Offer #2024-07102

PhD Position F/M [Campagne Allocation Région 2024] Re-designing the Input Pipeline in Interactive Systems

Contract type : Fixed-term contract

Level of qualifications required : Graduate degree or equivalent

Fonction : PhD Position

About the research centre or Inria department

The Inria University of Lille centre, created in 2008, employs 360 people including 305 scientists in 15 research teams. Recognised for its strong involvement in the socio-economic development of the Hauts-De-France region, the Inria University of Lille centre pursues a close relationship with large companies and SMEs. By promoting synergies between researchers and industrialists, Inria participates in the transfer of skills and expertise in digital technologies and provides access to the best European and international research for the benefit of innovation and companies, particularly in the region.

For more than 10 years, the Inria University of Lille centre has been located at the heart of Lille's university and scientific ecosystem, as well as at the heart of Frenchtech, with a technology showroom based on Avenue de Bretagne in Lille, on the EuraTechnologies site of economic excellence dedicated to information and communication technologies (ICT).

Context

The PhD candidate will join the LOKI research group based in the Inria centre at the University of Lille (France), and the Exii group of the Cheriton School of Computer Science at the University of Waterloo (Ontario, Canada).

Lille is at the northern tip of France and its metropolitan area, situated at the crossroads of northern continental Europe, is the 5th biggest in France. Kitchener-Waterloo is an international technology hub located 1 hour from Toronto. It's where Google chose to establish their Canadia headquarters (with 1500 employees) and it boasts numerous start-up incubation centres.

Both Loki and Exii are dynamic and multicultural teams with members coming from different countries (Germany, Colombia, Canada, China, France, etc.) and communicating daily in English.

Assignment

Routine tasks such as controlling a system cursor or moving a virtual camera involve continuous visuo-motor control from the user, to which the system has to respond accurately and with minimal latency. Modern Human-Computer Interfaces use multi-step input pipelines between the user's movements and the system's feedback that are frequently opaque to interaction designers. Each of these steps (sensing, filtering, transforming, predicting, etc.) strongly affects the next, as well as the pipeline's outcome. And yet, many of them are designed in isolation and calibrated by trial and error using legacy or ad-hoc approaches, or limited knowledge of the underlying psychomotor phenomena. This limits user performance and experience in everyday computer use, and hinders the design and adoption of new devices and sensing methods.

This Ph.D. will explore and address the knowledge gaps in the design of continuous input pipelines: in the way we design their steps, but also in our understanding of how users perceive, decide, and act in these real-time tasks. It will involve methods and tools from HCI, experimental psychology, machine learning, or control theory. The goal is to discover and establish generalizable guidelines, methods and algorithms to build input pipelines whose steps can fit and adapt to any user, system, or device.

Main activities

This is a vast topic that can take any of the following paths, depending on the interests of the candidate:

Input filtering / signal processing:

Raw input data needs to be processed to become usable in a UI, especially when captured by IMUs or optical tracking as it is often the case in Mixed Reality. This data is often noisy, and prone to sensing or timing inaccuracies that can strongly affect the quality of the system's response. On the other hand, filtering methods often introduce latency in the pipeline, which is also detrimental to performance even when users do not notice it (see related work [3, 8]). Our team developed the 1-euro filter [5] which has

become a standard in research and industry [https://gery.casiez.net/1euro/], based on the observation that the effects of input noise become less noticeable at high speeds. Its parameters are currently tuned by hand, however, so the next stage in this direction could consist in developing a better understanding of the perception and characterization of motion noise to assist or automatize the tuning of this filter. Other venues for research can include developing faster methods to infer the user's instant velocity in real time from noisy displacement and timing data, without adding delay, based on previous results by our research group [7].

Inferring / transforming:

End-to-end latency in the input pipeline derives mostly from the display side [2, 3] which is generally irreducible in a given system. A promising approach consists in predicting the near future of the user's ongoing movements in order to display the system's response to its expected current location, rather than to the last sensed location. Our research group has developed one such predictor [7] and there are many ways to develop this topic further. One is to improve existing predictors using better models of movement, another is to characterize the expected errors of a predictor in order to adapt the visual feedback to the system's confidence [8].

Once processed, inputs are generally transformed (e.g. with pointer acceleration) and converted into the output's frame of reference (e.g. the screen's) by so-called "transfer functions" [4, 6] at the system level before being sent to graphics libraries as exploitable events. These functions help adapt the unitless input events to the size and resolution of the display, and can improve performance and usability on certain tasks. However, the design and tuning of these functions remains poorly understood and ad-hoc. A possible venue for this PhD is to explore new methods to help interaction designers choose and tune these functions based on functional models [1] that can take into account the specific capabilities of the user and of the system, and the task at hand.

Sensing / hardware / fine motor actions:

New and existing sensing devices can be investigated to improve the user's degree of control, with different form factors or sensing characteristics better adapted to the task and context. This could involve exploring the effects of friction on classic touch devices like touch-pads or touch-screens, or designing new input methods based on Optical Finger Navigation (OFN) modules that can be used in a variety of mobile context, including Mixed Reality for which prolonged use of mid-air gestures can be tiring and imprecise.

Typical input devices such as mice and touch-pads express displacements in unitless counts or mickeys, or finger pressure in ad-hoc units, which do not convey the actual scale of user movements and therefore make it harder to exploit them optimally in the next steps of the input pipeline. One approach is to design better event protocols and standards to include this information, another is to develop methods to determine it automatically by using machine learning approaches to infer, e.g., the resolution of a mouse using only the unitless events that it emits.

