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The Adaptive Automation Design

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1. Introduction

During last years Adaptive Automation (AA) has received considerable attention in the academic community, in labs, in technology companies, because of the large use of automation in several domains (e.g. aviation; manufacturing; medicine; road, rail, and maritime transportation). AA is a potential solution to the problems associated with human-automation interaction, regardless of the complexity of the application domain.

The adaptive automation concept was firstly proposed about 30 years ago (Rouse, 1976), but technology has provided the empirical evidence of its effectiveness in more recent times. Several studies have shown that adaptive systems can regulate operator workload and enhance performance while preserving the benefits of automation (Hilburn et al., 1997; Kaber & Endsley, 2004; Moray et al., 2000; Prinzel et al., 2003). Still, inappropriate design of adaptive systems may even bring to a worse performance than full manual systems (Parasuraman et al., 1999). Therefore, methods and skills for designing adaptive automation systems should be fully mastered, before taking the implementation step.

Before analyzing the concept and impact of adaptation features, the meaning and definition of automation should be defined, in order to stress how human characteristics and limitations influence the use (or misuse) of automation

Andy Clark (2003) successfully tried to summarize the technological relationship between human and automated system: "humans have always been adept at dovetailing our minds and skills to the shape of our current tools and aids. But when those tools and aids start dovetailing back – when our technologies actively, automatically, and continually tailor themselves to us just as we do to them – then the line between tool and human becomes flimsy indeed".

Several researchers tried to define what adaptive automation is, using different and complementary concepts. In order to achieve a complete, if it is possible, definition of adaptive automation, it is needed to analyse the definition and the implication of automation itself.

AA aims at optimizing the cooperation and at efficiently allocating labor between an automated system and its human users (Kay, 2006) and it can be considered as an

alternative method used to implement automation in a system, whose purpose is to bridge the gaps of traditional automation.

AA refers to systems in which either the user or the system can modify the level of automation by shifting the control of specific functions, whenever specific conditions are met. In an adaptive automated system, changes in the state of automation, operational modalities and the number of active systems can be initiated by either the human operator or the system (Hancock & Chignell, 1987; Rouse, 1976; Scerbo, 1996). In this way adaptive automation enables the level or modes of automation to be tied more closely to operator's needs at any given moment (Scerbo, 1996).

2. From automation to adaptive automation

Automation refers to "systems or methods in which many of the processes of production are automatically performed or controlled by autonomous machines or electronic devices" (Billings, 1997). Automation may be conceived as a tool, or resource, that allows the user to perform some task that would be difficult or impossible to do without the help of machines (ibidem). Therefore, automation can be conceived as the process of substituting some device or machine for a human activity (Parsons, 1985).

Besides the conceptual definitions, a starting point for the understanding of what automation is, is the theoretical work of Sheridan about the Levels of Automation (LoA) (Parasuraman et al., 2000). LoA represent the 10-point scale which describe step by step the automation continuum of levels1. This approach takes into account the control assignment of the system between the human and the machine, focusing on the participation and the autonomy that humans and machines may have in each task to be performed. In the Sheridan model the human machine interaction is particularly stressed; the purpose is to find the best level that fits human needs, in order to maximise the system performance and to optimize its use2. Billings (1991) instead focuses his attention on automation at work: how automation may correctly perform some activities or parts of them, how automation may interact with humans or support them in their tasks. Billing (ibidem) defines LoA in functional terms: a level of automation corresponds to the set of function that an operator can autonomously control in a standard situation united to system ability at providing answer and solutions, at acting properly according to the proposed solution, and to check the results of its actions.

Tightly coupled with Billings definition are Rouse's observations (1988): the adaptive automation provides variable levels of support to human control activities in complex systems, according to the situation. Moreover, the situation is defined by the task features and by the psychophysical status of human operator. As a consequence, the human machine interaction should depend on what has to be automated, and on how and when this should

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[1] This model (Parasuraman et al., 2000) is made of ten levels: 1) the computer offers no assistance: human must take all decisions and actions; 2) the computer offers a complete set of decision/action alternatives, or 3) narrows the selection down to a few, or 4) suggests one alternative, 5) executes that suggestion if the human approves, or 6) allows the human a restricted time to veto before automatic execution, or 7) executes automatically, then necessarily informs the human, and 8) informs the human only if asked, or 9) informs the human only if it, the computer, decides to 10) the computer decides everything, acts autonomously, ignoring the human.

occur. Through empirical studies Rouse (1977) showed the advantages of implementing AA; specifically, AA allows a dynamic roles and tasks definition that is consistent for the operators and inserts into the system the capability to maintain adequate the human mental workload operating with the system.

