Platform-Pilot-Supervisor (PPS) when Mixed-Initiative Become Entity Agnostic

Weifei Xie[1], Cédric Herpson[1], Christophe Cambier[2] and Jean-Marie Dembelle[3]
[1]*Sorbonne Université, CNRS, LIP6, F-75005 Paris, France*
[2]*Sorbonne Université, IRD, UCAD, UGB, UMI, UMMISCO, F-75006 Paris, France*
[3]*Université Gaston Berger de Saint-Louis, Laboratoire d'Analyse Numérique et Informatique, BP.234 Saint Louis, Senegal*
[1]{*firstname.lastname*}*@lip6.fr,* [2]{*firstname.lastname*}*@ird.fr,* [3]{*firstname.lastname*}*@ugb.edu.sn*

Keywords: Mixed Initiative, Autonomy, Design Phase.

Abstract: Adaptive autonomy, adjustable autonomy or mixed initiative are introduced to allow the intelligent system to cope with a dynamic environment. In these approaches, the system is allowed to change the level of autonomy by itself or by an external actor. In this research, we introduce PPS, an analysis grid focused on the role of the entities that compose a human-non-human team. It evaluates the genericity and collaboration capabilities of existing architectures and mechanisms and can be used as a guide to design architectures covering all collaboration configurations...

1 INTRODUCTION

Any collaboration between entities with a certain degree of autonomy requires coordination. Whether these entities intervene jointly or alternately, are human, non-human or a combination of the two makes no difference. Indeed, every autonomous entity has a certain capacity for initiative. This capacity can be controlled or limited, either by the degree of autonomy the entity has in a given context (intrinsic limitation), or by rules, norms or protocols of coordination and interaction (extrinsic limitation). The challenge, widely described in the literature, is to ensure that teamwork brings more benefits than difficulties(Côté, 2013).

The various works that address these issues fall under the concepts of Adjustable Autonomy(Côté, 2013), Adaptive Autonomy(Frasheri et al., 2018) and Mixed-Initiative(Bevacqua et al., 2015). Intuitively, the concept of Adjustable Autonomy introduces the fact that the degree of autonomy of an entity can be changed according to the situation or in response to an event but does not make explicit who is responsible for this change (the entity itself or an external actor)(Côté, 2013). The concept of adaptive autonomy goes a step further and allows an entity to take the initiative to vary its level of autonomy by itself, and therefore the perimeter of its decisions (Frasheri et al., 2018). In both cases, the better reactivity of the system is achieved at the expense of the risk of error. Work on mixed-initiative mainly focus on the ways that allow different actors to intervene proactively in the progress of a mission in order to guarantee its success and maximise its performance. The degree of autonomy of each entity and the definition of what initiatives can be taken by them greatly influence the performance of the teams.

However, despite the efforts of the community to define a taxonomy (Frasheri et al., 2018; Côté, 2013; Bevacqua et al., 2015) and clear perimeters for these three concepts, there is no commonly accepted definition of each of its terms, many work that fall explicitly within one of the above concepts have features that overlap with the other two. Rather than focusing on defining the boundaries between these domains, we thought it would be interesting to look at the concept that links them: the notion of *role*.

To place us not at the level of the pilot of the platform but at the level of the roles – Pilot(s) and Supervisor(s) – associated to the Platform(s) offers an analysis grid of existing approaches that allows to evaluate both their genericity and their compatibility with evolutions likely to be encountered. We refer here as much about the direct uses of a platform as about its integration within a larger system. In this work in progress we introduce the proposed *Platform-Pilot-Supervisor (PPS)* analysis grid and illustrate how it could be use as a guide to design an architecture covering all collaboration configurations.

