Chapter 9
Body Motion Capture and Applications

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ABSTRACT

The motion capture (MoCap) is a highly popular subject with wide applications in different areas such as animations, situational awareness, and healthcare. An overview of MoCap utilizing different sensors and technologies is presented, and the prominent MoCap methods using inertial measurement units and optics are discussed in terms of their advantages and disadvantages. MoCap with wearable inertial measurement units is analyzed and presented specifically with the background information and methods. The chapter puts an emphasis on the mathematical model and artificial intelligence algorithms developed for the MoCap. Both the products from the important technology developers and the proof-of-concept applications conducted by Havelsan are presented within this chapter to involve an industrial perspective. MoCap system will act as a decision support system in either application by providing automatic calculation of metrics or classification, which are the basic tools for decision making.

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INTRODUCTION

As digitalization rises with the widespread use of available high-tech computers and autonomous systems, people from various sectors extensively apply intelligent solutions and smart human-machine interfaces to expedite their business. Motion capture (MoCap) is another inevitable digitalization technology, which captures and models the human motion varying from a single gesture to the full-body motion, to generate a digital twin of the subject for a predefined purpose. The MoCap technology is rigorously used in ample applications. The technology has been mostly used to generate animations and characters in the entertainment sectors like computer games and movies. Besides, the MoCap systems play a role in assisting decision support and monitoring system in the healthcare applications such as physiotherapy, rehabilitation, ergonomics, and tracing the treatment of posture-related anomalies. Similarly, it is also applicable in sports to monitor and measure the performance and metrics of a trainee in an exercise. MoCap systems have also miscellaneous application sectors like robotics in which emulations of human gestures and motions are used to interact remotely with the robots and smart autonomous systems.

The pioneer sector improving the MoCap technology is the entertainment sector as Max Fleischer invented the device called *rotoscope* in 1915. The device was projecting the image of a real human onto a light-table frame by frame so that the cartoons can be drawn more realistically by tracing the required edges (Kitagawa & Windsor, 2020). However, it was time-consuming, expensive, and limited to 2D. This technology has been further improved to the exoskeletons, inertial, and optical MoCap systems to model human motions in 3D (Menache, 2000). Currently, the optical MoCap is used in animations and character generation. It is not hard to predict that the entertainment sector (i.e., animations, video games, movies) will continue demanding more robust and accurate MoCap in the future.

The clinical applications use MoCap for monitoring the treatment of neuromuscular and musculoskeletal anomalies in physiotherapy and rehabilitation. The analysis of human locomotion is the fundamental of biomechanical and biomedicine concepts in the treatment (Dariush, 2003). As the analysis of lower limbs has been performed to make gait analysis (Wang, Ning, Tan, & Hu, 2004; Tao, Liu, Zheng, & Feng, 2012) for a very long time, there are established kinematics and biomechanics. On the other hand, the kinematics and biomechanics of the upper extremes are more complex due to the free movement of the arms; nevertheless, the transfer of profound knowledge and well-defined measurement techniques from lower limbs to upper limbs is difficult. The studies (van Andel, Wolterbeek, Doorenbosch, Veeger, & Harlaar, 2008; Rau, Disselhorst-Klug, & Schmidt, 2000) establish the methods for the biomechanics of the upper limbs. Furthermore, the full-body MoCap is

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