Chapter 12
Human Motion Analysis and Simulation Tools: A Survey

João F. Nunes
Instituto Politécnico de Viana do Castelo e Laboratório de Inteligência Artificial e Ciência dos Computadores da Universidade do Porto, Portugal

Pedro M. Moreira
Instituto Politécnico de Viana do Castelo e Laboratório de Inteligência Artificial e Ciência dos Computadores da Universidade do Porto, Portugal

João Manuel R. S. Tavares
Instituto de Ciência e Inovação em Engenharia Mecânica e Engenharia Industrial, Departamento de Engenharia Mecânica, Faculdade de Engenharia, Universidade do Porto, Portugal

ABSTRACT

Computational systems to identify objects represented in image sequences and tracking their motion in a fully automatic manner, enabling a detailed analysis of the involved motion and its simulation are extremely relevant in several fields of our society. In particular, the analysis and simulation of the human motion has a wide spectrum of relevant applications with a manifest social and economic impact. In fact, usage of human motion data is fundamental in a broad number of domains (e.g.: sports, rehabilitation, robotics, surveillance, gesture-based user interfaces, etc.). Consequently, many relevant engineering software applications have been developed with the purpose of analyzing and/or simulating the human motion. This chapter presents a detailed, broad and up to date survey on motion simulation and/or analysis software packages that have been developed either by the scientific community or commercial entities. Moreover, a main contribution of this chapter is an effective framework to classify and compare motion simulation and analysis tools.

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INTRODUCTION

Systems that are 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. Concerning in particular the study and simulation of human motion, these systems have a wide spectrum of relevant potential applications, with a noticeable social and economic impact.

Despite the fact that human motion analysis and simulation is not a recent topic of research, computer vision-based human motion analysis and simulation is a very active multidisciplinary research topic, where a great amount of research effort is being carried out. During recent years, relevant instances of attention devoted to this topic are the number of published surveys, special journal issues, workshops and seminars directly related to this field (J. K. Aggarwal & Ryoo, 2011; J. K. Aggarwal, Cai, Liao, & Sabata, 1994; J. K. Aggarwal & Cai, 1999; Gavrila, 1999; Ke et al., 2013; Liu, Jia, & Zhu, 2009; Moeslund & Granum, 2001; Moeslund, Hilton, & Krüger, 2006; Poppe, 2010; Turaga, Chellappa, Subrahmanian, & Udrea, 2008; J. J. Wang & Singh, 2003; L. Wang, Hu, & Tan, 2003; Zhou & Hu, 2008).

The interest on this field of research is not surprising, and owes to a number of factors. In part, from a technical point of view, it is due to its highly interdisciplinary nature, combining knowledge from several domains (e.g.: computer graphics, biomechanics, computer vision, machine learning, among others), where there are still many problems to solve. On the other hand, it is due to the massive availability of low-cost sensory hardware with significantly better performances (such as video cameras and depth sensors), due to the emergence of faster computational platforms (such as multi-core systems and those taking benefits from the graphics processing unit for general purpose computing) and the advances in computer vision algorithms, in addition to a global demand for a wide spectrum of relevant real world and potential applications.

Throughout this chapter we present a detailed, broad and up to date survey on motion simulation and/or analysis software packages that have been developed with the purpose of analyzing and/or simulate in detail the biomechanics of human motion. Beyond the comprehensive listing of these tools, the main contribution of this chapter is a proposed effective framework to classify and compare motion simulation and analysis tools. To accomplish the aforementioned 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 framework and a comparative overview of all the analyzed tools is summarized.

HISTORICAL PERSPECTIVE

Since the early days of science, the topic of motion analysis aroused a great interest in many researchers with different backgrounds, interests and motivations, like Hippocrates (460-370 BC), Aristotle (384-322 BC), Galen (129-217), Vesalius (1514-1564) and Galileo (1564-1642), among others. Leonardo Da Vinci (1452-1519) was the first to accurately depict the human adult spinal posture with its curvatures, articulations and number of vertebrae. He was particularly interested in the structure of the human body and how it relates to performance and also how to estimate its center of gravity and its balance. In his sketchbooks he stated that