

Is there still a need for CTW?

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1 Introduction

A changing of the editorial guard at CTW is a good moment to reflect on the research domain addressed by the journal and on what new challenges the research community in people, technology and organisations might need to address. So we take this opportunity to look back over the last 15 years and to identify some new opportunities for research in the area of interaction between technology and people, focussing on two areas that are fundamental to the journal.

2 Looking back

In 1999, when CTW started, the main mission of the Journal was “to bring together research that normally resides on the borderline between people, technology and organisations...” Its main focus was identified as “the study of people at work from a socio-technical and cognitive systems perspective” which demanded “research in background disciplines such as cognitive systems

engineering, human factors and cognitive ergonomics... at both a theoretical and a practical level” (Hollnagel and Cacciabue 1999). This mission was associated to a “*credo*”: respect for Intellectual Property and emphasis on quality of work as being the leading influences guiding the selection of topics and the excellence of contributions, in all domains of application. The result is that CTW can be seen as a “window” into the impact of human factors and cognitive science in designing, developing, assessing and validating different working contexts, where collaboration between actors is essential, independently of the fact that they are humans or machines.

There are different ways to evaluate what the Journal has achieved in these almost first 15 years of publication. One possible way is to follow the image of a window over the areas and domains of interest and scan through the journal issues. Focusing on domains of application, it is possible to look for energy/nuclear production (CTW, 2 (4), 2000; CTW, 15 (1), 2013), process and chemical industry (Salo and Svenson 2003; Baranzini and Christou 2010), manufacturing industry (Barroso and Wilson 2000; Upton et al. 2010), road transport (CTW, 8 (3), 2006a, b), maritime transport (Itoh et al. 2001; van Westrenen and Praetorius 2014), rail transport (CTW, 8 (1), 2006a, b) and aviation (Dekker and Woods 1999; Masson and Koning 2001; Rashid et al. 2013), household (CTW, 5 (1), 2003), healthcare (McCarthy and O’Connor 1999; Xiao and Sanderson 2013; Parush et al. 2014) and social services and emergency management (Militello et al. 2007; Kylesten and Nählinder 2011). Although in some cases the societal impact of certain events has increased the attention on specific issues (Johnson 2005), in general, the need to keep under attention the role of humans in managing systems and interacting with the actual control systems of real processes has always been favoured.

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Focusing on application areas, the impact and human contribution at the level of design, risk assessment and evaluation of plants has been the main locus of attention. In particular, the aim to for methods that go beyond the more established approaches associated to the concepts of “classical” HMI interaction and automatic control, has been constantly fostered, considering collaborative activities and distributed systems (Dekker and Woods 2002; Shalin 2005; Inagaki 2006; Vanderhaegen et al. 2006; Smith et al. 2007; CTW, 15 (1), 2013), cognitive systems engineering (Norros and Salo 2009; Inagaki 2010) and coordination in high-risk organizations (Grote et al. 2009), etc.

At a technical level, several topics involve the role of the joint-cognitive system of humans and control systems, primarily: decision-making, human machine interfaces, field studies and human related conditions that affect behaviour and error making, such as stress, workload, emotions and sensations. All of these aspects have always been popular. Decision-making—in particular in dynamic conditions—and team interaction have been constantly present and still play a very important role (Rogalski 1999; Kontogiannis 1999; Johnson 2002; Roth et al. 2004; Vanderhaegen 2010; Karikawa et al. 2013). Moreover, it can be noticed that emotional and personality factors have gradually become more and more relevant in different domains (Saad 2006; Nemeth 2007; Cacciabue and Cassani 2012; Perry and Wears 2012; Barnard et al. 2014).

All the above-mentioned studies are associated to theoretical frameworks, methods and modelling. In CTW, these elements have always been placed at the centre of the manuscripts that have been published. The idea is that any practical implementation must be sustained by a solid framework built on a theoretical method or model. Then, these must be described so that they can be applied or replicated by others in different domains for similar problems. In particular, attention has been placed on “new” methods and techniques of relevance for CTW. Therefore, in addition to the “typical” focus on joint-cognitive modelling and human reliability (Woods et al. 2002; Dekker and Hollnagel 2004; Healey and Benn 2009; Cacciabue 2010), special attention has been dedicated to theories and methods associated to Cognitive Work Analysis (Turner and Turner 2001; Miller et al. 2006; Xiao and Sanderson 2013), Ethnography (Farrington-Darby and Wilson 2009) and Resilience Engineering (Woods and Cook 2002; Re and Macchi 2010; Nemeth et al. 2011; Nemeth 2012; Hollnagel 2012).

