CASAC chair

Towards an efficient human-machine teaming

post-doctoral position

Supervisors: Caroline Chanel, Mickaël Causse, Nicolas Drougard

Starting date: April 2022
Post-doc duration: 18 months

Context:

The CASAC chair[1] aims to study the design of cognitive air systems that promote efficient, robust and safe human-machine teaming. In this end, the CASAC chair addresses the question of how to promote teaming performance while ensuring safety. In detail, the CASAC chair objectives can be summarized as follows:
(1) to define methods, tools and metrics that allow to monitor and quantify the quality of the human-machine synergy;
(2) to propose decision-making models for interaction management and task allocation between humans and machines;
(3) to imagine tools that could support operators (e.g. pilots or telepilots) in the conduct of the flights and in the realization of their missions.

The above objectives are strongly dependent on the identification of metrics (and associated tools) allowing the estimation of human mental states, and capable of assessing the quality of the Human-Machine coupling (Sheridan, 2016). The studied metrics will be formalized and implemented not only in the context of interface evaluation, but also in the context of interaction adaptation to enhance collaboration. All these studies and their relationship are illustrated in Figure 1.

In this post-doctoral position a particular interest will be given to the quality of the collaboration between the agents which are interacting to achieve mission goals.

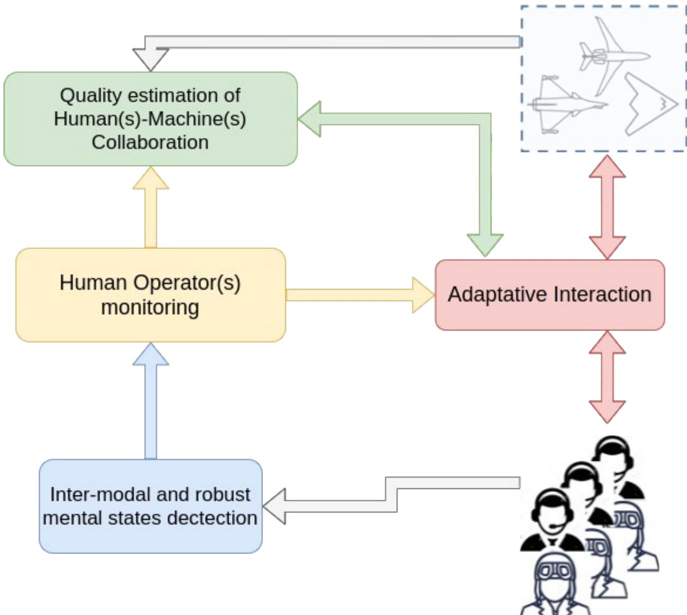

Figure 1: Illustrative example of inter-dependence of the research topics addressed in the CASAC chair.

[1] isae-supaero.fr/fr/isae-supaero/mecenat-relations-avec-la-fondation-isae-supaero/chaire-dassault-aviation-casac

Post-doc objective:

In this context, the purpose of this post-doctoral project is to study methods and metrics to quantify the human-machine teaming efficiency during collaboration. Interestingly (Mayima, et al. 2021) proposed several metrics that can be computed in real-time to evaluate the Quality of Interaction (QoI) when human and robot are collocated. Eventually, in this post-doc, we aim to investigate how such metrics can be exploited in human-machine teaming where interaction, which is handled through teleoperation interfaces, is a mean to collaborate in order to achieve mission goals.

According to (Mayima, et al. 2021), *human engagement* and *tasks effectiveness* are two useful concepts to measure the QoI. Both concepts are not directly measurable as quantities, in particular in real-time settings. Moreover, in our view, the interaction can be seen as a mean to effective collaboration, that in turn can be necessary to achieve mission goals.

A first research question is if the *effectiveness* (e.g. teaming performance) could be related to a more general concept: the collaboration and its alignment with the mission goals. For example, two agents may collaborate satisfactorily but the result of their actions is not beneficial given the mission objectives, and is therefore not very effective. So, could human-robot synergy be quantified by global measures of collaboration (Sheridan, 2016) - e.g., the tasks each agent chooses to perform and why - as well as by specific measures of collaboration (Young, et al. 2011) - e.g., agent actions (or task scores) in a given mission context? We will seek to establish principles for an objective evaluation of Human-Machine collaboration, where the interaction can be seen as a mean to collaborate. It will be also interesting to investigate how to take into account more explicitly the social dimension of the collaboration (Henschel, et al., 2020),(Dautenhahn, 2007) during interaction in remote operations settings.