The importance of the operator's psychophysical status is a crucial aspect examined by Parasuraman et al. (1992): the AA is the best combination between human and system abilities. This combination, or more properly integration, is leaded by a main decision criterion: the operator mental workload. In fact the first adaptive automation systems were implemented in associate systems based on models of operator behavior and workload (Scerbo, 1996). Particularly, the adaptive automation research has primarily focused on evaluation of performance and workload effects of dynamic allocations of control of early sensory and information acquisition functions as part of human-machine system operations (Kaber et al., 2002). There are several studies reviewing empirical researches about AA (Parasuraman, 1993), (Hilburn et al., 1993), (Scallen et al., 1995), (Parasuraman et al., 1996), (Kaber, 1997), (Kaber & Riley, 1999) that focused on the performance effects of Dynamic Function Allocation (DFA) in complex systems, specifically monitoring and psychomotor functions. These studies brought into evidence that AA significantly improves monitoring and tracking task performance in multiple task scenarios, as compared to static automation and strictly manual control conditions.

A further development for AA systems is the Neuroergonomics approach, which uses psychophysiological measures to trigger changes in the state of automation. Studies have shown that this approach can facilitate operator performance (Scerbo, 1996). Less work has been conducted to establish the impact of AA on cognitive function performance (e.g., decision-making) or to make comparisons of human-machine system performance when AA is applied to various information processing functions (Kaber et al., 2002).

AA carries all the established levels of automation: Scerbo (1996) specifies that the AA can start different types of automation, in relation with the context (system and operator). An integration to this conclusion is provided by Kaber and Riley (1999), which defined adaptive automation as a programming or a pre-definition of the control assignment between human and system, in order to improve the human performance. Human performance is in fact a crucial aspect of the functioning of complex system. As a consequence, the human operator should be involved in the control task, in order to avoid the out-of-the-loop performance. As stated by Norman (1989), without appropriate feedback people are indeed out-of-the-loop; they may not know if their requests have been received, if the actions are being performed properly, or if problems are occurring. Sharing the functions control is not only a matter of quantitative task to accomplish, but it involves the responsibility of the whole operation execution.

The dynamic function allocation (DFA) is a peculiar aspect of AA (Kaber et al, 2001). It basically consists of assigning the authority on specific functions to either the human operator or the automated system, depending on the overall context (i.e. operator's state and outer conditions) and on a defined set of criteria. DFA should therefore be designed by taking into account both the human and the system status, and considering the means for allowing context recognition.

Focusing on the participation and the autonomy that humans and machines may have in each task to be performed there is some debate. Some researches face the crucial issue of the authority that each part should have in controlling the system. Historically, humans played

the role of the supervisory control i.e. the machine decides about the actions and the humans evaluate these decisions; depending on this assessment, control on the actions is either regained by human operators or provided (Sheridan, 1992). In this effort a crucial role is played by the human skills and abilities and by the systems natural limits (Parasuraman et al., 2000).

There is a clear difference between the AA approach and the Level of Automation (Kaber & Endsley, ibidem). By contrast with the traditional view of automation that is shortly a fixed and highly regulated process designed to eliminate human interaction, AA is designed to expect and anticipate changes under active control of a developer while maintaining precise control of all background variables not currently of interest (Kay, 2006). AA is based on the dynamic allocation of the control of the whole task or of some parts, crossing along time manual and automated phases. The Levels of automation instead allow only a static function assignment, because the task level of automation is established in the design phase (Kaber & Endsley, ibidem). AA allows users to experiment with variables seen as key parameters in a system while preventing undesired secondary effects that could unexpectedly arise from variations in parameters not under study, which in manual systems might not be precisely controlled. Through adaptive automation, developers gain flexible control of parameters under study and confidence as well as automatic control of the rest of their systems (Kay, 2006). In this way, adaptive automation can be considered as a design philosophy with a heavy impact on the technological development. Rather than focusing on repetition of the same events, adaptive automation focuses on flexible process design and rapid process development. AA allows process development facilities to move beyond limited "automated instrument" development into a more fully integrated "automated process," in which individual instruments become part of a universal, fully-automated cycle (Kay, 2006).

