

How to Design and Assess Automation for Interactive Applications and Interaction Techniques

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ABSTRACT

This course takes both a practical and theoretical approach to introduce the principles, methods and tools for automation design. Automation is pervasive in interactive applications as it can high benefits to the users. However, bad designs jeopardize these benefits and induce human errors (e.g. automation surprises). This course will explain how to design automation and how to assess its pros and cons in terms of user-related properties such as usability, user experience, acceptance or trust. Examples are taken from industries that have been embedding automation in their systems for a long time (such as aviation, automotive, satellite ground segments . . .) and interactive hands-on exercises will explain how to "do it right".

1 INTRODUCTION

Automation may be defined as the execution of activities by something else than a human including sensing, analysis, decision and action. Automation takes place in the real world (e.g. gravity or time passing). Industrial revolution with mechanics and more recently computing systems have provided multiple means to support human activities. Early approaches in automation were focusing on allocating basic functions to the best player (e.g. Fitts' approach Machine Are Better At – Men Are Better At) [5] and more than 50 years later these findings were still used and transposed to computing systems [15]. Such concept of allocation of function to best actor was however deeply criticized in [16] as it misses (among others) the perspective of teamwork between automation and the operator. Indeed, migration of tasks come with additional concerns such as control transitions, authority and responsibility [23].

Standard interaction techniques encompass complex mechanisms (e.g. modification of the cursor's movement on the screen according to the acceleration of the physical mouse on the desk). The design of Interaction techniques represents a large design space

that has been for a long time explored by HCI researchers in order to improve performance of users, such as automatically rearranging objects occluded by the hand in touch interfaces [24] or augmenting and reducing size of menu items according to the proximity of the mouse cursor [25].

This demonstrates the need to include automation while designing interactive systems. This course focuses on the use of the concept of automation for interaction design and for interactive systems design. It advocates the point of view of automation as a design alternative resulting on the migration of actions previously performed by users to actions performed by a system. Current push in automation is towards fully autonomous systems (such as Tesla cars) raising critical issues such as: how to make it possible to users to foresee future states of the automation, how to disengage automation or how to make sure that users are able to take over when automation fails Beyond, introducing automation in users' work and activities changes deeply its own nature getting closer and closer to supervision, which is a different interaction and work paradigm. Another push is related to the introduction of AI-based technologies as a mean for implementing automations, while the course will introduce the benefits and limitations of this technology, it will not be a core element of the course.

This course builds on top of this perspective adopting the human-in-the-loop perspective and considering automation as an artefact supporting operators' work and users' tasks and not a goal per se with the underlying objective or getting rid of the users that are a source or errors as detailed in [19].

Supervision activities are very different from directly performing activities and the migration of activities to the system might have severe consequences:

- in terms of overall performance of the couple (user, system),
- in terms of skilling (and especially deskilling) [9],
- in terms of errors related to the very nature of human behavior [8], in terms of training [4] . . .

2 CONTRIBUTION AND BENEFIT

This course will provide newcomers with background knowledge in automation. It provides an overview on how the recent advances in automation can be exploited to design and assess interactive applications and interaction techniques. This course will also provide material for lecturers who want to include automation in their HCI courses. Finally, the course will provide examples from various domains including Aviation, Air Traffic Management, Automotive, Nuclear Power Plants . . . highlighting both successes and failures of automation. Concrete examples and exercises will also be provided to support the application of the course elements to practical cases.

3 OBJECTIVES

On completion of this tutorial, attendees will:

- Know the intrinsic and extrinsic characteristics of automation, [2, 5, 10],
- Be able to use AFAR paradigm (Allocation of Functions, Authority and Responsibility) [13] when designing and assessing automation for interactive systems,
- Know the RCRAFT framework that extends AFAR to incorporate Control Transition design and Resources [23],
- Know many examples on how automation has been used in various domains such as automotive, aviation, Air Traffic Control, space domain . . . [7, 11],
- Know and understand that automation is already pervasive in interactive systems and that the consequences are usually underestimated [2],
- Have experience in analyzing an interactive systems focusing on the tasks users have to perform with it and how automation impacts user's work and activities,
- Know the main objectives of automation and the design rules that must be followed to design usable partly-autonomous interactive systems [18],
- Know the limitations and the benefits of adding automation in interactive systems [12].

