Reliability Requirements on Driver Interaction with Car Assistance System Alliances

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2008

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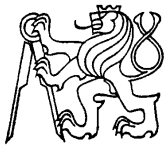
Academy of Sciences of the Czech Republic



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Research report No. V – 1028/2008, and LSS 343/08
to the grant
No. IAA201240701,

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Prague, November 2008

Abstract: In this report we focus our attention on problems concerning the requirements which have to be formulated in modern cars on operation reliability of alliances of in their cockpits installed assistance systems. A special interest is given to limitations resulting from influence of human factor, namely of the decreases of driver attention level in the course of long time driving, of enhanced probability of driver incorrect decisions and late and slow reactions. The possible driver inclinations to aggressive behavior when driving and to splitting their attention to marginal stimuli are discussed too.

This report involves some results reached in the range of solving the research of scientific project No. IAA201240701 also the projects:
ME 949 of the Czech Ministry of Education,
1F84B042520 of the Czech Ministry of Transport
and
102/07/1191 of the grant agency of the Czech Republic.

Content:

1. Introduction

The importance of system alliances as the most evolved kind of artificial systems in widely accepted now. They are applied in many areas of contemporary science and technology, like as in practical areas e.g. in the medical care, finance, security, defense etc.

For transportation play the concept of system alliance also very important role, namely as the part of the equipment of modern transportation vehicles or of railroad control and safety systems. One of the most widely used kinds of such system alliance represent the alliances of assistant systems installed in car cockpits.

Because of their significance, these will be also in the focus of our considerations in this report.

2. The structures of car cockpit assistance systems alliances

The general structure of car cockpit assistance systems alliance involves the set of alliance systems processing blocks controlling the individual systems actuators, collecting information and data detected on assistance systems sensors. All these partial assistance systems cooperate being supervised by assistance information tool (AIT) – see Fig. 1.

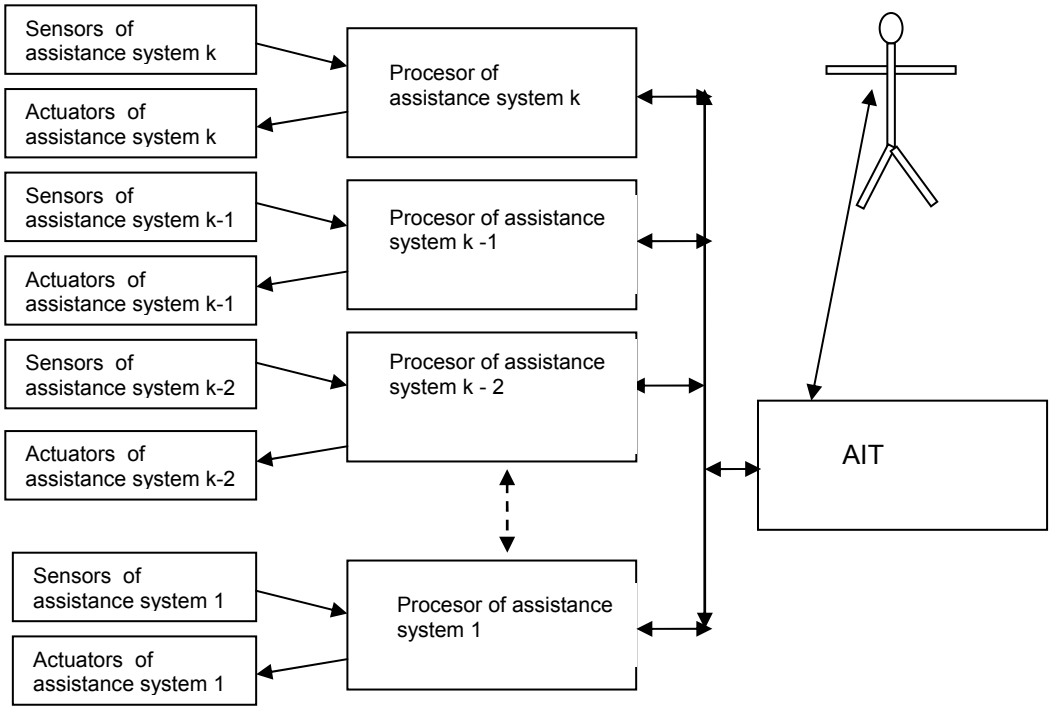

Fig.1: The general structure of car cockpit assistance systems alliance

Assistance systems installed in car cockpit cab be of three main kinds:

a) assistance systems for car operation control,
b) assistance systems for driving support,
c) assistance systems for driver and car crew comfort and entertainment.