3. Adaptation and the problem of authority: from the delegation metaphor to the horse-rider paradigm.

An accurate automation design includes an high level of flexibility, in order to allow the system to perform different operational modes, according to the task or to the environment. The flexibility level determines the type of system: adaptive automation systems can be described as either adaptable or adaptive. In adaptable systems, changes among presentation modes or in the allocation of functions are initiated by the user. By contrast, in adaptive systems both the user and the system can initiate changes in the state of the system (Scerbo, 1996). The distinction between adaptable and adaptive technology can also be described with respect to authority and autonomy. "As the level of automation increases, systems take on more authority and autonomy. At the lower levels of automation, systems may offer suggestions to the user. The user can either veto or accept the suggestions and then implement the action. At moderate levels, the system may have the autonomy to carry out the suggested actions once accepted by the user. At higher levels, the system may decide on a course of action, implement the decision, and merely inform the user (…). In adaptive systems, on the other hand, authority over invocation is shared. Both the operator and the system can initiate changes in state of the automation".

There is some debate over who should have control over system changes: the debate arises about the final authority on the control process: some researchers believe that humans

should have the highest authority over the system, because s/he has the final responsibility of the whole system behaviour. This position is supported by the conviction that humans are more reliable and efficient in the resources and safety management when they encompass the control over the automation change of state (Billings & Woods, 1994; Malin & Schreckenghost, 1992). To ensure the safety of the system is the issues about. However, it may be that strict operator authority over changes among automation modes is always justified. There may be times when the operator will be not the best judge of when automation is needed. Scerbo (1996) argues that in some hazardous situations where the operator is vulnerable, it would be extremely important for the system to have authority to invoke automation, because, for example, operating environments change with time, and it may not be easy for humans to make correct decision in a changed environment, especially when available time or information is limited (Inagaky, 2003) or when operators are too busy to make changes in automation (Wiener, 1989). The authority shared between humans and machines becomes a question of decision during design.

It is important to notice that human and automation roles are structured as complementary: one of the main approach to human interaction with a complex system is "delegation", that is patterned on the kinds of interactions that a supervisor can have with an intelligent trained subordinate. Human task delegation within a team is in fact an example of adaptable system, "since the human supervisor can choose which tasks to hand to a subordinate, can choose what and how much to tell the subordinate about how (or how not) to perform the subtask s/he is assigned, can choose how much or how little attention to devote to monitoring, approving, reviewing and correcting task performance, etc." (Miller et al., 2005).

Despite this such a system shows also adaptive elements in its behaviour. Delegating a task to a subordinate (in this case the automation), the subordinate may have at least a partial authority to determine how to perform those task. Moreover a good subordinate may have opportunities to take initiative in order to suggest tasks that need to be done or to propose information that may be useful (Miller et al., 2005). Note that the main difference between task delegation as performed by a supervisor and task allocation performed by a system designer has been that the supervisor had much more flexibility in what when and how to delegate and better awareness of the task performance conditions. The system designer, instead, has to fix a relationship at design time for static use in all context (Miller & Parasuraman, 2007). To vary the quantity of control and authority is an important issue, because in the case of emergency it may be needed to rapidly transfer the control, without distraction from the outcome problem.

The control and authority variation is also a communication matter (Norman, 2008). A way the machine can communicate its objectives and strategy is to present them to the human in an explicit manner. Miller proposes the playbook metaphor, that propose a model of shared knowledge, used to communicate. The Playbook model allows humans to interact with the subordinate automated systems almost as with human subordinates, originating a type of adaptive automation.

Despite of all the efforts to create a human-machine communication, there are no real communication capabilities built into systems. As Norman (2007) states: "Closer analysis shows this to be a misnomer: there is no communication, none of the back-and-forth discussion that characterizes true dialogue. Instead, we have two monologues. We issue commands to the machine, and it, in turn, command us. Two monologues do not make a

dialogue". The collaboration and communication failure by a even more powerful technology becomes a very crucial point. Collaboration requires synchronisation and trust, achievable only through experience and understanding (Norman, 2007).