4 DESCRIPTION AND CONTENT

This course focuses on the foundations of automation and how this concept can be used while designing and assessing interactive systems

- Introduction to automation, its basic principles and how this concept can be decomposed in components [10]. Beyond, we will present the analysis of multiple CHI papers that proposed new interaction techniques adding automation (usually without acknowledging the proposal as steps towards more autonomous interactions),
- Basic principles for describing user activity and tasks (hierarchical view on human activities, abstraction and refinement, temporal ordering, objects, information and knowledge . . . [6] and also about human activity with a focus on automation [14],
- Overview of automation designs and how they are pervasive in interactive systems and interaction techniques as well as their desired properties (intelligibility, transparency [2], continuity [20] . . .),
- Overview of automation principles that are used and deployed in various domains as well as their intended objectives (enhance user, protect the user via safety or security nets, increase user comfort, entertain used, protect against automation . . .),
- List of design principles for the identification of users' activities that could be good candidates for task migration towards automation, authority sharing, impact of automation degradation on tasks performance),
- Taking into account human errors [1] at design time as well as possible degradation of automation [3] to assess relevance of automation in a given context (identification of types, location and likelihood of human errors).

5 AGENDA

This course is composed of one single course unit going from conceptual to very practical. It includes interactive hands-on exercises, case studies and practice on automation design and assessment in the content of interactive systems design.

6 AUDIENCE AND PREREQUISITE

This course is open to researchers, practitioners, educators and students of all experience levels. No specific skills or knowledge are required beyond a background in User Centered Design. Paper [14] should be read before attending the lecture.

7 COURSE BACKGROUND

Three closely related courses have been given at CHI, but content and philosophy of this one is very different. This "fourth" edition takes into account the feedback from participants of the previous editions and thus focusses on Design aspects. The first course was about "Designing and Assessing Interactive Systems Using Task Models" (it was given at CHI 2015 and was using automation as a design alternative for tasks allocation) [17]. Feedback from participants showed that they would have a strong interest in automation per se (both foundations and applications) with a focus on autonomous cars. A second course was proposed at CHI 2018 about the risks and benefits of higher levels of automation and was entitled "Automation: Danger or Opportunity? Designing and Assessing Automation for Interactive Systems" [12]. A Third course entitled "Introductory Course on Automation and its Use for Interactive Systems Design and Engineering" [21] focused on engineering aspects and the foundations of automation. Again, feedback from attendees showed another interest in the foundations of automation and basic concepts for first time encounter with automation. This fourth course focuses on the use of automation in interaction design and in user interface design which was only touched by some examples of successes and failures in previous courses. The course will exploits recent advances in that area and will exploit objectives and design rules for automation [22] A longer version of this course it taught at Eurocontrol¹.

8 PRACTICAL ACTIVITIES

Various exercises will be given to the attendees. Exercises will consist in analyzing the automation in interaction technique presented at HCI conferences e.g. mouse acceleration or fisheye menus. Then the attendees will be faced with design activities proposing automations and assessing them.

9 INSTRUCTOR'S BACKGROUND

Philippe Palanque is professor in Computer Science at the University Toulouse 3. Since the early 90's his research focusses on interactive systems engineering proposing notations, methods and tools to integrate multiple properties including usability, dependability, resilience and user experience. He has been working on automation for more than twenty years, was a member of the SESAR Higher

¹<https://trainingzone.eurocontrol.int/ilp/pages/coursedescription.jsf?catalogId=896431&courseId=6629160>

DAutomation Levels in Aviation network of excellence and paper co-chair of ATACCS in 2015 (Application and Theory of Automation in Command and Control Systems). He is a member of the steering committee CHI conference series, is a member of the CHI acad-emy and chair of IFIP Technical Committee on Human-Computer Interaction (TC13).

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