Xie, W., Herpson, C., Cambier, C. and Dembelle, J.
Platform-Pilot-Supervisor (PPS) when Mixed-Initiative Become Entity Agnostic.
DOI: 10.5220/0011961600003622
In *Proceedings of the 1st International Conference on Cognitive Aircraft Systems (ICCAS 2022)*, pages 69-72
ISBN: 978-989-758-657-6

2 PLATFORM-PILOT-SUPERVISOR APPROACH

The goal of a collaborative system is to achieve the task given efficiently and safely. In our proposal (figure 1), the mission's designer does not necessarily determine offline the actors of each role. At a given time, a platform is driven by an entity *A* which has been given this role, and is supervised by an entity *B* (potentially the same, but not necessarily) which has been given a supervisory role. These roles can indifferently and dynamically be entrusted to one or more operators, human or artificial. And what is true for a platform is also true for a set of – homogeneous or not – platforms.
An entity is thus associated to a given set of roles according to the current needs, estimated benefits and capabilities available. An entity can be both the supervisor and pilot of one or several platforms for the whole mission, or linked to a given role for a certain amount of time.

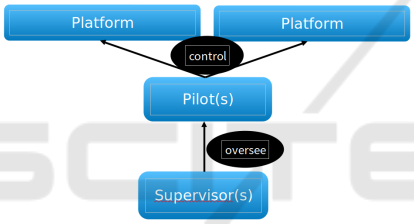

Figure 1: Illustration of platform-pilot-supervisor model. In this system, any platforms (aerial, terrestrial, submarine, subterranean) can be controlled by one or several operators, human or IA, either alternatively or concurrently. The supervisor role follow the same reasoning.

To ensure the performance of the system, several requirement should be verified:

- **Information Collection.** Both pilots and supervisors should be able to gather information with an acceptable delay. The information the pilot(s) require comes from both the supervisor and the environment. The information the supervisors should gather are related to the current pilots' capabilities and the situational awareness.
- **Communication.** Both roles should be able to express their opinion, in case of conflict between the two roles, the supervisor makes the decision. The interaction must be able to evolve according to the state of communication, for better or for worse.
- **Ability of Analysis.** Both roles need to be able to analyse the information gathered within an *acceptable* time frame. In both cases, they must deal with the noise and extract the essential information. In the case of the pilot role, he must be able to estimate the state of the platform. The supervisor must be able to detect if the platform is in danger and assess if the current entity(ies) assuming the pilot role are adapted to the situation.
- **Planning Ability.** This is an essential ability of both the pilot and supervisor roles. With the knowledge of the platform-pilot state, the pilot must be able to evaluate if it is able to cope with the situation and if so, move on to the planning of the movement (planning a sequence of actions to perform the task). In the case of a necessary re-planning, the pilot must insure that this could be done under a given time-frame. The supervisor must be able to determine if the pilot is able to cope with this situation. The supervisor must also be able to determine is it is necessary to change the pilot by taking into account both the current performance, the cost and risks of a role-change, and the expected performance. Both decisions must be explainable (in the case of a human, the human must be able to justify itself, in the case of an algorithm, the decision must be interpretable).
- **Execution.** The supervisor must have the ability to execute decisions. Pilot must be able to ask for help (transfer its role partially or fully) or execute the planned actions.
- **Knowledge.** Both roles must be able to update their knowledge to adapt their behaviour to uncertainty, incompleteness and imprecision which compose any real mission.
- **Record:** The system must be able to record all actions performed by any component of the triptych – Platform(s), Pilot(s), Supervisor(s) – so that any return of experience process could be realised.

2.1 Illustrative Examples

- **Mono-platform.** Unmanned Aerial Systems are used in many warfare of civilian context : Exploration, surveillance and reconnaissance, search and rescue,... Consider the case of one Optionally Piloted UAVs that should be used by a non-expert user to complete surveillance missions. In autonomous mode, the user takes on the role of supervisor to ensure that the auto-pilot is following the defined plan. When the human wants to switch roles to become the remote-pilot, the user takes on the role and the AI takes on the role of supervisor. It keeps the capability to take over control in the eventuality that the user's action puts the drone in danger of crashing or of violating flight rules. In the case of communication-losses the (embedded) AI assumes both the pilot and su-

pervisor roles. The advantage of allowing an AI to take on the role of supervisor is that we can insure that the safety level of the drone will be at least the minimum between the safety levels of the human and of the AI.
In the case where the pilot role is shared between several entities, for example an AI and a human, the AI can take responsibility for a subset of actions so that the human can more easily manage the platform. The AI can ensure that the quantity of information transmitted to the human does not overflow its processing capabilities and dynamically adapt the tasks to its level of expertise.

