variability and motor control, United States of America: Human Kinetics Publishers, 1993.

[2] I.-A. Zaiti, P. Stefan-Gheorghe and R.-D. Vatavu, On free-hand TV control: experimental results on user-elicited gestures with Leap Motion, In *Personal and Ubiquitous Computing*, vol. 19, pp. 821–838, 2015.

[3] J. Frank, S. Mannor and D. Precup, Activity and Gait Recognition with Time-Delay Embeddings, In *Proceedings of the Twenty-Fourth AAAI Conference on Artificial Intelligence Conference*, 2010.

[4] A. Sama, F.J. Ruiz, N. Agell, C. Perez-Lopez, A. Catala and J. Cebastany, Gait identification by means of box approximation geometry of reconstructed attractors in latent space, In *Neurocomputing*, vol. 121, pp. 79–88, 2013.

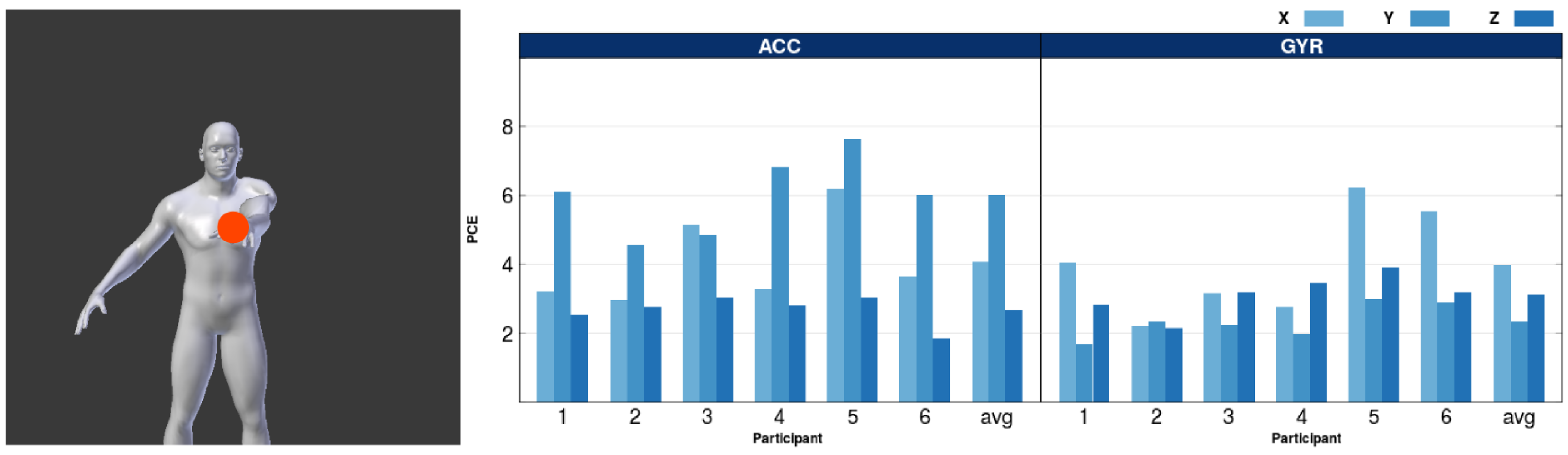
[5] N. Hammerla, T. Ploetz, P. Andras, P. Olivier, Assessing Motor Performance with PCA In *International Workshop on Frontiers in Activity Recognition using Pervasive Sensing*, 2011.