Several questions can be raised at this point. As an example: has CTW achieved and fulfilled its alleged mission? It is not really up to the editors to respond, but certainly the Founding Editors have sought to work with dedication in that direction. Another important question

may be whether it is possible to improve and/or whether CTW has a perspective? In both cases, the answer is simple and immediate. Yes, it is possible to improve, as improving is at the very heart of research and as long as there are “authors”, we can expect that they will provide better and better research in favour of mankind and science, and consequently better papers and manuscripts. In terms of perspective, we believe that CTW has a long future, as the subject matter of the journal is associated with human beings, their working contexts and “their tools”. These three components will always exist as long as the first one of them exists. Thus, the Journal will continue to be relevant, as long as there are authors and editors willing to pass the “baton” and keep running and working with dedication (and enjoyment) as has been the case in the past 15 years.

3 What are potential new topic areas for CTW?

3.1 Automation expanding into new domains

Our era is one in which automation is becoming pervasive, smarter, more autonomous and more connected (e.g. the internet of things). Until fairly recently, the predominant domain for automation was the workplace, going back at least to the roll-out of mass production and the introduction of the assembly line in the sphere of manufacturing in the early twentieth century. In the 1950s came automation in process industries, followed by automation in system management in such areas as air traffic control and in the control of technologically advanced and expensive vehicles such as airplanes and ships. In the domestic sphere, automation tended to be trivial, involving for example the replacement of manually controlled washing machines with “automatic” machines, which actually still required a great deal of human interaction and control. Thus, most persons, if they encountered automation in any significant way, did so in the context of work or in interactions where the automation was hidden from the user as in the case of road traffic signals.

Now automation is invading every sphere of life and is almost impossible to avoid. We have connected thermostats replacing time switches in the control domestic heating and cooling, and we have the dubious pleasure of interacting with automated telephone call management centres. With far more serious implications for human factors and safety, automation is now invading personal transport, where previously it was restricted to the provision of public transport. The Google Car may in part be hype but it does represent what could become a game-changing mode of transport. We already have a the penetration of many kinds of automated support systems into the driving domain—electronic stability control, adaptive

cruise control and automated emergency braking. We are on the cusp of driving vehicles with simultaneous automation of lateral and longitudinal control. In terms of emergency situations, almost all the vehicle manufacturers are developing crash avoidance systems with both braking and swerving authority (e.g. Isermann et al. (2008); InteractIVe project), while very high automation of continuous vehicle control is soon to be on offer (e.g. Cadillac SuperCruise). We are entering this brave new world of automation in personal transport with comparatively little research on the human factors issues. Were there to be as little regulatory oversight in civil aviation as there is over the assistance and automation systems in cars and trucks, there would be an outcry. Instead, we may well see the handover of the operation of a public realm, i.e. road space, to a multitude of completely uncoordinated and perhaps even incompatible systems.

This gives rise to the question of whether we can transfer knowledge and design good practice from commercial aviation to road traffic. Of course, it makes sense to reflect on whether the lessons learned in applying automation to civil aviation are relevant to the road vehicle domain and many authors have indeed argued that there are indeed major lessons to be learned (e.g. Stanton and Marsden 1996; Young et al. 2007). However, it can also be posited that the two domains are radically different—in the number and variety vehicles in service, in the training and professionalism of the operators, in the rigour of vehicle maintenance, in the prescription of routing and speed and in the potential for interaction with humans not in mechanically controlled vehicles (see e.g. Harris and Harris 2004). One simple illustration of the striking differences between the domains of commercial aviation and road traffic is that there are some 20,000 commercial airplanes in operation worldwide, as compared to 1 billion road vehicles (Ward's Automotive 2011). So automation of driving presents new challenges and requires its own line of research.

