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Contribution of a ‘comprehensive analysis’ of human cognitive activity to the Advanced Driving Assistance devices design

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For some years now the cars manufacturers, in relation with the development of in-board electronics field, have been involved in the design of *advanced driving support systems*. The first point to underline is the necessity to describe in some details the *drivers’ cognitive activities* as experienced by them with and without these systems, in order to find the network of their *bodily, situational* (including the considered support system) *and cultural determinants*. The second point is the necessity to develop these empirical studies of drivers’ cognitive activities all along the design process, and to integrate their results at every step of it. It is what we call a ‘*comprehensive analysis’ of human cognitive activity*, of which we will outline the practical results for the design process.

Key-Words : Advanced Driving Assistance, Ergonomics, Human-Machine Interaction, Cognitive activity, Situated Cognition, Embodied Cognition, Situation Awareness

Introduction

In Europe a key-step in the design of advanced driving support devices had been the program named Prometheus (PROgraM for European Traffic with Highest Efficiency and Unprecedented Safety) which gathered together, between 1986 and 1994, cars manufacturers, car industry suppliers and transport research laboratories for working on the concept of ‘intelligent vehicle’. Advanced driving support systems are now a reality and some of them, such as navigation systems which help the driver to find and follow an itinerary, are available on vehicles recently launched on the market. The development of such systems obviously requires technical abilities. It also requires takling the question of the relevance of the technical choices made to the users’ needs. Indeed, the quality of this relevance determines, first how the drivers will accept and appreciate the new driving system, second the quality of the human-machine interaction and finally the conditions of the integration of the new driving assistance into the driving activity. Involved in the design process of several new advanced driving support systems as ergonomists, we take here the opportunity to make a synthesis of the lessons learnt from this experience (see [4], [5] and [9]).

1. Main ergonomic questions of driving support systems design

Research and development is being conducted on more and more aspects of car driving in order to design driving support systems of varying degrees of sophistication. In this context, it is useful to formalise the distinctions between these systems, as their design raises different and specific ergonomic questions. This section is devoted to this. Based on our experience and knowledge, driving support systems can be classified into two principal categories, depending on their purpose and the relationship between the system and driver that this purpose creates, each category raising particular ergonomic questions:

- *Information systems*, the main purpose of which is to provide information to the driver in more or less sophisticated ways and using different media, for example, traffic information systems or driver warning systems. More advanced systems can also be placed in this category, for example, systems which aim to provide step by step guidance to the driver for a specific type of action, such as navigation systems which assist the driver in planning and following a route, or systems giving precise instructions to help the driver perform a given manoeuvre. This category of system essentially raises ergonomic questions in relation to: defining the most appropriate information for transmission to the driver in order to help him; defining how this information should be presented (in particular warning information) and, as it becomes more widespread, how the display media should be shared between providers or systems; sharing the attention resources of drivers, which comes back in particular to the question of defining the most appropriate moments - or the ones to avoid - for transmission of this information.

- *Interactive systems*, the purpose of which is to assist the driver with one or more particular aspects of driving. These are mainly vehicle control support systems (regulation of speed, distance or the lateral positioning of the vehicle etc.) or active safety systems such as braking or trajectory control systems, etc. These systems, some of which intervene directly in the activity of the driver or reinforce his action, raise very specific questions in terms of their relationship to the driver, questions which it is not always easy to immediately answer. They sometimes result in a significant modification of the interactions between the driver, his vehicle and the environment, resulting in the following questions being asked of ergonomists, in particular: the conditions required for drivers to accept a new system or device; how the functions between the driver and a given support system should be distributed and in particular, how control of the interaction should be shared; how the system should intervene in the driver's activity so that it is integrated as effectively as possible, and constitutes real assistance and not a constraint, even if only occasional.