The need of sharing trust and knowledge between humans and machines leads to the so called H-Metaphor, that studies and tryes to reproduce the relationship between a horse and its rider. The "horse-rider paradigm" is introduced at first time in 1990 by Connell and Viola, then it was developed by Flemish et al (2003), that named it "H-metaphor" and faced also by Norman (2007). The "Horse-Rider paradigm" explains the relation between human and automation like the relation that a rider establishes with his/her horse: the human receives information about the actual system status through an osmotic exchange with it. Human intention and actions become the parameters the system uses to offer him the correct solution or answer to the faced context. In this way it is possible to improve the human performance that represents the crucial hearth of the interaction in complex systems. Besides the operator is maintained in loop during the system control, in order to avoid or reduce the out-of-the-loop performance.

2. Implementation of Adaptive Automation principles

The main purposes of adaptive automation are to prevent errors and to reduce the out-of-the-loop performance, preserving the adequate level of situation awareness and of mental workload (Kaber Riley, Endsley 2001).

These approaches redefine the assignment of functions to people and automation in terms of a more integrated team approach. Hence, the task control has to be shared between the human and the system, according to the situation. The adaptive automation tries to dynamically determine in real time when a task has to be performed manually or by the machine [Endsley 1996] (see figure 1).
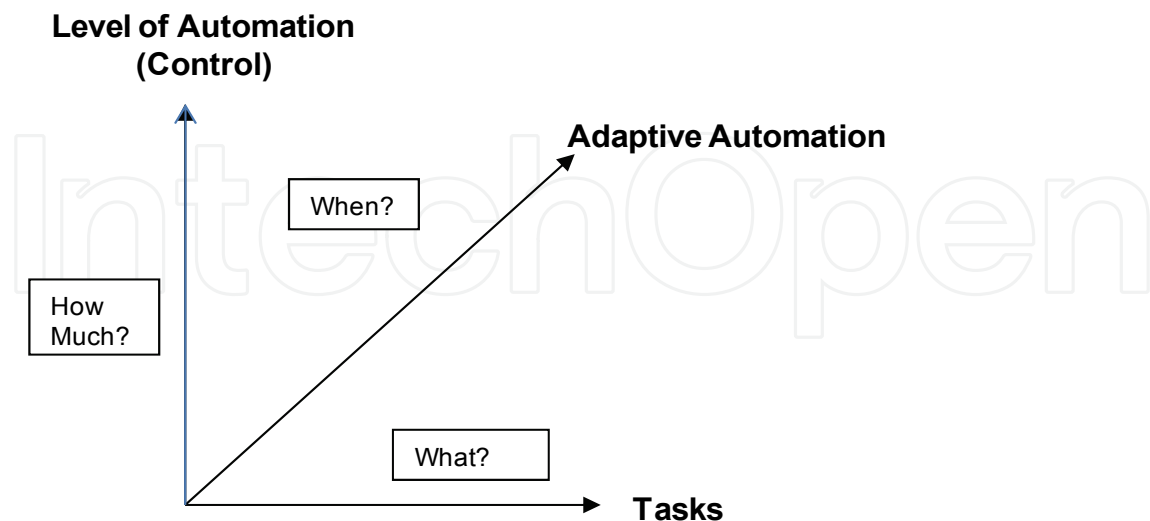

Fig. 1. *Automation Design Consideration* (Endsley 1996).

Along the axes of figure 1 are shown two orthogonal and complementary approaches: one approach (Level of Automation - Control) tries to find to optimisation in the assignment of control between the human and automated system by keeping both involved in system operation. The other (Adaptive Automation, AA, or Dynamic Function Allocation, DFA) illustrates how the control must pass back and forth between the human and the automation over time, and seeks to find ways of using this to increase human performance [Endsley 1996]. Although the adaptive automation is very promising, some problems are still unsolved, i.e. to identify the task features that determines the optimal level for the AA implementation. It has to be carefully taken into account the effects on the cognitive and physically activities, specifying the best AA implementation for each activity. Besides, the human machine interfaces have to be studied in order to support correctly the AA [Kaber, Riley, Endsley 2001]. Another difficult issues is about when AA should be invokes. It is needed to work in order to address questions of periodic insertion of automation into manual task. "Research is also needed to explore the interaction between adaptive automation and level of control – how much automation needs to be employed may be a function of when it is employed" [Endsley 1996]. It should be determined also how to implement AA, that is another controversial matter. Many systems allow operators to invoke automation, but in critical sistuaations, the human my be 1) so overloades as to make this an extra encumber, 2) incapacitaded or unable to do so, 3) unaware that the situation calls for automated assistance, or 4) a poor decision maker. Otherwise leaving the system with the authority to turn itself on and off may be even more problematic, as this forces the operator to passive accept the system decision [Endsley 1996]. The final authority may be traded flexibly and dynamically between humans and automation, because there can be the cases in which automation should have the final authority for ensuring the safety of the system [Inagaky 2001].