Another trend is that automation of a serious kind with considerable authority is moving from very structured environments (aviation, production lines and chemical plants) to more unstructured domains—driving, the home, etc. In the former, organisational aspects have often been paramount (see e.g. Reason 1997) and sensible function allocation principles (Fitts 1951; de Winter and Dodou 2014) are routine. In the latter, cultural and attitudinal aspects need to be given far more consideration as to a large extent the behaviour of individuals, their error propensity and even their willingness to engage in risky behaviour may be the limiting factors. Individuals may also choose to use automation inappropriately, i.e. for reasons of personal motivation, and so transgress principles of function allocation. An example would be the use of a Lane

Departure Warning System as an aid to driving in conditions when drowsiness is likely to occur. That some drivers view LDW as an assistance for driving when tired was confirmed in a survey of users conducted in the AIDE project (Portouli et al. 2006). This is a violation of one of the basic requirements for effective function allocation between the human and the automated agent: “each agent must be allocated functions that it is capable of performing” (Feigh and Pritchett 2014). Here, we have an instance of using automation to assist in non-capable performance of driving.

This creates a need to give far more attention to individual aspects and to catering to less homogeneous populations and environments. Work on creating models of behavioural adaptation to different levels and type of automation needs to take place. It is interesting here to note that a recent review of behavioural adaptation in the driving and road safety domain hardly makes any reference at all to automation (Rudin-Brown and Jamson 2013). Models combining personality and cognitive aspects in the driving domain have been proposed (e.g. Rudin-Brown and Noy 2002; Carsten 2007; Cacciabue and Carsten 2009), but they have not been extended or applied to automation. Currently, the literature on modelling of function allocation between humans and automation tends to focus almost exclusively on cognitive aspects, ignoring behavioural issues (see e.g. Pritchett et al. 2014).

A further set of challenges lies beyond operator interaction with the vehicle or device in the area of how design should manage external interactions. For driver–vehicle units are not autonomous—they do not drive on empty roads. Drivers must continuously interact with other driver–vehicle units and with pedestrians, cyclists, motorcyclists and even animals (both ridden or steered and unriden). Automated vehicles will similarly have to interact with all these other road users. That will require not only interpretation of the intentions of the other road user, which even human drivers do not always manage successfully, but also successful interpretation of the intentions of the automated vehicle by the other road users. Here again is a field that is ripe for exploration.

Such interaction between road users and automated vehicles can be likened to human–robot interaction. Robots are escaping from the factory and will very likely permeate many aspects of daily life. They will assist the elderly and infirm, patrol the streets for crime prevention and detection, inspect dangerous locations (such as nuclear power stations), provide rescue in floods and other natural disasters and perform hard physical labour in farming. If then robots become pervasive, what are the design and human-system challenges? Will the robot-carer assisting an elderly person correctly interpret the needs of that person and will the elderly person comprehend the communications and

intentions of the robots? And will the robot know how to deal with critical and emergency situations? Will the robots require remote monitoring at all times and if so how will operator attention in the monitoring centre be maintained? These are major challenges in health care.

3.2 What are the future challenges for risk analysis?

Many papers in CTW have contributed to the development and the validation of risk analysis methods for the study of technical, human and organisational factors. Risk analysis consists mainly of identifying undesirable risks in terms of occurrence and consequences of events, and at making them acceptable by proposing new system functional specifications that suppress these undesirable risks. Various communities are involved in such a process: engineering sciences, social sciences, cognitive sciences. Several solutions can result from these analyses: the integration of technology to control particular unsafe events, the development of specific training programmes to make human operators sensitive to the management of unsafe scenarios, the control of task or function allocation between decision-makers, the definition of degrees of automation, etc. These solutions are efficient, and their associated methods are continuously being improved to expand their scope, but are they sufficient?

The use of information systems such as on-board automated systems for cars presents sometimes operational risks that were not taken into account with classical risk analysis methods. For instance, the ABS system was designed for safety reasons: it prevents the wheels from locking in an emergency braking. For most of users of this system, it is a comfort system that allows them to drive faster and reduce separation distances in the belief that it improves the braking performance of their vehicle (Vaa 2013). This is a typical dissonance between the risks assessed by the designer of a system and the risks perceived and controlled by the users of this system. The simple example shows how a system function can evolve and be different between group of people such as the designers and the users of a given system. Here, we have a case of behavioural adaptation that illustrates how the functional stability of a system is not guaranteed.