Of course, the boundary between these two categories of system is not clear cut. In fact, it is better to think of there being a continuum between these two categories and that a given type of system will sometimes be an information system and sometimes an interactive one, depending on the purpose of the assistance devised by its designers. Thus, a manoeuvre support system can be purely informative, for example giving the driver information on the distance separating him from another vehicle during a reversing manoeuvre or on how the wheels are positioned. It can also be designed more as an interactive system if the system directly controls the dynamic of the vehicle or movement of the steering wheel for example. Similarly, a system whose purpose is to assist the driver in staying in his lane of traffic may be "only" informative if its action is "limited" to warning the driver when he veers from the lane; it will be more of the interactive type if, once the warning is given, the system also acts directly on the steering wheel. There is also no clear cut boundary between the two main groups of ergonomic questions mentioned

above. They are in fact relevant for all systems, whatever their category, but carry different "weight". For example, the question of how information should be presented to the driver is obviously also of relevance for interactive systems, but to a lesser degree. Similarly, the question of acceptance of a new system and that of its integration into the entire driving process is applicable to information systems as well as interactive ones, but is more crucial for the latter as the resulting modification of driver / system interaction is more significant and of another type, particularly with respect to safety concerns.
For our part, we have mainly worked on driving support systems that we have described here as interactive, that is, which directly intervene in the driving process. The examples supporting our ideas in what follows are therefore particularly relevant to these systems and the ergonomic and design problems associated with them. Be that as it may, our purpose here is to discuss the fact that, whatever category of driving support system the devices we are looking to design come from, it is clear from examining the literature in this area (or the different sometimes visible technological developments which their creation has given rise to) that their design is associated with only one particular view of human activity, which may be coined as classical. However, recent scientific progress in the cognitive sciences, neuroscience, psychophysiology and psychology has contributed to the emergence of new paradigms regarding humans in activity. These paradigms are particularly interesting in light of the reappraisal of technological problems related to the design of innovative and appropriate driving support systems. If these new paradigms are taken into account, we in fact obtain a different view of human activity from the approach which still currently traditionally dominates the area of human cognition in general and, as a result, that of car driving. This different view of human cognitive activity also results in a different view of the role of technical devices in this activity. We will therefore now examine current scientific knowledge of human cognitive activity and its relevance for driving support systems design.

2. Current state of scientific knowledge of human activity and driving support systems design

In order to analyse a human activity such as car driving, and to evaluate a support system for this activity, we need to have an understanding of human activity in general and of the role that tools and other artefacts play in it. For some years now, the fields related to the study of human activity (cognitive sciences, psychophysiology, psychology, cognitive anthropology, robotics and ergonomics) have seen the development of a new emphasis on *action* and the historical, material and physical *situation* in which it takes place. We now speak of situated action, of situated and distributed cognition, of autonomous robotics, enaction and constructivism. A brief summary of this new perspective will be very useful in providing the background to our questions and analyses.

2.1. Towards an alternative vision of human activity

Firstly in the area physiology, as [1] has shown, we have moved from a physiology of reaction - or reflexology - to a physiology of action. That is, we have moved from a physiology in which stimuli are given in order to study responses, to a physiology in which we study the action produced endogenously by an animal or person on the basis of his involvement in the world at a given moment. This has become possible by the progress made in methodology. For fifty years researchers worked on anaesthetised animals by giving them stimuli and recording their reflexes. Since then we have moved from this reflexology to a physiology of anticipation, planning and action, in which action and perception cannot be separated, in which there is no perception without action. In other words, contrary to what was previously thought, the brain does not transform passive sensory information into reconstructions of objects in the world. The brain pre-specifies the objects that it wants to analyse and constructs the world on the basis of hypotheses. These ideas put forward in modern neurophysiology and experimental psychophysiology actually reflect a biological reality. In cognitive sciences, physiology, cognitive psychology and ergonomic cognitive anthropology, another parallel revolution is also occurring, namely the "reincarnation" of cognition. This is the fact that [1], [8], [3] and [6] (see also, more specifically, [2] and [7]) all respectively insist on, to quote just one work in each of these four disciplines. We are leaving an era characterised by, on the one hand, muscular energy, or humans as "human motors", and on the other, a formal study of cognition, or humans as "human computers". After the disappointments of traditional artificial intelligence, a new approach to human cognition is tending to replace the ideas of symbolic representation or mental image with those of active constitution of the perceptive experience and of coupling with a concrete situation.

In the classical approach to human cognition, cognitive activity is divided into a sequential chain of information processing operations ended by the execution of an action. This is easily understood if one sees the cognitive activity of humans as information processing. The modelling of perception, reasoning and decision-making are thus directly based on how computers operate. In the new approach that we are describing here, the actions of the person are present from the outset, in the very constitution of the perceptions themselves. Similarly, reasoning and decision-making are understood in terms of a gradual transformation of the concrete situation (material environment, bodily posture, internal memory and external inscriptions, motivations, etc.). This new approach has important consequences for how we consider the role of artefacts in human activity and in particular for understanding the use of information processing technologies. These technologies are central to the support systems that we have examined.