2.1 Human centred automation

The studies about adaptive automation share their field of interest with the researches about the human centred automation, that is a design practice that takes into account the human factors [Parasuraman, Sheridan 2000]. As Sheridan (1997) states, the human-centered automation has many

alternative meanings ranging from: "allocate to the human the tasks best suited to the human, allocate to the automation the tasks best suited to it," through "achieve the best combination of human and automatic control, where 'best' is defined by explicit system objectives." The meanings he presented span from a function-oriented perspective to a mission-oriented view. As we have explained, automated systems, have negative consequences on the human situation awareness, expecially in the understanding and projection of future states and favourites the out-of-the-loop performance. The human-centred automation will is to correct this aberrant effects typical of the technology centered automation, facilitating the human system cooperation in the control and managing of complex systems [Kaber, Endsley 2004].

The design of complex systems supporting the operator situation awareness is the bridge between human centred automation theory and adaptive automation techniques [Kaber, Riley, Endsley 2001]. Since the human centred automation claims an acceptable workload and a good situation awareness, then the adaptive automation is the vehicle for the reaching of these purposes. Hence the AA can be defined as a kind of human centred automation. On

this hand there are empirical evidence on positive effects of AA on SA and workload [Kaber 1997], on the other hand there is not a unique theory that give designer a general guideline suitable for each application field, such as aviation, automotive, rails, tele-robotics and manufacturing.

The human centred automation refers both to the system output and to the human input. Automation may involve different phase of the whole decision and action processing, that involves four main steps, and copes with the Sheridan ten-point scale of level of automation [Parasuraman, Sheridan 2000].

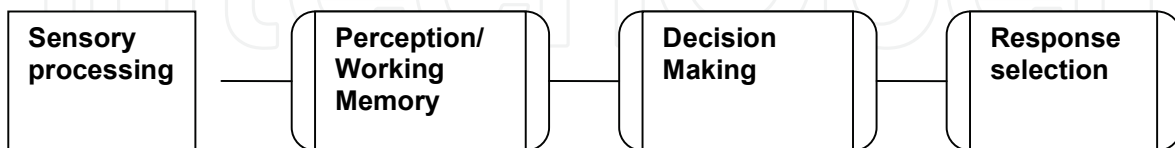| Sensory processing | Perception/ Working Memory | Decision Making | Response selection |

Fig. 1. Stages of Human Information Processing

This four-stage model is certainly a relevant simplification of the many components of human information processing as deeply explained cognitive psychologists [Broadbend 1958].

The sensory-processing phase refers to the acquisition and registration of multiple sources of information. In this stage the positioning and orienting of sensory receptors, sensory processing,

initial pre-processing of data prior to full perception, and selective attention are included. The perception/working memory phase considers conscious perception, and manipulation of processed and retrieved information in working memory [Baddadely 1996]. The decision phase involves the decision reaching based on such cognitive processing. The final action phase refers to the implementation of a response or action according with the decision choice [Parasuraman, Sheridan 2000]. Adaptive automation can be applied to the output functions of a system (automation of decision and action selection) and also to the input functions (sensory processing and perception) that precede decision making and action [Parasuraman, Sheridan 2000].

2.2 Design adaptive automation

In order to develop an adaptive system, some theoretical instruments guiding designers are available. In this paper task analysis and function allocation methods will be presented. These methods are applied during the preliminary study phase. Task analysis and function allocation both aim at matching the human abilities with the system ones, in order to automate the tasks best suited to machines and to maintain as manual the functions best suited to human (Harrison, Johnson, Wright, 2001). The task analysis is namely a graphic representation (as flow chart) of tasks and sub tasks that the operators may accomplish with the system. Once the basilar functions have been founded, they will be allocated, in order to consider the consequences of the match of functions with roles and scenarios. As Harrison, Johnson, Wright [2001] defined, a function is an activity that the man-machine system is required to be capable of performing in order to achieve some result in the domain under

consideration. From this point of view it is possible to state that Work systems perform functions or units of work. Roles, instead, are more difficult to define. They make sense to consider it as an activity that can be performed either by human or machine (Harrison, Johnson, Wright, 2001).

