Project Team Inria: FLOWERS

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Title of the proposal: Machine learning for adaptive personalization of sequences of exercises in digital learning technologies to train attentional skills

Keywords: adaptive personalization, digital learning technologies, machine learning, attentional skills, visual games

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Application date: Preferred before 22nd march

Scientific context:

Digital learning technologies offer great opportunities for personalizing sequences of training exercises, which can enable more efficient learning and higher motivation for diverse profiles of human learners. Recently, in the KidLearn project, the Flowers team developed a personalization algorithm (Zpdes, Clement et al., 2015, 2018), based on computational models of curiosity-driven learning in children (Oudeyer et al., 2016), which was tested in a large scale experiment where 500 children aged 7-8 used a tablet-based educational app to learn various mathematical concepts. The algorithm, leveraging multi-armed bandit techniques and a cognitive model of intrinsic motivation, personalized adaptively for each student the sequence of exercises through sequential tuning of hierarchical parameters. The experiment showed that this form of adaptive personalization enabled more learning efficiency and more motivation in a more diverse set of student profiles than a hand-made sequence built by a pedagogical expert.

This postdoc aims at studying whether and how this proof of concept of the cognitive and motivational learning impact of such an algorithm could be adapted and scaled up to a different domain. While the KidLearn project considered learning abstract mathematical concepts (number decomposition), it is an open question whether it could be applied to train subjects for tasks like low-level perceptual/attentional learning. Here we will focus on the objective of training several attentional skills using forms of visual tasks (simple visual games like multi-object tracking, reproducing some features of forms of action video games that have attentional learning impact, Green and Bavelier, 2003).

The potential educational and societal impact of such training activities is large, as such visual training tasks have been shown to produce long-term cognitive improvement in a wide diversity of skills ranging from spatial cognition, bottom-up and top-down attentional control, multitasking, inhibition, verbal cognition, sciences, reading, professional skills like surgery, visual disorders like amblyopia, or dyslexia, and from college-aged students to adults (Bediou et al., 2018).

Work description. The postdoc will begin by familiarization with the Zpdes algorithm, the experimental and software infrastructure used in the KidLearn experiment, as well as the results of the KidLearn experiment. She/he will also familiarize with the recent results studying what are the required characteristics of digital attentional visual tasks needed to produce robust and generalizable attentional skill learning. This will enable to formalize precisely the novel constraints imposed by these forms of low-level perceptual exercises, leading to address a technical challenge consisting in adapting the Zpdes algorithm in this context. Indeed, here cognitive load and forgetting can lead to regular decreases of performances (non-monotonic learning dynamics), as well as to exercises where the performance result has several dimensions, which is not currently dealt with the Zpdes algorihm. The candidate will then design an experimental protocol, including appropriate visual exercises and their parameterization, and experimental psychology methods to assess the perceptual/attentional learning efficiency, tested with adults (potentially using online tests, testing with children will be considered if there is enough time). Different versions of the algorithm as well as standard personalization baseline algorithms used in the literature will be compared.

This project will involve a collaboration with Daphne Bavelier, professor at the university of Geneva and world specialist of the educational impact of visual games on various attentional, cognitive and motivational skills.

Required knowledge and background:

Candidates should have an outstanding expertise in at least one of these areas, and ideally have experience in several of them:
- Machine learning algorithms applied to personalization in educational technologies
- Intelligent tutoring systems, e-learning
- Methodologies for assessing educational technologies with users
- Cognitive modelling of attentional skills in humans

Other requirements:
- Good skills in programming languages such as python and javascript
- Motivation to work on a project that combines machine learning, cognitive sciences and user studies

Advisors: Pierre-Yves Oudeyer and Hélène Sauzéon (with a collaboration with Daphne Bavelier)

References :

Clement, B., Roy, D., Oudeyer, P-Y., Lopes, M. (2015) Multi-Armed Bandits for Intelligent Tutoring Systems, Journal of Educational Data Mining (JEDM), Vol 7, No 2.

Green, C. S., & Bavelier, D. (2003). Action video game modifies visual selective attention. *Nature*, *423*(6939), 534.

Bediou, B., Adams, D. M., Mayer, R. E., Tipton, E., Green, C. S., & Bavelier, D. (2018). Meta-analysis of action video game impact on perceptual, attentional, and cognitive

skills. *Psychological bulletin*, *144*(1), 77.

Oudeyer, P. Y., Gottlieb, J., & Lopes, M. (2016). Intrinsic motivation, curiosity, and learning: Theory and applications in educational technologies. In Progress in brain research (Vol. 229, pp. 257-284). Elsevier.

KidLearn project: https://flowers.inria.fr/research/kidlearn/

Web site of Flowers Lab: https://flowers.inria.fr

Duration: 12 months (possibly extendable to longer period)