Many support systems are *information* processing systems which deliver *information* to the driver. However, if we no longer compare human cognition to a simple information processing operation, these two uses of the concept of information mask a confusion between sensation, perception and interpretation which should be uncovered and clarified. Information for technical computerised calculation or communication systems is a clear and well-defined concept. This is information in the sense used by Shannon, obtained by discretisation (and coding). Perception by a human cognitive system is very different. It is not the simple passive analysis of sensory data. It is created over time as a synthesis of a heterogeneous set of sensations obtained via various sensory processes on the basis of the actions undertaken. When engaged in a perceptive activity, humans are not aware of the sensations received, but their attention is placed on the object perceived. For example if we use a stick to explore our environment, we will perceive the relief of the ground at its end, where our exploratory action of moving the stick determines the changes in sensation at the level of our hand. But as soon as our attention is placed on this perception, we will not be aware of the movements and vibrations of the stick in our hand. In the same way, engaged in a visual perception, we are not aware of the extremely variable sensations received on our retina. It is at this point that one leaves the levels of analysis covered by experimental physiology and psychology for those which are covered by phenomenological psychology and ergonomic cognitive anthropology. What is perceived is not always the concrete situation in which the human activity is directly taking place. These can also be signs which then have to be interpreted, for example, the screen of the speedometer, or the terminal of a geographical guidance system. This interpretation depends on the experience of the person involved, but also on the circumstances in which he finds himself and his state at that particular time. Either the interpretation is direct: the signal has an unambiguous meaning for the person because its variations have a direct causal link with the state of the situation (for example the rev-counter, or an audible or kinaesthetic signal triggered by leaving the road) which they have learnt to evaluate. Or the interpretation requires the person to use a symbolic system: the link between the signs and their meaning is then arbitrary, relative to other signs, and conventional (for example the milometer or an audible speech message). It should be noted that even in the first case, the perception of the signal must sequentially precede the understanding of its meaning: for example, the attention must first be placed on the rev-counter, before the current state of the motor can be understood. However as we know, drivers who are even just a little bit experienced use this indicator very little. Its use is better replaced by the direct perception of the relationship between action on the accelerator and sensory feedback (noise of the motor, acceleration, resistance of the steering wheel, various types of stress feedback, etc.). In fact, in this sensory-motor loop, the attention is placed directly on the motor functioning without requiring intermediate focusing on the dashboard.

2.2. Towards an alternative view of driving support systems design

In the classical approach to human activity, support systems are often developed using prior modelling of this activity which is understood as a series of information processing operations. Support systems are then developed which artificially perform some of these operations, and which are thus intended to replace the human operator. The tools are therefore essentially designed as artefacts replacing human activity. In contrast, in an approach which places the priority on action and physical involvement in the situation, the tools are firstly designed to allow modifications in the perceptive and operating possibilities of the human operator. Indeed, if perception is created through the activity of the operator, it depends directly on his ability to act and feel (what is known as the “proper body”). The perceptive organs are understood to be coupling devices since they allow a relationship between action and sensation to be established through coupling with the environment. On this basis, any tool, if it is correctly understood, can be seen as a coupling device which is integrated into the “proper body” of the perceiving person. For example, the white stick used by blind people is a coupling device giving them access to tactile perception a little way ahead of them. In this perspective, support systems, like any other tool, are artefacts designed to increase the possibilities of human activity, and not to replace it.

When it operates as a coupling device, the tool becomes transparent for the human operator since it participates in his perceptive activity. At the moment when it is used to perceive and act, it is not actually perceived itself. Appropriation of a tool corresponds to how successfully this process is “integrated into the proper body”, in other words whether the driver “embodies his car”. He will thus perceive the road under “his” wheels, the gravel he is driving over or the edge of the pavement which he has just touched (and no longer consciously perceives the relationships between the feeling of vibration of his seat or steering wheel and his motor commands). Attention is directed outside the vehicle (and no longer towards the vehicle). Appropriation of a new tool is not immediate. It is achieved through learning repeated relationships between action and sensation through this device. It is successful when the device becomes transparent: the tool is used directly for the activity and is no longer the object of a learning activity.