The York Method (developed at the Department of Computer Science, University of York) provides theoretical instruments to define functions, rules and scenarios, and then represents them by some specific grids. The aim is to decide which functions are suitable to which rules, considering different scenarios [Calefato, Montanari, Tango 2007]. "A function may be separable from all roles, and technically feasible and cost effective to automate, in which case the function may be totally automated. Alternatively it is possible that the function maps entirely to one of the roles, and is infeasible to automate, in which case the function is totally performed within that role. In most cases however functions fit into neither category. In this situation the function is to be partially automated" (Harrison, Johnson, Wright, 2001). Functions and roles have to be set into one or more scenarios.

The scenario development process involves several steps [Calefato, Montanari, Tango 2007] : 1) identification of goals and objectives; 2) scenario definition, including specifications and development of needed model elements and performance measures; 3) preparation of specific component models; 4) program specific performance measures; 5) scenario programming; 6) testing, upgrading and validating of the system on the chosen scenarios. In taking into account the driving scenario, it has to be measured the driver's competences in tasks critical to performance and safety.

These concept can be clarified by an example belonging to the automotive domain. We can hypnotize to have to design a preventive safety system. In order to design the application, the driving scenario and its corresponding manoeuvres have been broken down into functions and sub-functions in order to outline which functions have to be performed manually, automatically or both. Secondly, system and driver's roles have been combined with functions in order to outline which functions suite best to which roles, considering the given scenarios. The scenarios have been selected in order to measure the driver workload and situation awareness. Consequentially the selected scenario shows the whole behaviour of the system, along the seven LoA implemented [Calefato, Montanari, Tango 2007].

3. Side effects of automation

Despite of the wide advantages of automation such as the increased capacity and productivity, reduction of small errors, manual workload and mental fatigue, the relief from routine
operations, and decrease of performance variation due to individual differences, there are several drawbacks that must be taken into account. Since automation brings same changes in the task execution (i.e. setup and initialization), in the cognitive demands (i.e. requirements for increased situational awareness), in the people roles related to the system (i.e. relegating people to supervisory controllers). Beside a decrease of job satisfaction automation lead to a lowered vigilance and an increased mental workload, fault-intolerant systems, silent failures, false alarms. This framework is strictly connected with other

negative effects due to the human interaction with the system: over-reliance, complacency, over trust and mistrust, manual deskilling [Prinzel 2003].

Nowadays the adaptive automation is claimed as the solution for the problems inducted by the automation. In this paper we aim to show how the adaptive automation may be successfully used in the design of automotive user interfaces that control automatic or partially adaptive systems, named ADAS (Advanced Driver Assistance Systems).

4. Automotive applications: preventive safety systems

One of the most important application field of the adaptive automation design principles is the automotive domain, where the preventive safety approach is applied in the designing of the driving task, turning the automation in a safety tool. The ergonomic studies about the driving safety are a wide and well-known field (Campbell et al. 1998; Mariani, Bagnara, Montanari 2001; Bekiaris et al. 2003; Green 2003). Particularly, the systems that foresee the integration of automation elements into the driving task (i.e. the ACC, adaptive cruise control) are studied by the information ergonomics, that deals with the improvement of signalling and command devices whose efficient information is often crucial. It is specifically the case of in-vehicle information systems (IVIS), that nowadays include also the nomadic devices, like pocket pc and mobile phones; of the new integrated dashboards, that show the driver, apart from traditionally information (such as speedometer, odometer, rev counter, etc.), other information about the trip (instantaneous consumption, fuel autonomy, covered distance, direction to follow, etc.); of innovative commands like haptic devices or vocal commands.

These systems are based on several technologies: sensing technologies for environment perception, in-vehicle digital maps and positioning technologies, wireless communication technologies

One of the current research area in automotive is aimed at improving driving safety with regards to the development of so-called preventive warning systems, also called ADAS (i.e. Advanced Driver Assistance Systems). These are systems able to detect an incoming dangerous in advanced, allowing a time to perform a repairing manoeuvre. ADAS (Advanced Driver Assistance Systems), thanks to their sensors, are able at monitoring the external environment and if a critical situation is detected, and at alerting the driver about a possible danger (Berghout et al. 2003), supporting him/her in several driving tasks. The driver needs to be supported with scenario and task information especially when some dangerous events can occur all-around the vehicle, because preventive information can improve the road-safety, such as in the case of the collision avoidance system and of blind spot systems. Other situations that can be supported by ADAS are low visibility (night vision systems) or correct driving behaviour handling (lane keeping or lane warning).