Variability of Simplistic Movements

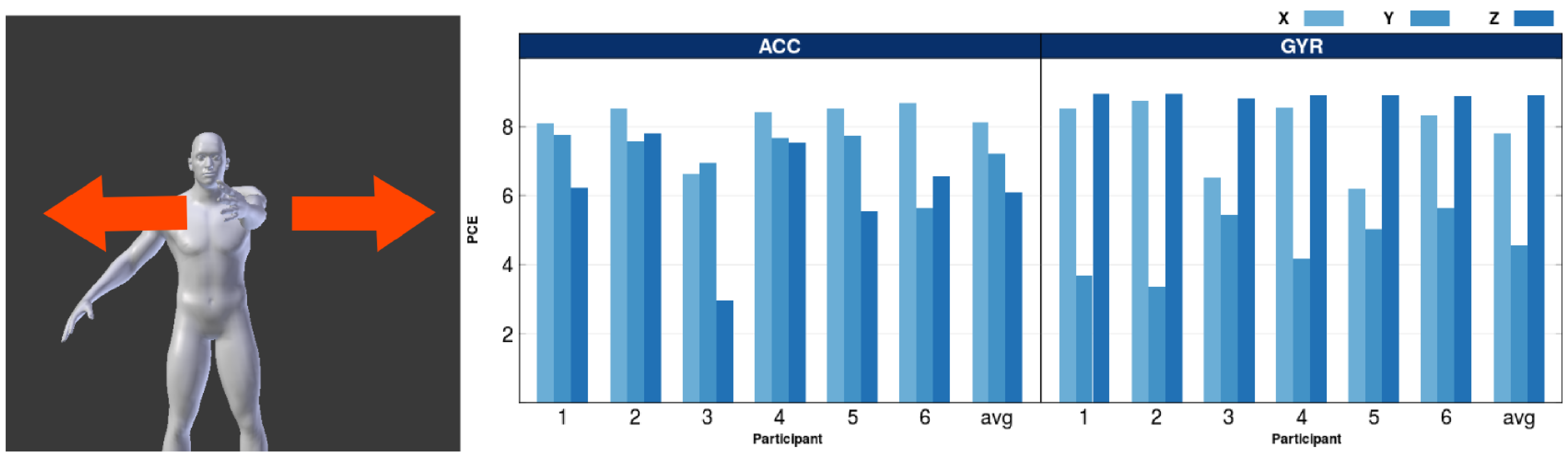
The values of percentage of cumulative energy (PCE) are presented for triaxial accelerometer (ACC) and triaxial gyroscope (GYR) sensors accross partipants and their average denoted by "avg".

It is apparent that circular and 8-shape movements show a constant trend between participants; however, such a trend is not evident for the other movements. We assume that the evident variability for the static, horizontal, vertical and diagonal movements is due to the flexibility in the experiment where participants were only asked to perform the movements at a comfortable speed.

