A Survey on Human Motion Analysis and Simulation Tools

João Ferreira Nunes

Instituto Politécnico de Viana do Castelo, Portugal

joao.nunes@estg.ipvc.pt

Pedro Miguel Moreira

Instituto Politécnico de Viana do Castelo, Portugal

LIACC - Laboratório de Inteligência Artificial e Ciência de Computadores,
Universidade do Porto, Portugal

João Manuel R. S. Tavares

Faculdade de Engenharia da Universidade do Porto, Portugal

INTRODUCTION

Systems able to identify objects represented in image sequences and to track their motion in a fully automatic manner, allowing a detailed analysis of the involved motion and its simulation, are important in several fields of our society. As examples, it can be cited: the identification, analysis and simulation of faces and gesture expressions, the analysis and simulation of human movements in biomechanics applications, and the recognition and analysis of actions. Although this is not a new topic of research, computer vision-based motion analysis is currently a very active multidisciplinary research topic within the Computational Vision, Computer Graphics, Machine Learning and Biomechanics communities [5, 1]. During recent years, relevant instances of attention devoted to this topic are the number of published surveys, special journal issues and the workshops and seminars directly related to this field.

With this work we present a detailed, broad and up to date survey on the most cited motion simulation and/or analysis software packages that have been developed both by the scientific community and commercial entities. Beyond the comprehensive listing of motion analysis tools, the main contribution of this study is an effective framework to classify and compare motion simulation and analysis tools. For the mentioned purpose we have identified and described a set of relevant features. As the main outcome, the surveyed tools were classified in respect to the proposed classification framework and a comparative overview of all the analyzed tools is summarized in a table. Finally, we draw some conclusions about the resulting data.

HUMAN MOTION ANALYSIS AND SIMULATION

The number of potential applications that somehow make use of the human motion is vast. The usage of these tools becomes fundamental in various areas, like in health, sports, gesture-driven user interfaces, smart surveillance, just to name a few, demonstrating seamlessly the growing usefulness of the human motion on a day-to-day humanity.

A good understanding of the human motion, taking into account the biomechanical foundations and the physiology of the elements involved, is extremely important. It can help to reveal the distinct patterns that classify a particular movement [2]. For example, stroke victims exhibit movements that are quite distinctive from healthy people [4]. With effective classifiers it is possible to have quicker diagnoses and more effective rehabilitation techniques that specifically address the needs of the individual patient. Also, the biomechanical analysis and simulation of the movement has became crucial in

sport, allowing athletes to understand and improve their performances, or with dynamic simulations of the movement, allowing athletes to observe and learn new techniques [6]. In fact, simulations offer many advantages opposed to experiments: they can be used to evaluate and analyze the effects of a hypothetical surgery, to design new products and processes, reducing the number of physical prototypes, expenses and the associated risk [3].

PROPOSED CLASSIFICATION FRAMEWORK

To accomplish this study we made a comprehensive research to select the most cited motion simulation and/or analysis software packages within the literature, resulting in a total of thirteen tools. Then, we proposed key features to be grouped into four main categories: a) generic features - in order to accommodate qualities such as maturity, expansibility and availability; b) modeling features - in respect to main modeling capabilities; c) data acquisition - describing how and what data can be acquired for analysis purposes; d) analysis and simulation - describing the kind of analysis provided and indicating when simulation of human motion models is achievable.

CONCLUSIONS

Human Motion Analysis and Simulation is socially and economically relevant due to its wide spectrum of relevant potential applications. Applications vary from diverse areas from clinical tools, through sports performance analysis or pure entertainment. Recent technological developments allow to provide researchers with automated and semi automated tools in order to model, analyze or simulate human motion.

This work surveys the state of the art in respect to automated tools in human motion analysis and simulation. We present our perspective on how these tools can be classified and compared and a logical, structured and feature oriented classification framework is described and presented.

REFERENCES

[1] J. K. Aggarwal and Q. Cai. Human motion analysis: A review. *Computer Vision and Image Understanding*, 73:428–440, 1999.

[2] J. E. Boyd and J. J. Little. Biometric gait recognition. In Massimo Tistarelli, Josef Bigun, and Enrico Grosso, editors, *Advanced Studies in Biometrics*, volume 3161 of *Lecture Notes in Computer Science*, pages 19–42. Springer Berlin Heidelberg, 2005.

[3] J. M. Garcia, M. Doblare, and J. Cegonino. Bone remodelling simulation: a tool for implant design. *Computational Materials Science*, 25:100–114, 2002.

[4] K. Kaczmarczyk, A. Wit, M. Krawczyk, and J. Zaborski. Gait classification in post-stroke patients using artificial neural networks. *Gait & posture*, 30(2):207–210, 2009.

[5] Shian-Ru Ke, H. L. U. Thuc, Y. Lee, J. Hwang, J. Yoo, and K. Choi. A review on video-based human activity recognition. *Computers*, 2(2):88–131, 2013.

[6] M. R. Syamsuddin and Yong-Moo Kwon. Simulation of baseball pitching and hitting on virtual world. In *International Conference on Complex, Intelligent and Software Intensive Systems*, pages 663–667, 2011.