Towards a predictive modelling of the normal and pathological gait

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ABSTRACT

If biomechanical models have been widely used in order to evaluate joint torques and muscle efforts in an inverse dynamics approach, the predictive simulations are far less documented. This means that they cannot be exploited to predict gait pattern modifications when certain parameters are changed (e.g., muscle strength weakened or specifically trained, a joint mobility alteration, hip or knee joint replacement, or a neurological drug treatment).

The main objective of this project is to develop predictive modelling tools for gait motion analysis. For that purpose, we model not only the biomechanics of the musculo-skeletal system but also the neurofeedback, which is necessary to simulate a stable gait. Such models could be used to better understand the influence of some rehabilitation programs, medical treatments or disease evolution on the gait.

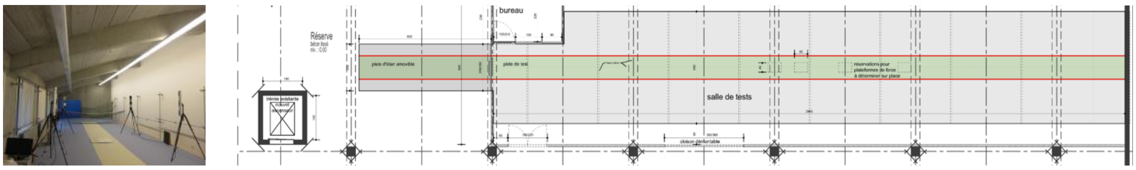

Fig. 1: Laboratory of Human Motion Analysis.

To achieve this, the study is carried out in two parts: experimental and numerical. The experimental study of gait takes place at the Laboratory of Human Motion Analysis at the University of Liège (see Fig. 1). The laboratory is equipped with the CodaMotion system measuring the 3D position of active markers placed on the skin of the subject. The laboratory also disposes of force platforms and electromyographs (EMG's) to measure the muscle activation patterns.

The experimental results will allow us to identify the key biomechanical parameters of the numerical model, such as joint torques and muscular efforts. The numerical study will go beyond inverse dynamics method [1].

Modelling the neural feedback is of major importance for the development of predictive models, see Fig. 2. Let us briefly summarize previous works found in the literature. The principles of neurological motor control have been studied by neurophysiologists [2] and some neuromechanical models based on physiology have been proposed in [3], [4]. Assuming that the brain finds the best muscle activation pattern for a given task, a predictive gait was evaluated by solving an optimal control problem in [5],[6]. Also, the neural feedback is sometimes modelled by simple feedback laws, to stabilize the vertical posture of biomechanical models [7],[8]. More advanced techniques, such as the stochastic optimal feedback control, based on the Linear Quadratic Gaussian regulator (LQG) can also be used [9]. These various methods will be investigated in this project for neural feedback modelling.

A development of a closed-loop neuronal motor controller, coupled with a biomechanical model (see Fig. 2) is thus our main objective.

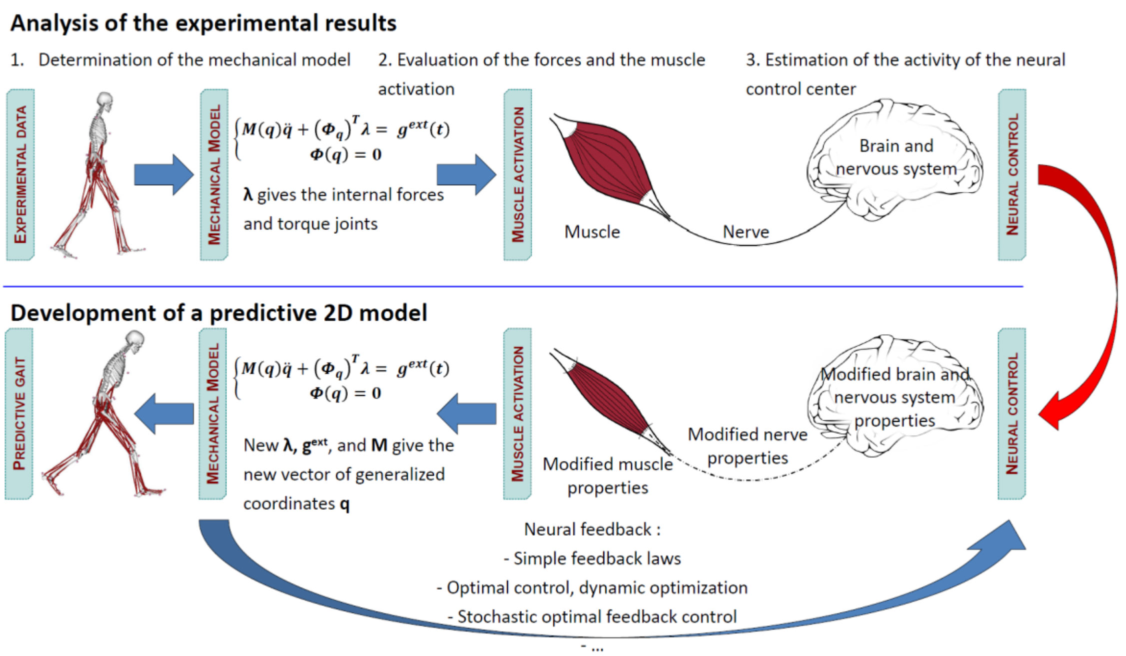

Fig. 2: Biomechanical model coupled with a closed-loop neuronal motor controller.

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