In general, internal “information”, that is, a signal emitted by the car (symbols on the dashboard, forms projected on screens), creates a dissociation between the driver and his vehicle. The perception of this form, its recognition and its interpretation imply a spatialisation-exteriorisation of the dashboard before it is interpreted. Interpretation of the situation becomes confused and fragmented when the user has to quickly switch from perception with a coupling device to perception of this device itself (like trying to perceive with a stick, and at the same time perceiving the stick in your hand). A rule governing the acceptability of a tool states that not only must it not hinder direct perception (the user does not need to look away from the road significantly), but also that it should be possible for it to become "invisible" in the course of its use. In other words, using the formula of the 19th century psychologist, A. Bain, who said "thinking is holding yourself back from acting", such a tool must not force you to think when you should be acting.

3. "Comprehensive analysis" of human cognitive activity: theoretical and methodological principles

We developed our studies in driving support systems design over the last few years along this new approach to human activity. In this section and in the next one, we will describe how we did in practice when looking more specifically at car driving.

3.1. Understanding activity in order to design appropriate support systems

In the driving support systems design projects, we systematically start from the basic idea that, in order to be effective and accepted, and constitute real assistance and not an additional constraint for the user, as is unfortunately sometimes the case, a technical system must correspond to the essential characteristics of the activity which it is dedicated to. In order to do this, detailed knowledge of these characteristics and what determines them is required, thus making it possible to do more than simply describe the phenomena observed. This point of view determines the particular conditions governing knowledge of this activity, in other words the conditions for collecting and analysing data on that activity. It is in this context that we have developed the concept of "comprehensive analysis" of the activity, with which specific theoretical and methodological principles are associated, as we will now describe and illustrate using examples from studies conducted during our involvement in different design projects.

3.2. Collecting qualitative and quantitative data on situated driving activity

Taking into account the construction of the action in the situation, and considering action and perception as inseparable in this construction, our approach gives priority to the study of drivers' activity in a natural driving situation. For us this is a basic condition for understanding the complex and dynamic character of the activity of driving, and its eminently contextual dimension. We believe in fact that driving is largely created as a function of circumstances, never possible to fully anticipate and constantly changing. In addition, driving is multi-sensory and the driver is also almost permanently interacting with other drivers. In order to take account of all these characteristics and of the construction of driving in relation to a given situation, we feel it is essential to put drivers in real driving situations and to consider their point of view on how they carried out the activity, in order to collect "explanatory" data on it. Our studies were mostly based on field studies on the open road during which a combination of quantitative and qualitative data were collected, firstly in relation to these general characteristics of the activity of driving. For example, we were very systematic in collecting data on the dynamic of the vehicle and of certain other vehicles with which the driver was interacting (speed, acceleration, use of the brake, deceleration methods, combinations of speeds used, etc.), on the behaviour of the driver (manoeuvres, positioning in traffic lanes, action carried out on the vehicle and/or particular equipment, etc.), and on the context encountered by the driver (traffic, infrastructure, manoeuvres of other drivers, etc.). Secondly, we also collected data in relation to the characteristics specific to the particular dimension of the activity that we wanted to provide assistance with. It was thus possible to collect data on lateral veering or the immediate repositioning of the driver in his lane of traffic in the context of a study conducted for the design of a "Lane Keeping" type system. Relative speed and relative distance data were collected more particularly in the context of studies on management of speeds and distances. Similarly, data on distance in relation to an obstacle or another vehicle were collected more specifically for studies looking at how manoeuvres are carried out. In all cases, important emphasis is given in the studies that we conduct to the point of view of the driver himself on his activity, as an access to his involvement in the driving situation. This emphasis takes the form of collecting verbal data while the activity is actually being carried out and/or in an autoconfrontation situation (the driver watches a film of his journey, the latter being systematically recorded, and comments on it to clarify his actions after the event). It should be noted in this regard that in the perspective we adopt, the point of view of the driver and of the observer cannot be identical and it is therefore necessary to develop special methodological principles which allow these to be articulated, a question which we examine elsewhere.