More generally, the stability of a system relates to a sustainable equilibrium of its functioning around a predefined value or point, or around an interval of points of values. Outside this given reference, the system state is unstable and any deviation from this reference generates risks that may affect criteria such as safety, productivity, quality, human workload, etc.

Classical risk analysis focuses on the identification and the control of undesirable events and aims at providing the human-machine systems with barriers in order to protect

them from the occurrence or the impact of these events. Despite these barriers, accidents remain and retrospective analyses can help the designers to identify what was wrong. Safety-based analysis can apply different methods. The RAMS-based methods (Reliability, Availability, Maintainability and Safety-based analyses) are concerned with technical failures. Human reliability or human error-based analyses focus on the success or the failure of human behaviours, respectively. Results of such analyses are mainly offline, static and mono-criterion (i.e. safety analysis) without taking into account that the field analysis made by the users or the human operators are online, can evolve over time and integrate several criteria such as safety, activity quality, or production, workloads, etc. Methods for online multi-criteria risk analysis and user-centred analysis are then required for both short-term and long-term perspectives.

More recently, resilience- or vulnerability-based methods consider the analysis of the success or the failure of the recovery control of the system stability, respectively (Hollnagel et al. 2006; Zieba et al. 2010; Ouedraogo et al. 2013). These approaches aim at identifying the technical, human and organisational factors that make a system resilient or vulnerable in the face of particular situations such as unpredictable or unprecedented events. The main difficulty for such approaches is to predict the unpredictable or the unprecedented! These approaches will be useful for designing resilient systems and take advantages of contributions from various applications: the medical domain, psychology, production systems, computer science, transport, robotics, or ecology for instance.

The design of a human-machine system requires the control of its stability, i.e. the control of its sustainable equilibrium after the occurrence or the consequences of particular events. The resilience concept is adequate for that purpose. Indeed, it relates to the management of stable or unstable states of a system in order to: to maintain the system stability whatever the perturbations; to return to a new stable state or to a previous stable state after the occurrence or the consequences of perturbations; to avoid or to recover any loss of control; to control the holistic stability of the system; or to control the individual stability of the decision-makers that may affect this global stability. Future research may then be done for such study of system stability.

However, is it correct to try to maintain stability for safety reasons? Dissonance generated artificially aims at breaking such stability and at improving knowledge by active learning (Aimeur 1998). Such a breakdown of system stability may identify risks associated with monotonous activity or repetitive activity, e.g. risks of hypovigilance, risks of inattention, or risks of human error, etc.

Dissonance engineering is another perspective for studying risks of the stability of a given system use. A cognitive dissonance is defined as an incoherence between individual cognitions (Festinger 1957). Cindynics dissonance is a collective or an organizational dissonance related to incoherence between persons or between groups of people, e.g. designers versus users (Kervern 1995). Various recent contributions on dissonance study show the current interest the scientific community has for this concept (Chen 2011; Telci et al. 2011; Vanderhaegen 2013).

The management of dissonances requires the reinforcement of knowledge by applying different strategies of learning in order to learn from negative and positive feedbacks related to dissonance management. This needs the adaptation or the development of specific learning algorithms or tools (e.g. case-based reasoning systems, neural network-based systems, genetic algorithms, etc.) to refine, modify, delete or create knowledge.

Several dissonances have already been studied: automation surprise, barrier removal, erroneous affordances, lack of sense-making, lack or loss of knowledge, etc. This list is not exhaustive and a more detailed taxonomy of dissonances and associated methods to assess these dissonances are required. This will extend the risk analysis process of a human–machine system based on the stability of some decision-makers' characteristics such as knowledge, availability, prescription, or preferences.

Future CTW contributions may then study such new challenges based on the system stability for risk analysis, regarding short-term and long-term delay of use, taking into account high and low levels of stability variation such as weak signals that are not directly perceived or not directly considered as important and that may provoke accidents.

4 Conclusion

Our view, perhaps not surprisingly is that CTW still has a vital role. The fundamental proposition which gave rise to the journal is still correct. Some new challenges have been identified above, which is only natural as technologies and methods of managing systems develop. But of course, the contributors to the journal are ingenious and will themselves generate their own new topics. We can look forward to that.

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