Evaluation of the impact of the biomechanical complexity of the manikin in a motion analysis framewok for ergonomics

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Context & Objectives

Biomechanical constraints in the workplace (repetitive movements, heavy physical effort, uncomfortable postures, vibrations, etc.) account for a significant proportion of the factors leading to the appearance of musculoskeletal disorders. The design of a workstation or task must therefore take these constraints into account as an integral part of the specifications. Ideally, virtual prototyping of the system, incorporating human simulation, is a low-cost and promising solution, enabling this phase to be systematized and integrated as an essential part of the design cycle. Today, there are numerous manikins (dummies) available in most leading CAD software packages. Most of these dummies are static, allowing only very partial studies of the biomechanical stresses involved. The emergence of efficient motion simulation methods (Quadratic Programming controllers, reinforcement learning) has opened the door to the development of virtual dummies enabling tasks to be simulated dynamically, and thus enabling the biomechanical constraints involved in a task to be assessed much more realistically. Nevertheless, the use of motion synthesis tools can sometimes lead to the manikin being overstressed to achieve the desired objectives, notably due to its simplicity from a biomechanical standpoint. The aim of this internship is to **vary the level of biomechanical complexity of the manikin in a motion synthesis framework, and assess the consequences of this complexity on the generated motion and the associated efforts,** for representative work tasks.

Work Plan

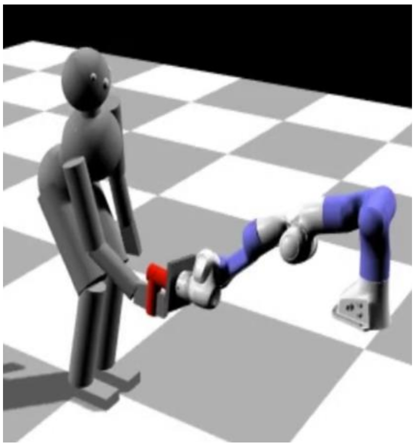
The student's task will be to implement biomechanical elements on the basis of a digital manikin representing a worker. This digital dummy is implemented in a physical simulation framework and controlled via a Quadratic Programming (QP) controller [2,6], developed at LORIA in Nancy, enabling the synthesis of tasks such as pointing, load carrying, etc. The biomechanical elements to be investigated will be i) kinematic modeling (osteo-articular model of the upper limb) ii) posture-related actuation capacities (maximum effort generation capacities derived from the literature) iii) velocity-related actuation capacities.

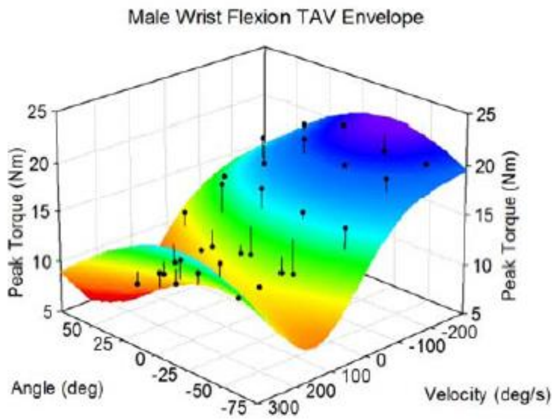
As a first step, the candidate will carry out a literature review on digital manikins, on the data that can be calculated with them, and their biomechanical "realism". The candidate will also investigate the fundamental elements that enable the biomechanical representation of humans at work (kinematics, joint amplitudes, effort generation capacities, etc.).

The practical part of the project will involve implementing the different elements on the manikin developed at LORIA. A simulation protocol will then need to be developed to test the modifications made to the dummy on a series of standardized tests, enabling the simulations to be compared with each other. In particular, we are thinking of situations where the hands are held at a height (e.g. overhead screwing), a load is carried, or an object is pushed.

Profile

Biomechanical engineer with a keen interest in computer science and simulation, or robotic engineer with a strong interest for biomechanics (M2 student).


(a)



(b)

Figure 1 - (a) digital dummy from the LORIA simulation framework ; (b) joint torque envelopes from [4]

Organization

The candidate will work in the Larsen team of Loria-Inria Nancy, and will be co-supervised by Charles Pontonnier (IRISA, Rennes) and Pauline Maurice (Loria, Nancy). The internship can have a duration of 5 to 6 months, depending on the academic requirements.

The salary is about 600€/month. The Nancy bus pass can be reimbursed for 50 % of its price.

Application

Applicants should send their CV, motivation letter describing their specific interest for the topic, and their Master's grades by email to Pauline Maurice (pauline.maurice@loria.fr) and Charles Pontonnier (charles.pontonnier@irisa.fr), with « Augmented Biomechanics Internship – Application » as the object.

Bibliography

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[3] Puchaud, P., Sauret, C., Muller, A., Bideau, N., Dumont, G., Pillet, H., & Pontonnier, C. (2020). Accuracy and kinematics consistency of marker-based scaling approaches on a lower limb model: a comparative study with imagery data. Computer Methods in Biomechanics and Biomedical Engineering, 23(3), 114-125.

[4] Xia, T., & Frey–Law, L. A. (2015). Wrist joint torque–angle–velocity performance capacity envelope evaluation and modelling. International Journal of Human Factors Modelling and Simulation, 5(1), 33-52.

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[6] Zhong, Jacques, et al. "Interacting with a torque-controlled virtual human in virtual reality for ergonomics studies." 2022 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW). IEEE, 2022.