

EXPERT SYSTEMS FOR AUTOMOTIVE SAFETY

Iacob Ionel ^{1*}
Mihălcescu Cezar ²

ABSTRACT

To ensure your safety and those around you means to behave responsibly, always to drive defensively and to invest in vehicle safety technologies. Automotive Safety consists of vehicle equipment like airbag or seatbelts and driver assistance technologies.

Safety has become a leitmotif in the XXI century, and researchers are constantly investigating ways to reduce the risk factors to which we are exposed on public roads. Advanced Driver Assistance Systems are based on expert knowledge and are implemented on vehicles. They use information from traffic, cameras, sensors and respond in real time contingency occurring while driving. Although expert systems work faster than human, sometimes only the driver reflexes can save the day because "It's not the speed that kills. It's the sudden stop!".

KEYWORDS: *expert system, safety device, optimization, innovative technologies.*

1. INTRODUCTION

*"In a modern business environment, fast adaptability to the complex and diverse requirements of the market can be a definitive factor that places a company before 10s or hundreds of other companies in the same field, which ignore competitiveness, flexibility and efficiency."*³ The big manufacturers invest a lot in the acquisition of software products meant to ease human activities and to enhance their safety and integrity. Efficiency of some technologies and devices can influence the turnover of a multi-national, citizens wishing to ensure optimal safety conditions for their families.

Automotive safety refers to road designing, studying and creating construction drawings, equipment and rules to minimize the number of accidents and their consequences.

Automotive safety can be assured through adopting of a responsible behavior, increase of safety degree of the vehicle through innovative technologies and enhancing the automotive infrastructure through use of information and communication technology.

^{1*} Corresponding author. Lecturer, PhD., Romanian-American University of Bucharest, iacob.ionel@profesor.rau.ro

² Prof. PhD, Romanian-American University of Bucharest, cezar.octavian.mihalcescu@profesor.rau.ro

³ Iacob I., 2012, "Programare ORACLE 10g - Soluții informatice pentru dezvoltarea aplicațiilor economice utilizând PL/SQL și ORACLE DEVELOPER", Editura Universitară, p.9

The 2013-2020 National Strategy for Automotive Safety is a document of coherent rules and unified politics in the sphere of automotive safety, on the long term, that appeared as a result of unsatisfying existing directions in the field. This strategy will be brought into effect by institutions with attributions in this domain, specialised divisions of the public central administration together with the administration's public local authorities representatives recognised by law.

Vehicle safety increases through the implementation of *Advanced Driver Assistance Systems*

"An expert system is an informatic system intelligent enough to deduct logic conclusions in an actual domain and to ensure solving specific tasks"¹.

Expert systems are created based on experts' knowledge and specialists that solve specific problems from varying domains, such as : medicine, finance, geology, banking system, marketing. Thanks to the recorded breakthroughs made in the technological domain, an expert system is capable of "*simulating studying, memorising, reasoning, communication and processes of action for the human expert in a particular domain*"² and to provide specialised consultancy, replacing thus the need of human experts.

An expert system is a program that analyses knowledge and rationalises in order to obtain results for an activity that is usually meant for human experts. Functionally, an expert system is a program who's main characteristic is derived from it's knowledge base, together with a search algorithm specific to the rationalising method.

An expert system is based on 2 distinct and complementary components :

- a. Programming technologies that allow the use of a large volume of knowledge, as well as their inference mode with them
- b. Evolved constructions and methodologies, that allow effective use of these technologies.

In an expert system, *reasoning and knowledge* must not be treated separately because such a system assumes their harmonisation.

The expert that understands the necessity of using an expert system in his activity domain can obtain help from *the knowledge engineer* (IT specialist) because following discussions with him, som knowledge will be reformulated in a way that it can be applied on a computer.

Among work tools of expert systems are considered to be models through which a knowledge base can be shown, recorded and represented. The main quality of computers is their capability of realising fast speed calculations. Each programming language tries to

¹ Moise M., 2010, "Inteligența artificială și Sistemele Expert" - Ediția a IV-a rev. și adăug. - Pro Universitaria, p.206

² Pigford D.,V., Baaur G., 1990, "Expert Systems for Bussiness Concepts and Applications, Featuring VP.", *Expert Boyd&Fraser Pub. Co.*, p. 14

make the computer as efficient as possible in the computing speed aspect. In realising a program that reasons a starting point is that the processing symbols can be numbers, text or other concepts. These are considered “physical symbols” and the computer can manipulate such symbols. A viable expert system, coupled with the computer calculation speed can streamline an work domain.

