Resumos da DSM2022
2ª Conferência Nacional de Dinâmica de Sistemas Multicorpo
F. Marques e C. Quental eds.
Guimarães, Portugal, 5-6 dezembro 2022

CURRENT PERSPECTIVES ON THE MODELING OF THE FOOT-GROUND INTERACTION FOR HUMAN MOTION ANALYSIS

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ABSTRACT

Contact-impact events are multifaceted phenomena because their modeling process strongly depends on multiple factors, such as the geometry of the contacting surfaces, the local physical properties of the materials, and the numerical representation of the interaction between the contacting bodies. In particular, when the geometric and material properties are of complex nature, it is still a quite challenging problem to accurately represent the contact mechanics. This is the case of the human foot-ground interface. The dynamic simulation of the human motion is conditioned by the foot-ground contact forces since the response of muscles, ligaments and articular reaction forces and moments is highly affected by them. Therefore, the accuracy of contact models that describe the human foot-ground interaction play a key role in biomechanical dynamic simulations. Several formulations to mimic the human foot-ground interaction have been proposed in the literature, which provide numerical approaches to calculate the ground reaction forces without the need of any experimental measurement. This work reviews and discusses the methodologies utilized to study the foot-ground interaction in human locomotion available in the literature. For this purpose, PubMed, Web of Science and Scopus electronic databases were searched on September 2021 to identify publications focusing on foot-ground contact modeling strategies. A total of 30 papers, dated from 1995 to 2020, were selected and thoroughly analyzed. Different contact geometries were established with the goal of defining the foot and ground surfaces, in which the most common were based on points, circles, ellipses, spheres, ellipsoids and surfaces obtained from 3D scanning procedures. Regarding the contact resolution, the formulations based on contact force approaches were preferred to the methods based on geometrical constraints. Several studies considered both computational and experimental approaches. One of the main limitations reported in the analyzed papers dealt with the restriction of the motion to the sagittal plane.

Keywords: Foot-ground interaction; Human motion; Contact models; Biomechanical systems; Multibody dynamics

ACKNOWLEDGMENTS

This work has been supported by Portuguese Foundation for Science and Technology, under the national support to R&D units grant, with the reference project UIDB/04436/2020 and UIDP/04436/2020, as well as through IDMEC, under LAETA, project UIDB/50022/2020. The second author expresses her gratitude to the Portuguese Foundation for Science and Technology through the PhD grant (2021.04840.BD).

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