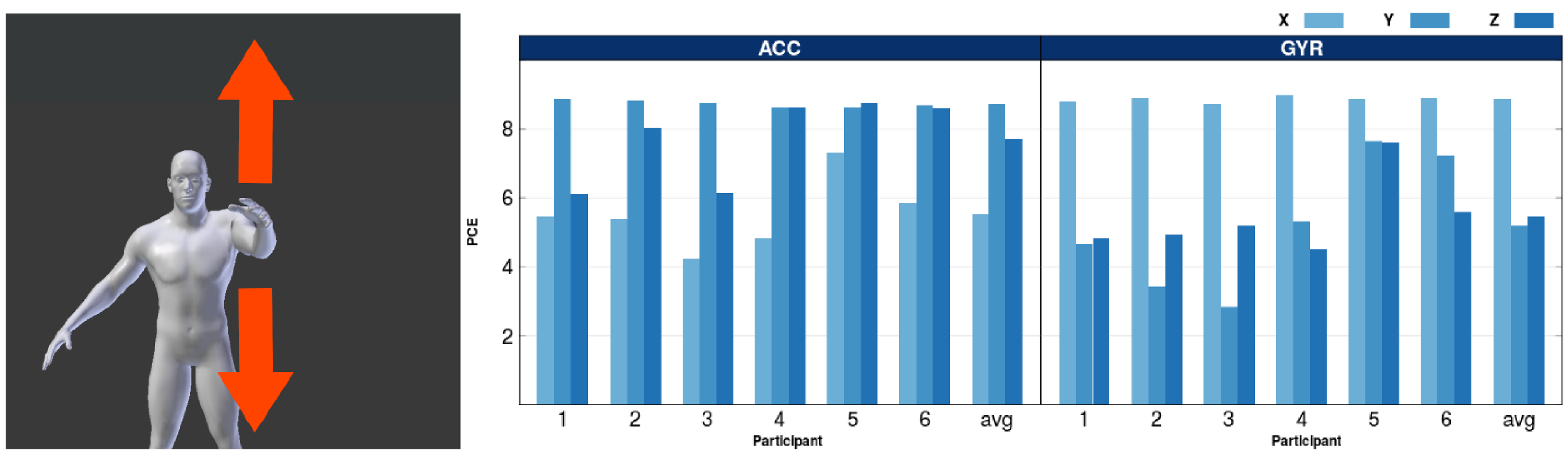
Static



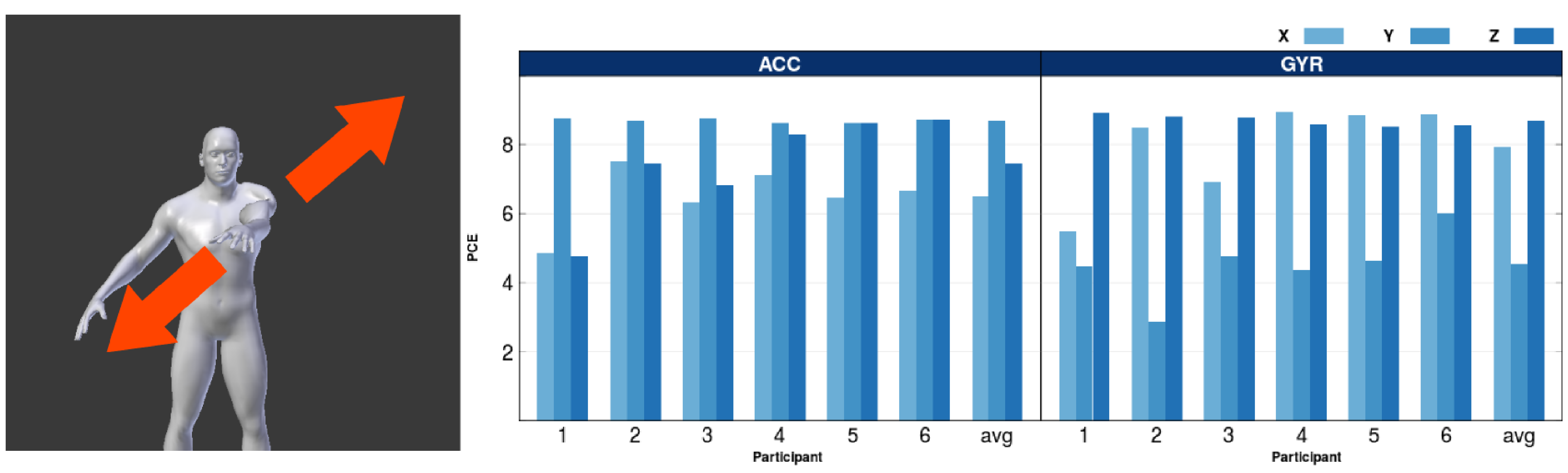
Horizontal



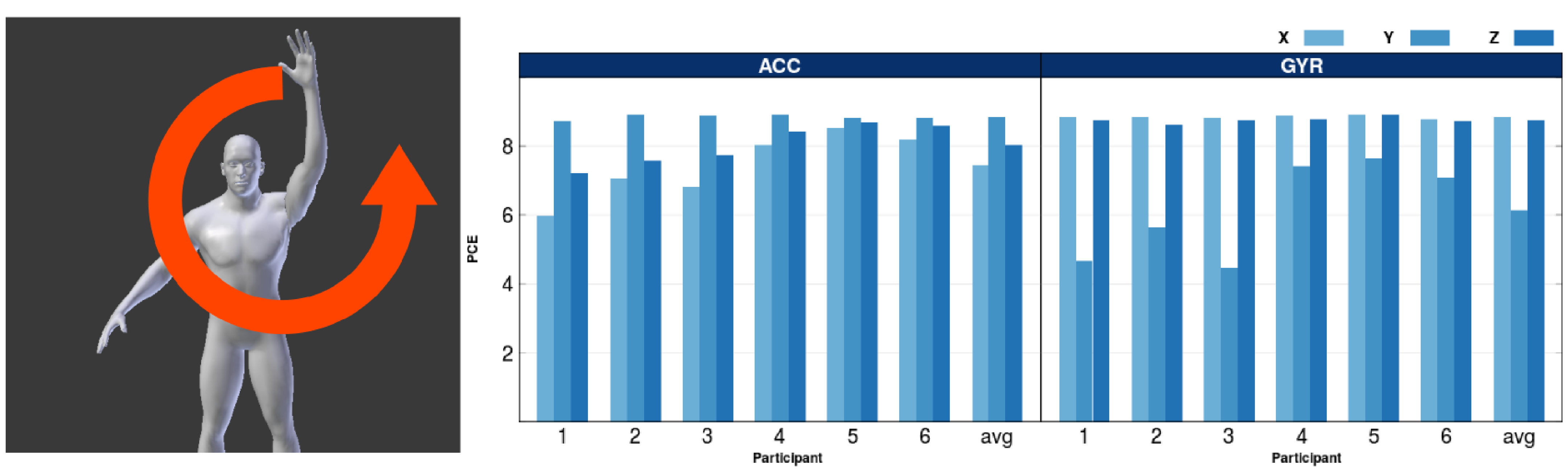
Vertical



Diagonal



Circular



8-shape