A second research question relates to the capacity of estimating *human engagement* in scenarios involving teleoperation. (Mayima, et al. 2021) proposed to quantify human engagement by means of nonverbal communication measurements (e.g body gesture, posture, displacements), however these metrics can be hardly applied in teleoperation scenarios. Alternatively, (Dehais, et al. 2020) advocates that targeting specific mental states, such as fatigue, stress, or workload, that precede a reduction of human performance, can help to estimate human engagement. (Roy, et al. 2020) then suggested several physiological measurements and associated metrics that seems to be useful for human-robot interaction to detect such undesirable mental states. Our aim is to investigate how behavioural (e.g keystrokes and clicks, gaze position, fixations) and physiological measurements (e.g heart-rate, heart-rate variability) can be used to estimate human engagement.

The quantification of Human-Machine collaboration can serve to perform an online adaptation of the interaction, for example by changing/adding tasks allocated to artificial agents when the human operator is overloaded, and it can also serve to objectively quantify an interface design, which can be useful during the preliminary conception and certification steps.

Means:

Two platforms have been recently developed in ISAE-SUPAERO to study human-robot(s) collaboration: the Firefighter Robot Game (see Fig. 2) and the Airtime U-track application (see Fig. 3). These platforms propose two study cases in which an human operator must collaborate with one or more robots (terrestrial or aerial) to accomplish mission objectives, despite exogenous events, and under time constraints. These platforms can be used during this post-doc to evaluate the state-of-the-art ad the proposed metrics during experimental campaigns. Several physiological measurements will be also used during the work, in particular electrocardiogram (ECG) and eye-tracking (ET). These sensors Can provide objective measures of the operator mental state (Roy et al, 2020, Chanel et al, 2020).

Figure 2: The Firefighter Robot Game (see robot-isae.isae.fr), and the ISAE-SUPAERO robotic experimental room facilities.

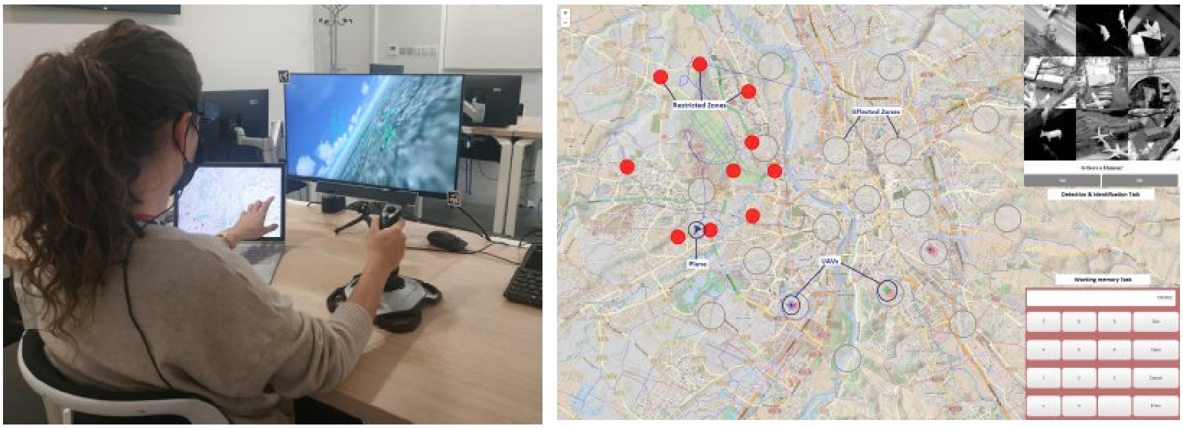

Figure 3: The Airtime U-track application. A human pilot is required to collaborate with aerial robots in a search and rescue mission context.

Candidate's qualification: PhD in human-machine interaction, human-robot interaction or related disciplines.
Candidate's skills and background: Psychology, human studies, human/mental state monitoring, physiological computing, measuring the quality of interactions, reasoning in robotic systems, cognitive robotics, evaluation methods, algorithmic and programming, problem-solving, teaming work, autonomy. An experience with ECG and/or ET will be appreciated.

Applications including CV and motivation letter must be addressed to:
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References

(Mayima, et al. 2021) Mayima, A., Clodic, A., & Alami, R. (2021). Towards Robots able to Measure in Real-time the Quality of Interaction in HRI Contexts. International Journal of Social Robotics, 1-19.

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