While the assistance systems of the first mentioned group must operate without direct interaction with driver, solving such tasks as optimization of engine operation with respect to maximal efficiency, minimal fuel consumption and minimal

environment pollution (air, heat, noise, vibrations), both the second kinds of car assistance systems need the interactions with driver.

All these interactions split the driver attention from his/her main task – the reliable and safe driving, the main condition of which is visual and in certain respect also acoustic observing of the situation on the road in front of car, on its sides and behind it. Such kind of stimuli coming to driver senses can be considered as the primary or functional.

Each driver has in principle only limited amount of his/her attention capacity C_{AT} at disposal. In the course of time this capacity is subsequently exhausted, both by natural decrease of driver attention level L_{AT} due his/her load by driving and observing of functional stimuli, and also due observing of all the other - the so called marginal stimuli, and driver reactions on them.

Naturally, the requirements on maximal reliability and safety of driving procedure lead to the limitation of the part of C_{AT}, which can be spend to observing of marginal stimuli and reaction on them.

Such limitations concern both the above mentioned kinds of assistance systems b) and c).

3. Requirements on reliability of assistance systems alliances functionality

Assistance systems installed in car must be itself of high reliability in any case. In the course of driving there is no time and opportunity to repair their eventual faults. Also the valuable driver attention capacity C_{AT} cannot be exhausted by any repairing procedures.

This concern before all the assistance systems of firstly mentioned kind which have direct influence on the operation quality and safety of cars (and their engines). Therefore in their structures the significant reliability improving of functional blocks should be involved – especially of those, which operate on the basis of predictive diagnostics (see Fig.2).

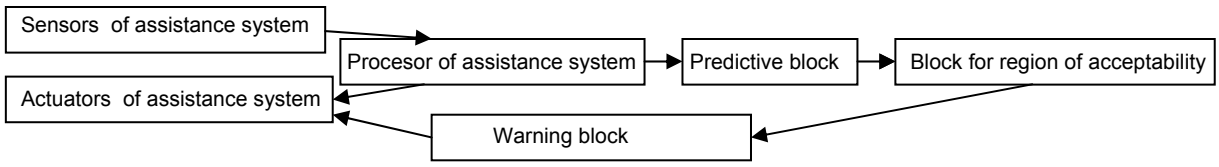

Fig. 2: Functional blocks for predictive diagnostics in assistance systems of the kind a)

These blocks continuously analyze the system parameter values x_i of the respective assistance systems, the values of by them produced system functions F_k, which are generated by them, compare them with the required (nominal) function values $F_{k\,0}$, analyze the trajectory Ψ (t) of the vector X of system parameter values in the system parameter space (see Fig.3).

If this trajectory approaches the boundaries of the region of acceptability R_{AT} involving all the points X corresponding to acceptable functions of respective assistance system, this event has to be taken as the signal for restoration procedure realized either by the respective system parameters adjustment – if possible in the course of its operation, or for its replacement by some spare system or in the worst case by stopping the operation and starting the necessary warning.

Such activities are usually coordinated by the AIT, supervising the operation of the whole alliance.