3.3. Defining the questions about the drivers’ activity to be answered for support system design

Developing such a study is not, however, self-evident and preparatory stages are necessary in order to determine the different methods involved. To do this, our first step in this procedure is to identify as precisely as possible the requirements of the designers themselves. We identify the questions they ask themselves, the elements which they need to progress in the project, in particular regarding the interaction between the driver and the future or close-to-completion system. The objective is then to agree on the questions which the ergonomic study must attempt to answer and in what form, but also to clearly ask those which are not directly within its remit. Thus, in the context of our involvement in the development of a manœuvre support system, a prior ergonomic study was conducted (that is, before any introduction of a support system), the principal objectives of which were to contribute to the definition of the functions to be developed, to determine the methods of interaction between the system and the driver, and how the information would be given back to drivers, as well as defining the most relevant criteria for evaluating already existing intermediate technological solutions and the prototypes which would then be developed. This prior work, devised to closely reflect the concerns of the designers, determines the kind of study protocol produced, and defines in particular the study situation selected.

3.4. Defining the situations under study

Conducting field studies on the open road is not sufficient to guarantee the natural character of the drivers’ activity. The following stage is to therefore select the experimentation situation which will allow the activity we want to examine to take place as naturally as possible, while also allowing us to obtain the response elements relevant to the technological concerns of the designers. In this perspective, we feel it is also particularly important to put drivers in a realistic driving situation and one which will reflect, as far as possible, the probable future situation in which the system under design will be used. For example, in the context of our involvement in a project to design a speed and distance control system for urban and suburban situations, in consultation with the designers, we decided to ask a panel of drivers to make their usual home-work and work-home journeys and at their usual time. Regarding the drivers (who were company employees, largely for reasons of confidentiality), they were mainly selected on the basis of not being involved in the project which resulted in the study, or even in any similar technological project conducted by the company. For example also, in the context of evaluating a prototype distance control system, a first study consisted of asking pairs of drivers to make a relatively long motorway trip, representative of the type of journey and use for which this system is designed (for example a holiday journey). During a later study, drivers completed a journey of several hundred kilometres several times that they actually had to make in the context of their professional activity. In addition, in order to reinforce the natural character of the driving during our studies, we do not give particular instructions to drivers in terms of specific tasks to be completed or performances we want them to attain. The drivers are in fact encouraged to drive as they would normally. For example, in the context of a study on overtaking manoeuvres, it is the drivers themselves who decided whether or not to overtake a vehicle, and at what moment and how to perform the overtaking manoeuvre. We do, however, give them specific explanations of the methods used to collect the verbal data, by explaining to them what it is essential for us to collect, in order to then have enough elements to allow us to understand the phenomena observed. This type of methodological choice, closely reflecting our theoretical hypotheses on human cognitive activity, obviously does not allow us to make precise comparisons between drivers. However, the objective is in fact to identify, for example relative to the cognitive mechanisms used in the management of speed and distance in urban and suburban contexts, or relative to the use of a particular support system, firstly the determining regular features, in particular contextual ones, and secondly the typical specific features, from among a very diverse panel of drivers.

4. Main practical results provided by a comprehensive analysis of the activity

The practical results of such “comprehensive” studies of drivers’ activity in natural situations, in particular when they take place sufficiently upstream of the design process and are not simply of an exploratory nature, lie in the fact that they constitute a solid and essential base of knowledge which provides elements on several of the dimensions involved in design issues. These elements are even more valuable since they will be useful throughout the design process, at each of its stages, and also can be transferred, at least in part, to other design processes. In this concluding section, we will present the main ones.

4.1. Identifying the characteristics of situations in which support systems are used

Being positioned a long way upstream of the design process, one of the first practical results of a comprehensive analysis of drivers' activity is to assist in the identification and specification of the most relevant typical situations for the probable future use of the system being developed. At a later stage when a prototype system is evaluated, the analysis is used to validate and complete identification of these situations and above all to characterise them in as much detail as possible in relation to realistic use of the system. In particular, it allows us to define the sometimes critical nature of some of these situations. In the two cases, both the quantitative and qualitative results produced by comprehensive analysis of drivers' activity allow us in particular to understand the diversity of these situations, as well as the constraints created by the road context. For example, in the case of a study for a project to design a speed and distance control system for urban and suburban contexts, conducted before any introduction of a support system, two major elements were revealed in terms of the characteristics of the situations of use which the future system would have to be able to deal with. On the one hand, this study showed that there are no standard urban or suburban journeys but in fact a huge variety of them. In addition to this simple observation, our study helped to define the sources of this diversity in great detail, and, for a given panel of drivers, the combinations of diversity within a particular journey. From a methodological point of view, it can be seen that we were able to obtain this result because we chose to ask our panel of drivers to make their respective usual home-work journeys, thus placing them in diverse and therefore real situations, rather than imposing on all of them a journey that we had identified beforehand (and perhaps wrongly) as a typical urban or suburban journey. On the other hand, given that the purpose of this speed and distance control system for urban and suburban contexts is to manage speeds and distances in dense to very dense traffic situations, it was possible in the context of the same design project to identify and characterise different types of traffic jam. This was important because, as we were able to demonstrate on the basis of various objective parameters and using the drivers' points of view of their activities, the elements of the situation to be taken into account, i.e. the constraints for drivers, particularly in relation to risk-taking and time factors, were actually different depending on the type of traffic jam in question. For the design, these results were of direct relevance to the question of how to manage the approach of a traffic jam as well as manage a succession of traffic jams, the latter possibly being of different types. For example also, in the context of a study devised to evaluate the advanced prototype of a speed and distance control system, we were able to determine those situations where use of the system was particularly costly for the driver, for example notably because of some of the laws of control implemented. In addition to this observation, it was the data produced from the detailed analysis of the coupling between drivers, the system and the environment which allowed us to fully understand what was happening in these specific situations and to thus determine precise recommendations for the development of the system.