- **Multi-platform.** The PPS approach can also be used to describe multi-platforms configurations. Consider multiple drones working together to find an objective on a map. In the case of Optionally Piloted UAVs, supervisors could be both embedded humans or AIs. Once a point of interest is founded, a human can take control of the closest drone to specifically observe it, in this case he becomes the pilote of one platform, and the supervisor of this OPUAV can be either a human or an AI while the configuration can remain different for the other components of the fleet.

3 RELATED WORK

As previously introduced, the 3 main concepts that relates to the question of the autonomy of AI-Human team and to collaboration between autonomous entities are Adaptive autonomy (ADA), Adjustable autonomy (AJA) and Mixed initiative (MI). The 3 approaches are defined differently by different authors. For (Singh, 2021), there is no difference between ADA and AJA, and MI is a special case of ADA. In the case of (Bevacqua et al., 2015) MI is restricted to the case where a human and AI share the control of a robot and the AI is the human assistant. In (Chanel et al., 2020), MI means that each agent, human or not, can seize the initiative, the role of each entity is decided by its current capabilities. For (Frasheri et al., 2018), ADA means that the AIs could adapt their autonomy during the session by themselves. In this document, we choose to follow the definitions proposed by (Hardin and Goodrich, 2009) where the level of autonomy, and thus the initiative capability of an AI, is primarily controlled by the human in the AJA model whereas the entity mainly controls its autonomy in ADA. In this work, MI tries to define the coordination conditions between Human and artificial entities.

Table 1 synthesise the 6 basic configurations that can be met when the focus on the roles instead of the actors. At these configurations should be added the cases where several entities are allowed to simultaneously collaborate to assume a given role.

Table 1: Different roles configurations that should be considered with one unique platform: 1) Pilot and supervisor are assumed by the same AI. 2)Pilot and supervisor are different AIs. 3)Human pilot with AI supervisor. 4) AI pilot with human supervisor 5) Pilot and supervisor are one unique Human 6) Pilot and supervisor are different Humans.

Supervisor \ Pilot	AI	Human
AI	2 / 1	3
Human	4	6 / 5

The combination of theses modes cover the 3 previously introducted concepts. ADA, as presented in (Abraham et al., 2021) can be presented with a combination of cases 1,4,5. The ADA perspective proposed by (Frasheri et al., 2018) for the search and rescue scenario can be presented as a combination of modes 1 and 3 while the (Rubio et al., 2004) model for path planning restricted to the cases 1 and 2.

AJA generaly integrates a human supervision dimension. In the work of (Côté, 2013), the human may choose to assist the system by providing information about the waypoints or directly takes control, which can be done by a combination of cases 1, 3 and 4. The work of (Crandall and Goodrich, 2001) presents a model that allows human integration in both high and low autonomy level. Taking into account communication delay, the supervision can be delegated to the AI to avoid serious defects. This model cover the cases 1,3,4.

The MI model can also be represented by the combination of the basic modes. (Allen et al., 1999) propose a model in which each participant must constantly monitor the situation to make the best decision. This model can be represented by a combination of cases 1, 3, 4 and 5. (Adams et al., 2004) propose to monitor the human state to achieve better cooperation, this could represent a combination of cases 1,3,4,5. The model proposed by (Bruemmer et al., 2003) can be covered by the cases 1,3,4,5.

Some work also attempts to reduce the needs of the human operator, with the aim of achieving full autonomy. Their approach is also similar to ADA or mixed initiative, such as the model proposed by (Schwerd and Schulte, 2021) which be represented by a combination of the cases 1, 3, 4 and 5.

The integrated guidance system in a multi-drone system (Donath et al., 2010) can be represented by a combination of modes 1,3,4,5. In other words, these

approaches attempt to build a system where humans only play the role of supervisor, without the capacity of pilot.

PPS allows to categorise existing approaches and highlight the fact that several combination that make sense operationally are forgotten. Allowing a supervisor to not be a pilot or to call for different experts during a given mission depending of situation to be managed could improve the overall performance.