At a higher perspective, the knowledge gained on these topics will be used to help to redesign the input pipeline in current interactive systems.

The three supervisors have recognized expertise at the international level on these topics with papers published in leading conferences of the domain. The avenues of research described above expand beyond one thesis so the specific topics covered by the candidate will be tailored based on preference and profile.

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[1] Bye, R.T. and Neilson, P.D. 2008. The BUMP model of response planning: Variable horizon predictive control accounts for the speed–accuracy tradeoffs and velocity profiles of aimed movement. Human Movement Science. 27, 5 (Oct. 2008), 771–798. DOI:https://doi.org/10.1016/j.humov.2008.04.003.
[2] Casiez, G., Conversy, S., Falce, M., Huot, S. and Roussel, N. 2015. Looking Through the Eye of the Mouse: A Simple Method for Measuring End-to-end Latency Using an Optical Mouse. Proceedings of the 28th Annual ACM Symposium on User Interface Software & Technology (New York, NY, USA, 2015), 629–636.
[3] Casiez, G., Pietrzak, T., Marchal, D., Poulmane, S., Falce, M. and Roussel, N. 2017. Characterizing Latency in Touch and Button-Equipped Interactive Systems. Proceedings of the 30th Annual ACM Symposium on User Interface Software and Technology (New York, NY, USA, Oct. 2017), 29–39.
[4] Casiez, G. and Roussel, N. 2011. No More Bricolage!: Methods and Tools to Characterize, Replicate and Compare Pointing Transfer Functions. Proceedings of the 24th Annual ACM Symposium on User Interface Software and Technology (New York, NY, USA, 2011), 603–614.
[5] Casiez, G., Roussel, N. and Vogel, D. 2012. 1 € filter: a simple speed-based low-pass filter for noisy input in interactive systems. Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (New York, NY, USA, mai 2012), 2527–2530.
[6] Casiez, G., Vogel, D., Balakrishnan, R. and Cockburn, A. 2008. The Impact of Control-Display Gain on User Performance in Pointing Tasks. Human–Computer Interaction. 23, 3 (Aug. 2008), 215–250. DOI:https://doi.org/10.1080/07370020802278163.
[7] Nancel, M., Aranovskiy, S., Ushirobira, R., Efimov, D., Poulmane, S., Roussel, N. and Casiez, G. 2018. Next-Point Prediction for Direct Touch Using Finite-Time Derivative Estimation. Proceedings of the 31st Annual ACM Symposium on User Interface Software and Technology (New York, NY, USA, Oct. 2018), 793–807.
[8] Nancel, M., Vogel, D., De Araujo, B., Jota, R. and Casiez, G. 2016. Next-Point Prediction Metrics for Perceived Spatial Errors. Proceedings of the 29th Annual Symposium on User Interface Software and Technology (New York, NY, USA, Oct. 2016), 271–285.

Benefits package

- Subsidized meals
- Partial reimbursement of public transport costs
- Leave: 7 weeks of annual leave + 10 extra days off due to RTT (statutory reduction in working hours) + possibility of exceptional leave (sick children, moving home, etc.)
- Possibility of teleworking and flexible organization of working hours
- Professional equipment available (videoconferencing, loan of computer equipment, etc.)
- Social, cultural and sports events and activities
- Access to vocational training
- Social security coverage

Remuneration

2100€ gross per month for the 1st and 2nd years

2190€ gross per month for the 3rd year

General Information

- **Theme/Domain :** Interaction and visualization
  Information system (BAP E)
- **Town/city :** Villeneuve d'Ascq
- **Inria Center :** Centre Inria de l'Université de Lille
- **Starting date :** 2024-10-01
- **Duration of contract :** 3 years
- **Deadline to apply :** 2024-04-30

Contacts

- **Inria Team :** LOKI
- **PhD Supervisor :**
  Casiez Gery / Gery.Casiez@inria.fr

About Inria

Inria is the French national research institute dedicated to digital science and technology. It employs 2,600 people. Its 200 agile project teams, generally run jointly with academic partners, include more than 3,500 scientists and engineers working to meet the challenges of digital technology, often at the interface with other disciplines. The Institute also employs numerous talents in over forty different professions. 900 research support staff contribute to the preparation and development of scientific and entrepreneurial projects that have a worldwide impact.

The keys to success

A successful candidate must hold a MSc in Human-Computer Interaction, Computer Science, or Control Theory, and show a great interest in performing high quality research. The candidate must demonstrate experience or strong interest in software development. Creativity, independence, team working and communication skills are valuable advantages.

Due to the collaborative nature of this PhD offer, a good level of technical and scientific English is necessary. It is not required to speak French.

Warning : you must enter your e-mail address in order to save your application to Inria. Applications must be submitted online on the Inria website. Processing of applications sent from other channels is not guaranteed.

Instruction to apply

CV + cover letter

Defence Security :
This position is likely to be situated in a restricted area (ZRR), as defined in Decree No. 2011-1425 relating to the protection of national scientific and technical potential (PPST).Authorisation to enter an area is granted by the director of the unit, following a favourable Ministerial decision, as defined in the decree of 3 July 2012 relating to the PPST. An unfavourable Ministerial decision in respect of a position situated in a ZRR would result in the cancellation of the appointment.

Recruitment Policy :
As part of its diversity policy, all Inria positions are accessible to people with disabilities.