4.2. Defining functional and interaction requirements

Upstream of the design process, this characterisation of the situations to be taken into account regarding future use of the system thus represents a first contribution to the functional definition of this system, by providing information on the functions necessary for it to meet the requirements of drivers in terms of the situations they will be confronted with. Data on the activity produced from a comprehensive analysis of that activity also help to specify the modalities of driver / system interaction throughout the design process. The objective is in fact, on the basis of the previously identified defining characteristics of the activity, to help determine what the optimum modes of dialogue are in order to implement the functions of the system and what information feedback is most relevant in relation to its operation. We also aim to provide guidance for designers regarding the actual relationship between the driver and the system. For example, with respect to speed and distance control systems for motorway journeys, which act directly on the longitudinal control of the vehicle (that is, which accelerate, decelerate and even brake themselves depending on the speed and distance of the vehicle in front in the same lane), the crucial aspect is not so much the level of information to be supplied to the driver, but the laws of behaviour which will be implemented in the system. The important thing here is to fully understand the dimension of the activity which will be computer-supported (in our example, regulation of acceleration and deceleration), but also the global context in which it takes place, so that, to continue with our example, deceleration is managed in different but always appropriate ways for the smooth running of the driver's activity, depending on whether he gets closer then stays behind the vehicle, or whether he gets closer and then overtakes it.

4.3. Defining situations and evaluation criteria

When the prototypes start to be developed and can be evaluated, this knowledge of the factors determining the aspect of driving to be computer-assisted provides specific criteria which can be used to judge how accurately the system developed meets the needs of drivers, and also to identify the directions which should be focused on in order to optimise driver / system / environment interaction. As in a classical ergonomic evaluation, these criteria will be in terms of both the usefulness of the system in question and its "usability", that is, its ease of use. A particular aspect of it is how quickly drivers get used to and learn the system developed. In the case of innovative driving support systems, we should add two fundamental elements for judging the appropriateness of the system: firstly, the degree to which drivers will successfully appropriate to themselves the new system, which depends in particular on the degree of confidence it gives them when used in a driving context; secondly, how compatible use of the system is with the determining characteristics of driving as a whole. In particular, the new system must be in line with and respect this activity in all aspects of its components, otherwise it will become a hindrance or constraint (or even partial hindrance) for the driver instead of assisting him. This is why it is important to know these determining characteristics in as much detail as possible and, preferably, as far upstream in the design process as possible, so that the optimum conditions for successful adoption of the new system can be determined and fully integrated into the driving process. In addition, for all these aspects, the knowledge produced from a comprehensive analysis of the activity can be used, during the evaluation phases, to select the most relevant situations for analysis, to identify the criteria to focus on, and to guide the interpretation and understanding of the results of this evaluation. For example, in the context of a project to design an intelligent cruise control system for urban and suburban contexts, the prior study meant we were in a position to guide the choice of journeys to be made by the drivers used in order to evaluate a prototype of the system, during which its ability to manage speeds and distances on different types of journeys with different types of traffic jam could be tested. To conclude this point, we would also point out that the knowledge produced from a comprehensive analysis of the activity can be used to not only identify the most relevant criteria for evaluating the system covered by the design project, but is also useful for evaluating families of systems, existing intermediate solutions and solutions under development.

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