# Internship proposal

## Computational models to predict user trajectories in dynamic environments

**keywords:** target selection, VR, optimal motor control, motor learning, HCI

**Context of the project** Reaching an object (e.g selecting a 3D object in VR or an icon on the desktop) is one of the most fundamental tasks in Human Computer Interaction (HCI). In HCI, Fitts' law [1] has been extensively used to predict the pointing time depending on the distance and size of the target (object). It has been used to compare different devices, as well to develop advanced interaction techniques [10]. However, Fitts' law remains a behavioural model providing little explanation regarding the cognitive processes [3] and thus it does not explain/predict how users adapt their behaviour in dynamic environments *e.g.*, tasks involving external forces or dynamic mappings between physical and virtual movements. A model that would predict human produced trajectories in dynamic environments would inform the design of many non-static input-output mappings (*e.g.*, adaptive mice [6], VR techniques that manipulate the mapping [5]), by allowing counterfactual reasoning [7].

**Objectives** The objective of this internship is to understand how people produce and adapt their trajectories in a new and/or dynamic environment. We embrace a model-based view of action, where human policy builds on predictions of an internal world model of the task to be accomplished, in line with the optimal control framework pioneered by Todorov [11, 8]. In this classical framework, the internal model is static and identified beforehand. We hypothesise that, rather than being static, this internal model is continually kept up to date, in light of conflicting prediction and sensory information. Modelling and integrating this learning process in the optimal control framework is the open problem that we address. To achieve this, we will adapt Todorov's classical model, by having the internal model inferred. This inference will be achieved by progressively updating the original outdated internal model, based on an error signal between predicted and observed outcome. The rates of updating (how often the model parameters are updated and by how much) will be determined from empirical data that we already have.

**Positioning in relation to the state of the art** Several advanced models have been proposed in the motor control literature to describe how humans perform movements in the physical world [11, 4, 2], but these models don't consider dynamic environments and thus fail to represent how people will modify their actions over time in such an environment. How people learn to adjust already well-practiced actions is called motor adaptation [**?**]. Motor adaptation is a topic that has been widely studied, and for which several motor adaptation paradigms have become classical. This includes experiments where reaching movements are perturbed by external forces [9], or where the mapping between physical motion and visual feedback is altered [**?**]. Unfortunately, works in motor adaptation usually reduce whole trajectories to a scalar variable known as the extent of adaptation. While that extent of adaptation is well characterized over the course of several movements, the actual adaptation of the trajectory over the course of a single movement is not. A few exceptions exist, for example a model-free optimal feedback mechanism,similar to reinforcement learning has recently been proposed [**?**], but it provides few links with the leading optimal control framework.

## References

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