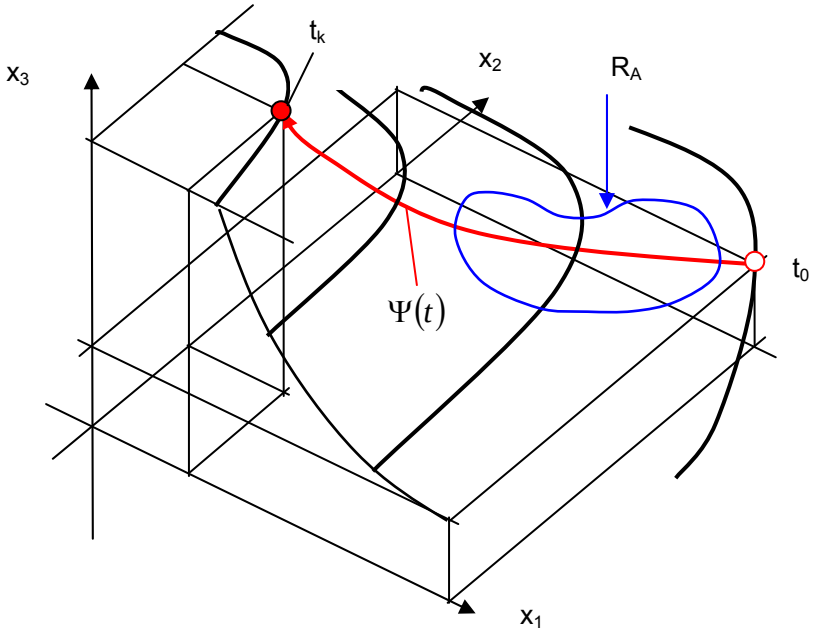

Fig. 3: Trajectory Ψ (t) of the parameter vector X in the parameter space X}

The efficient algorithms for self-coordination and implicit coordination are not sufficiently known yet.

Besides this the blocks for predictive diagnostic included directly into partial assistance system structures therefore also the overall predictive diagnostic functional block has to be involved in the AIT structure (see Fig. 4).

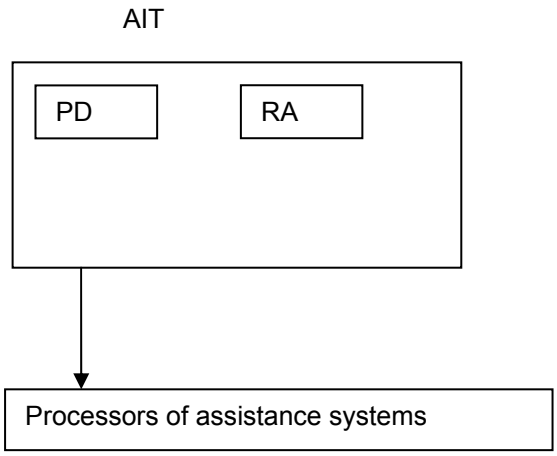

Fig.4: Block for predictive diagnostics in the AIT

All these predictive blocks do not only follow the partial systems parameter trajectories Ψ (t), but predict also their further development and if they involve in their memories the knowledge on respective regions of acceptability, they can estimate, how long the respective assistance systems will be able to fulfill their requested functions. Such estimations are of high importance before all in the case of the overall predictive diagnostic block in AIT, because in well designed alliance some functional deviations between various assistance systems can at least be partially mutually compensated (e.g. between the ABS and EPS etc).

As concerns the assistance systems of the kind b) and c), the requirements on their own reliability are usually not so high, because in the case of their functional failure, the safety of driving is not immediately decreased. Therefore, there is not so straight need to insert in their internal structures the functional blocks for predictive diagnostics. In the case of assistance systems of the kind b) among them belongs e.g. the communication and navigation systems before all, the eventual system failures can have eventual both long time and also short time negative influence on driving safety too, because the loss – especially the sudden loss - of information which driver receives from them can have also deep negative influence on his/her decisions quality and mood. It can provoke a tendency to driver panic reactions eventually.

As concerns the assistance systems for comfort and entertainment (kind c)), the eventual loss of their functionality is usually taken as unpleasant – of course, but not immediately dangerous, except the cases when it provokes some attempts for amateur repairs in the course of driving. In such cases – and they happen from time to time – the driver attention is for considerably long time split from functional stimuli

to repairing attempts, which very often leads to accident. Surprisingly, such danger is more significant for skilled driver who have some technical abilities than for driver who do not have it. These are usually disappointed by such faults, but do not split their attention on marginal restoration activities.