The solution offered by AA can be applied not only to the automatic functions but also to the user interface that manage them. There may be interesting solutions of dynamic adaptation of interface to the external context and to the user psychophysical condition. An contemporary research field is about the introduction of dynamic displays into adaptive system interfaces. Dynamic displays allow *ad hoc* configurations of informative needs and of interaction styles. For instance, dynamic in-vehicle displays can provide specific interface features on the basis of the time of the day, like what happens with the night modality of

navigator displays, which invert their colours. Flexible display configurations that satisfy driver's information needs are able at improving the situation awareness and the driving performance (Calefato, articolo di HCI).

It comes into evidence the importance of the design of in-vehicle interfaces to carefully evaluate which kind of information to take into account. From the human side the choose is among visual, auditory, and haptic information. From the automation side the choose is among psychophysical information: i.e. workload, situation awareness, distraction, ecc.

From the human factors point of view (Green 2003), driving is considered as a complex cognitive task that can be summarized by four main sub-processes: perception, analysis, decision and action. To be performed, each phase presumes the achievement of the previous one.

ADAS, both the prototype and the devices already available on the market, alert the driver by visual, acoustic and tactile alarms that a critical situation has been detected, but they also modify the driver behaviour: the driver is earlier warned about dangers, but as it happens with automation, the same warnings may interfere with the driving task (Wickens 1984; 1989), augmenting the driver's mental workload, often already high (De Waard 1996) and favouring the failure of the whole human-machine system.

The European Project PREVENT (www.prevent-ip.org) has been dedicated to developing of preventive safety applications and technologies, able to help drivers to avoid or mitigate an accident through the use of in-vehicle systems which sense the environment and the importance of a possible danger, taking also into account the driver's state. Preventive safety makes use of information, communications and positioning technologies to provide solutions for improving road safety. Generally speaking, the PREVENT technologies should progressively act, according to the significance and timing of the threat. The preventive applications have to early inform the driver, warn him or her if no repairing manoeuvre has been undertaken, and finally actively assist or intervene in order to avoid an accident or mitigate its consequences. The main applications taken into consideration by these researches are:

- maintaining a safe speed
- keeping a safe distance
- driveing within the lane
- avoiding overtaking in critical situations
- safely passing intersections
- avoiding crashes with vulnerable road users
- reduce the severity of an accident if it still occurs

Apart from ADAS, other new in-vehicle technologies are being introduced on the market: they are the In-Vehicle Information Systems (IVIS), that are often connected with a wide range of nomadic devices (i.e. mobile phones, personal digital assistants and other portable computing devices). The use of these technologies can be a benefit for the road safety enhancement. On one hand IVIS and nomadic device provide in-vehicle access to new information services, on the other hand they may induce dangerous levels of workload and distraction. The general objective of another relevant EU project named AIDE is to generate the knowledge and develop methodologies and human-machine interface technologies required for safe and efficient integration of ADAS, IVIS and nomad devices into the driving environment (www. aide-eu.org). More in details AIDE aim is to develop innovative

technologies able to maximise the efficiency and the safety benefits of preventive safety system and minimize the side effects of IVIS, and finally to reduce the level of workload and distraction induced by the even more complex cockpit.

5. Conclusions

After considering the positive effects of adaptive automation implementation, this chapter focuses on two partly overlapping phenomena: on the one hand, the role of trust in automation is considered, particularly as to the effects of overtrust and mistrust in automation's reliability; on the other hand, long-term lack of exercise on specific operation may lead users to skill deterioration. As a future work, it will be interesting and challenging to explore the conjunction of adaptive automation issues and neuroergonomics, multiple and intelligent user interfaces, distributed cognition.

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Human Computer Interaction: New Developments

Edited by Kikuo Asai

The book consists of 20 chapters, each addressing a certain aspect of human-computer interaction. Each chapter gives the reader background information on a subject and proposes an original solution. This should serve as a valuable tool for professionals in this interdisciplinary field. Hopefully, readers will contribute their own discoveries and improvements, innovative ideas and concepts, as well as novel applications and business models related to the field of human-computer interaction. It is our wish that the reader consider not only what our authors have written and the experimentation they have described, but also the examples they have set.

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