Classification of Body Motions Based on Posturographic Data

Sashi K. Saripalle, Laxmi S. Gajjala, Thomas C. Cliett III, Gavin C. Paiva, Reza Derakhshani, Christopher T. Lovelace, Gregory W. King

University of Missouri – Kansas City

Introduction

The human body, while standing, can be modeled as an unstable feedback system. This produces a continuous sway pattern, which manifests itself as varying ground reactions that are measured with force plates and quantified as Center of Pressure (Murray et al., 1967). COP is affected by a variety of sources including visual cues, illnesses, or body motions, and may therefore be used to identify a broad spectrum of motions, aliments or even mental states. The purpose of this experiment is to demonstrate that known body motions may be identified via carefully selected parameters extracted from COP data.

Methods

COP data was collected from 14 subjects performing 11 motions while standing on a force plate. The motions ranged from shoulder shrugging to foot tapping. A total of 23 different features were extracted from the data. Examples of COP features extracted include COP displacement, velocity, and frequencies of oscillation (Diener et al., 1984; Hasan et al., 1990; Lehmann et al., 1990; Maki et al., 1994; Nardone et al., 1998; Wolff et al., 1998). All features were then analyzed using wrapper methods (Guyon & Elisseeff, 2003; Saeys et al., 2007) to determine which features or sets of features would allow the best identification of subjects' motion. This involves using a precise but computationally intensive method for the final classification and a less precise but lightweight method to rank the features 'wrapped' around it. After ranking is complete, features that degrade performance are pruned (Jain & Zongker, 1997). After careful selection of feature sets, several methods of classification were explored. The outputs of these analyses were compared with known motions to determine classification accuracy. Each motion was assigned a ranked feature set as well as a method of classification that best identified it.

Results

At least one method was able to classify even the subtlest motion observed. In the worst cases, the classifier was able to correctly identify the motion approximately 70% of the time. In the best cases nearly 100% accuracy was observed. Within the context of this experiment, no single method was able to successfully outperform the others and therefore a combination of methods was used for the results.

Discussion

The primary purpose of this investigation was to classify a set of known human postural and gestural movements. The reliability of a large set of COP parameters was assessed. This study demonstrates a method for non-obtrusive detection of gestural and postural movements using floor-embedded force plates. Our method may be used in the fields of human motion analysis, psychophysiology, biometrics, and human-computer interactions. Additionally, it is possible to distinguish among movements without the use of cameras. This allows the technology to be deployed portably or into situations where vision is occluded. With refinement these applications include the study of human reactions, identification of pathological neuromuscular conditions, resident-aware smart homes, and credibility assessment.

References

Diener, H. C., Dichgans, J., Bacher, M., & Gompf, B. (1984). Quantification of postural sway in normals and patients with cerebellar diseases. *Electroencephalogr Clin Neurophysiol*, *57*, 134-142.

Guyon, I., & Elisseeff, A. (2003). An introduction to variable and feature selection. *J. Mach. Learn. Res.*, *3*, 1157-1182.

Hasan, S. S., Lichtenstein, M. J., & Shiavi, R. G. (1990). Effect of loss of balance on biomechanics platform measures of sway: influence of stance and a method for adjustment. *J Biomech*, *23*, 783-789.

Jain, A., & Zongker, D. (1997). Feature Selection: Evaluation, Application, and Small Sample Performance. *IEEE Trans. Pattern Anal. Mach. Intell.*, *19*, 153-158.

Lehmann, J. F., Boswell, S., Price, R., Burleigh, A., deLateur, B. J., Jaffe, K. M., et al. (1990). Quantitative evaluation of sway as an indicator of functional balance in post-traumatic brain injury. *Arch Phys Med Rehabil*, *71*, 955-962.

Maki, B. E., Holliday, P. J., & Topper, A. K. (1994). A prospective study of postural balance and risk of falling in an ambulatory and independent elderly population. *J Gerontol*, *49*, M72-84.

Murray, M. P., Seireg, A., & Scholz, R. C. (1967). Center of gravity, center of pressure, and supportive forces during human activities. *J Appl Physiol*, *23*, 831-838.

Nardone, A., Tarantola, J., Galante, M., & Schieppati, M. (1998). Time course of stabilometric changes after a strenuous treadmill exercise. *Arch Phys Med Rehabil*, *79*, 920-924.

Saeys, Y., Inza, I., & Larranaga, P. (2007). A review of feature selection techniques in bioinformatics. *Bioinformatics*, *23*, 2507-2517.

Wolff, D. R., Rose, J., Jones, V. K., Bloch, D. A., Oehlert, J. W., & Gamble, J. G. (1998). Postural balance measurements for children and adolescents. *J Orthop Res*, *16*, 271-275.