The advanced alliances of assistance systems have therefore take into account this fact. Their AITs must very carefully compensate each eventual faults in assistance systems of the kind a), but if such failures without respect to all tendencies to reach high functional reliability in respective assistance system itself appear, they have at first to present corresponding information concerning the appearing fault in time to driver in some quiet and understandable form, together with the ask not to try for any case to repair it in the course of driving. Such eventual attempts can be suggested only after the car safely stops.

4. Requirements on reliability of interactions between driver and assistance systems alliance

Of the key importance is however in any case the reliability of interactions of driver with control tools of any assistance systems. Such interactions split in any case the driver attention, especially it they are done not by driver free will, but on particular assistance system request.

This interaction reliability has therefore to be carefully taken into account when designing any such assistance control tool.

Preferred are the tools of simple switches or press buttons before those, which need adjustment in certain precise position. This is usually very difficult operation when driving. Also the use of touch screen displays need to be solved so, that the projected symbols are large enough (at least 1 cm^2 in size) and that their position is not changed. The displays must be controllable just by fingers, without any additional tools. Under such conditions the use of touch screen displays for inserting the phone number in mobile communication can be considered as acceptable, but not recommendable. However, as far as we know, all up to now realized attempts to use such displays for target insertion into navigation system in the course of driving completely failed. Therefore, the AIT has do not allow such activity in the course of driving, if this is realized by driver directly. This must be taken as the task for co-driver or somebody else from the car crew.

The only safe possibility how to insert a new target in the navigation system, which can be used by driver in the course of driving is to use the voice commands. However the technical quality and recognition reliability of all at present disposable systems is not high enough.

5. Influence of assistance system alliance operation to limitation of driver faults

The well designed alliance of assistance systems operating in car cockpit can represent a very important tool for significant improvement of all aspects the driver – car reliability. However, for to be able to reach such goal, one has to respect several fundamental requirements and recommendations.

These are before all:

All the assistance systems of the above mentioned kind a), serving for support of the driver activity concerning the car operation control must be designed with respect to maximal reliability. Often the principles of predictive diagnostics and the particular assistance system parameters readjustment in the course of its operation should be applied. Because these assistance systems operate mainly without the help of interactions with driver, their function does not exhaust the driver disposable attention capacity. Nevertheless, driver has to be informed on their correct operation and warned, if they fail.

As concerns the driver interaction with the systems of the kind b), serving for driving support, their correctness should be permanently tested. If evidently false interaction appears, the driver has to be warned.

Assistance systems for driver and car crew comfort and entertainment (kind c) do not require special blocks for reliability improvement, however their control tools must be designed and arranged with respect to minimizing the driver attention splitting from its focusing to situation on the road. This concerns not only the inserting of new targets into the navigation systems, tuning of radio sets, inserting the call numbers in mobiles, but also the control of ventilation, heating and cooling, opening and closing windows, switching of lights and adjusting the parameters of seats.

6. Open problems

The requirements on interaction reliability between driver and the alliance of in car cockpit installed assistance systems differ significantly according the particular driver individuality. There is only hardly possible to form some general valid limits. In any case the overall valid minimal obtainable reaction time of about 250 ms has to be taken into account. However, also reaction times of 1 sec are not exceptions. The factor of driver individuality has to be compensated by the possibility to pre-adapt the assistance systems parameters by the use of AIT according some aspects, typical for certain group of drivers (mainly the age categories, typical style of car use etc) and also by the possibility to change the assistance systems properties in the course of driving, if necessary.

Such advanced alliances of car cockpit assistance systems must therefore continuously monitor the main driver psycho-physiological parameters, his/her behavior and reactions and change the partial system properties with respect to maximal interactions reliability. If such possibilities are exhausted, their AIT has to correct adequate driving parameters on the one hand and to warn the driver and traffic supervisor on the other hand.

Evidently the development of advanced alliances of car cockpit assistance systems needs before all a significant improvement of the at present disposable knowledge of typical driver behavior, its variation changes in time (not only in the course of driving, but also in the longer driver life history) and under environmental influences. Also the application of new approaches to design of high reliable assistance systems structures allowing intelligent self-reparation will be necessary.

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