



Cooperation of One and Multi-Joint Muscles

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Abstract: In this paper an analysis of equations describing single and multi-joint muscles cooperation during movement of limb segments is presented. Additionally, the Pareto-optimum problem is considered for the human upper limb in case of movement in sagittal plane. Uncertainty of this problem and some additional physiological restrictions such as angular range of motion or tissue tension are described. Moreover, effects of practical verification based on the video analysis of the volunteers arm movement and its lack of reproducibility are addressed. Examination of the artificial arm prototype shows similar behaviour to the human biological musculo-skeletal system. Furthermore, results of comparison with those obtained by other authors are shown.

Keywords: *biomechanics; muscle cooperation; motion analysis.*

Mathematics Subject Classification (2010): 93A30.

1 Introduction

The structure of biological systems is complex, which causes serious challenging problems in their control. The occurred imperfections, external actions on the objects under investigations or fatigue of musculo-skeletal systems affect trajectories of motion, their speed and precision of repetitions. It is conjectured that a movement of biological system is not determined along one fixed trajectory. Namely, there are infinite number of admissible paths of moving from one point to another one. In order to verify the hypothesis a mathematical model of cooperation of one and multi-joint muscles of the human upper limb during motions is proposed and analysed. This model is used to illustrate the way of cooperation of any number of single and multi-joint flexors and extensors of an arm

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