4 SYNTHESIS AND FUTURE WORK

This paper introduce PPS, an analysis grid that focus on the roles of the entities that composes a team. PPS allows to evaluate the genericity and collaboration capabilities of existing architectures and mechanisms that tries to improve the efficiency of team of heterogeneous entities, either human or artificial. In particular, PPS showed that there exist several use-cases, either mono or multi platform, where a dynamically changing supervisor could offer overall performance improvements. In the near future, we will propose and instantiate a management architecture that will cover the different cases described by PPS on a mono-uav surveillance set-up before extending it to multi-platform use-cases.

REFERENCES

Abraham, S., Carmichael, Z., Banerjee, S., VidalMata, R., Agrawal, A., Islam, M. N. A., Scheirer, W., and Cleland-Huang, J. (2021). Adaptive Autonomy in Human-on-the-Loop Vision-Based Robotics Systems. *arXiv:2103.15053 [cs]*. arXiv: 2103.15053.

Adams, J. A., Rani, P., and Sarkar, N. (2004). Mixed-Initiative Interaction and Robotic Systems. page 8.

Allen, J., Guinn, C., and Horvtz, E. (1999). Mixed-initiative interaction. *IEEE Intelligent Systems and their Applications*, 14(5):14–23. Conference Name: IEEE Intelligent Systems and their Applications.

Bevacqua, G., Cacace, J., Finzi, A., and Lippiello, V. (2015). Mixed-Initiative Planning and Execution for Multiple Drones in Search and Rescue Missions. page 9.

Bruemmer, D., Marble, J., Dudenhoeffer, D., Anderson, M., and McKay, M. (2003). Mixed-initiative control for remote characterization of hazardous environments. In *36th Annual Hawaii International Conference on System Sciences, 2003. Proceedings of the*, page 9 pp., Big Island, HI, USA. IEEE.

Chanel, C. P. C., Roy, R. N., Drougard, N., and Dehais, F. (2020). Mixed-Initiative Human-Automated Agents Teaming: Towards a Flexible Cooperation Framework. In Harris, D. and Li, W.-C., editors, *Engineering Psychology and Cognitive Ergonomics. Cognition and Design*, Lecture Notes in Computer Science, pages 117–133, Cham. sc.

Crandall, J. and Goodrich, M. (2001). Experiments in adjustable autonomy. In *2001 IEEE International Conference on Systems, Man and Cybernetics. e-Systems and e-Man for Cybernetics in Cyberspace (Cat.No.01CH37236)*, volume 3, pages 1624–1629, Tucson, AZ, USA. IEEE.

Côté, N. (2013). *Raisonnement et décision mixte pour l'autonomie ajustable et le partage d'autorité*. Theses, Université de Caen.

Donath, D., Rauschert, A., and Schulte, A. (2010). Cognitive assistant system concept for multi-UAV guidance using human operator behaviour models. page 16.

Frasheri, M., Curuklu, B., Esktrom, M., and Papadopoulos, A. V. (2018). Adaptive Autonomy in a Search and Rescue Scenario. In *2018 IEEE 12th International Conference on Self-Adaptive and Self-Organizing Systems (SASO)*, pages 150–155, Trento, Italy. IEEE.

Hardin, B. and Goodrich, M. A. (2009). On Using Mixed-Initiative Control: A Perspective for Managing Large-Scale Robotic Teams. page 8.

Rubio, J. C., Vagners, J., and Rysdyk, R. (2004). Adaptive Path Planning for Autonomous UAV Oceanic Search Missions. In *AIAA 1st Intelligent Systems Technical Conference*, Chicago, Illinois. American Institute of Aeronautics and Astronautics.

Schwerd, S. and Schulte, A. (2021). Operator State Estimation to Enable Adaptive Assistance in Manned-Unmanned-Teaming. *Cognitive Systems Research*, 67:73–83.

Singh, G. (2021). *Enhancing manned unmanned teaming with physiological computing and adaptive interaction*. These de doctorat, Toulouse, ISAE.