Engineering Automations: From a Human Factor Perspective to Design, Implementation and Validation Challenges

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ABSTRACT

In the literature, automation is usually addressed as a goal (produce systems that are as autonomous as possible) as a process (producing systems with autonomous behaviors) or as a state (a system performing in an autonomous way). These uses suggest that automation is a global concept that does not need decomposing. However, when designing systems (including interactive systems), automation can only be incorporated at very low-level details, when some functions (previously performed by humans) are migrated to the system. There is a similarity between this global vision of automation and the global vision of human body in biology before the advent of anatomy (that aims at decomposing organisms in parts) and physiology (that aims at understanding the functions of organisms and their parts). This presentation will follow the path of anatomy and physiology to understand better what automation is, how automation can be designed, how partly autonomous systems can better support users and why full automation is a desirable but foolish, inadvisable and unwise target.

KEYWORDS

Engineering, automation, function allocation, authority

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1 INTRODUCTION

Early approaches dealing with automation and Human – Computer Interaction were focusing on the Human Factors aspects of users interacting with automation. Generic functions to be performed were listed and allocated to the best player between machines and users (e.g. Fitts' approach Machine Are Better At - Men Are Better At [3]). Such lists were supposed to support design of function allocation and produce better systems, which was then contradicted by later studies [2]. Other approaches such as [4] proposed high level metaphors to design automation at a high-level of abstraction and ended up being never implemented in systems.

Current push in automation is towards fully autonomous systems (e.g. Tesla or Waymo cars) raising critical issues such as:

- How to ensure dependability of fully autonomous systems and how to test them?
- How to make it possible for users to foresee future states of the automation?
- How to disengage automation?
- How to re-plan automation after disengagement?
- How to carry on activity and overall service provision under automation degradation?
- How to learn how to use automation?
- How to not deskill operators that are using automation?
- How to ensure that the system is serving the user and not the opposite?
- How to address legal issues (e.g. responsibility) raised by safety concerns (both for users and the environment)?

This list of questions is far from being complete but provides an idea of some critical aspects of automation design. Some of it is concerned by the predictability of automation,

Figure 1: Michiel Jansz van Mierevelt - Anatomy lesson of Dr. Willem van der Meer, 1617 (Public Domain)

other parts are concerned by transparency and controllability [1] (which are typical HCI problems) while other ones are more related to dependability and software engineering aspects. It demonstrates that automation brings additional complexity at design, specification, development, validation and deployment phases with respect to more standard interactive systems.

To support designers and developers of interactive systems exhibiting autonomous behaviors, it is critical to go at the lowest level of details as possible, as this is where the devil hides. This is not new for interactive systems designers as, for instance, animation is a very good example of automation (only at the output level) and it is known that design, tuning, programming and ensuring graceful degradation is critical [5].

Instead of the classical high-level view on automation usually adopted by Human Factors specialists as well as by funding agencies where higher-level of automation [6] is a requirement[1], we argue that it is of prime importance to understand the anatomy and the physiology of automation. The discussion during the presentation will not be an anatomy lesson as the one on Figure 1, but an anatomy investigation on automation. With a better understanding of the organs and their functions, solutions can be found from design to deployment, ensuring that cooperation and collaboration with the partly autonomous interactive system meets all the required properties both from HCI domain (e.g. usability, user experience and learnability) and dependable computing (e.g. reliability, resilience, certification).

I will try to demonstrate that integrating these usually conflicting properties brings challenges at every level of interactive systems architecture and require pluri-disciplinary skills to address them. Illustrative examples will be taken from multiple application domains (such as aircraft cockpits, air traffic management, satellite ground segments and desktop applications) that we have studied for more than two decades.

[1]See page 5: 17 projects and 13 PhD funded by SESAR Joint Untertaking towards higher automation levels in aviation http://www.sesarju.eu/sites/default/files/documents/events/sesar2020-20150504/3_SESAR2020_ER_Info_Day_FV_David_Bowen.pdf

2 BIOGRAPHY

Philippe Palanque is professor in Computer Science at the University Toulouse 3 and is head of the ICS (Interactive Critical Systems) research group at IRIT. Since the early 90's his research focus is on interactive systems engineering proposing notations, methods and tools to integrate multiple properties such as usability, dependability, resilience and more recently user experience. These contributions have been developed together with industrial partners from various domains such as civil aviation, air traffic management and satellite ground segments. He is now involved in the specification of future interactive cockpits and in the modelling of operational states of civil aircraft (with direct support from and close collaboration with Airbus). He has been working in the area of automation for more than ten years. He was a member of the SESAR Higher Automation Levels in Aviation network of excellence and paper co-chair of ATACCS (Application and Theory of Automation in Command and Control Systems) 2015 conference. He is the secretary of the IFIP Working group 13.5 on Resilience, Reliability, Safety and Human Error in System Development and is steering committee chair of the CHI conference series at ACM SIGCHI. He is a member of the CHI academy and chair of IFIP Technical Committee on Human-Computer Interaction (TC13). He edited and co-edited more than twenty books or conference proceedings including the "Handbook on Formal Methods in Human-Computer Interaction" published by Springer in 2017.

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