One of the founders of Artificial Intelligence, H. Simon said about expert systems that they are *a representation of human behavior, which is based on the limited rationalising model, that keeps in mind limits that have been found based on a real cause, both in the information plan and the reasoning.*

Another original definition belongs to the teachers J. Giarratano and Riley (NASA) : *un Sistem An expert system is a system that emulates the ability of taking decisions by an human expert. The term « emulates » means that the system is meant to act in all matters as a human expert. Emulation is more than simulation, that requires only actions through limiting realised conditions.*

Definitions given by other authors are also very similar. *Expert systems are programmed systems based on techniques of Artificial Intelligence, that stores knowledge of human experts in a specific domain and then uses it in order to solve problems from that domain ; a computer system that is able to give advice in a particular domain of knowledge, due to the fact that it contains knowledge of an human expert from that domain.*

The traditional definition of a program is :

$$\text{Algorithm} + \text{Data Structure} = \text{Program}$$

In expert systems, the definition changes :

$$\text{Inference Engine} + \text{Knowledge Base} = \text{Expert System}$$

Despite having given different definitions of Expert Systems, some common characteristics can be settled. Some ideas that settle into shape the notion of Expert Knowledge are :

- Expert Systems contain knowledge and the ability of sustaining human intellectual activities ;
- Conceptually, Expert Systems refer to human rationalizing based on expertise obtained from experts
- Expert Systems are organized in order to obtain and use knowledge from a particular domain called the problem domain ;
- Expert systems have invoking methods for knowledge and expressing expertise , acting like an « intelligent assistant »
- On an design level, expert systems are based on the principle of separating knowledge (knowledge base) from the program that work with it (inference engine) ;

- Expert systems are capable of storing knowledge, making connections between various knowledge parts and situations based on facts and processing uncertain information

Expert Systems try to reproduce the human experts reasoning over knowledge presented to them in a certain manner, ending up modifying them and even offering explanations for their reasoning.

The base concepts of an expert system are the expertise and the experts, the transfer of expertise, inference rules and the ability to explain.

The architecture of an Expert System

All the characteristics of the expert systems determine a specific structure of them, structure that can be grouped in 3 main modules, modules that determine an *essential system*: *Knowledge base, inference engine and a Facts base*.

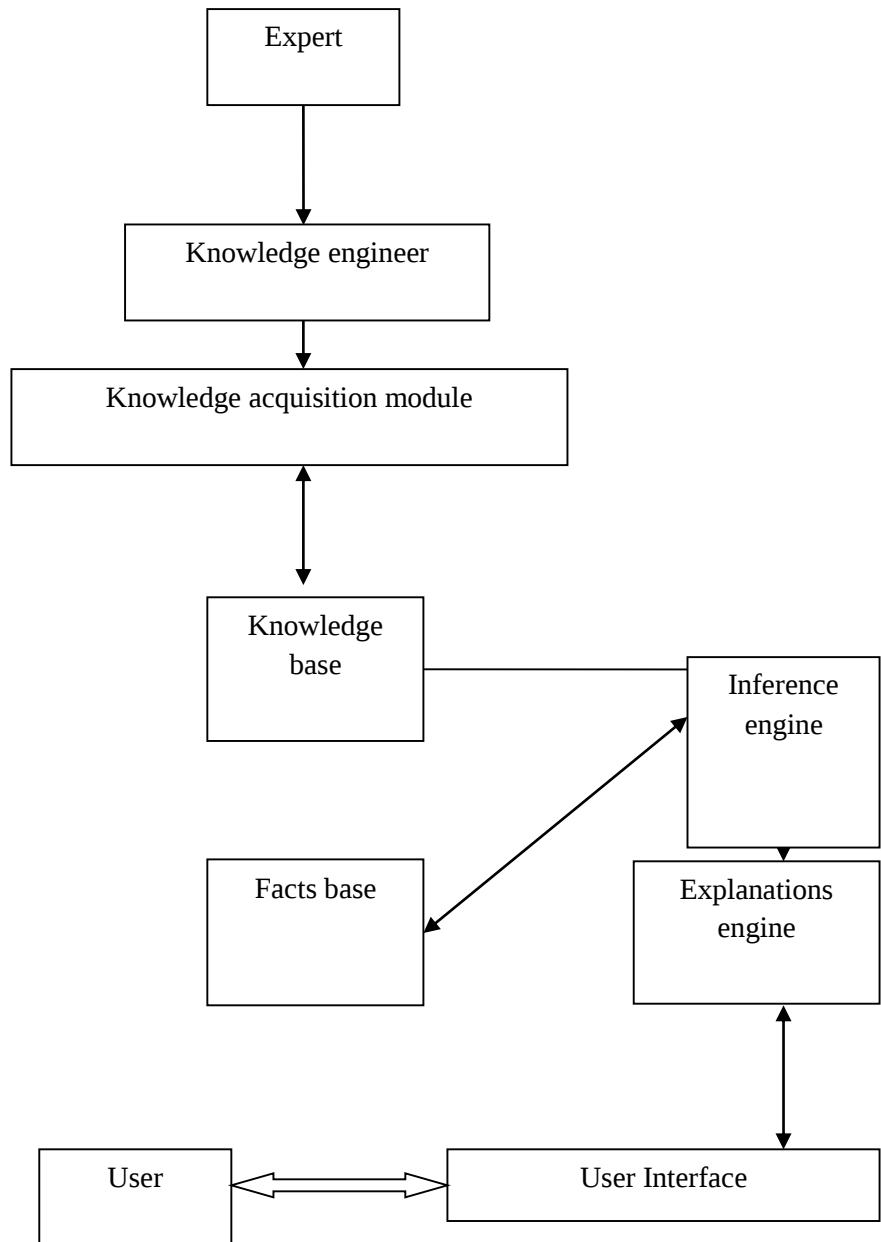
Despite all of these, an expert system is based on 2 distinct and complementary components: new programming technologies that allow use of vast knowledge, as well as the inference mode between them and new constructions and developed methodologies that allow the effective use of these technologies for complex problems. Combining them in a more efficient way leads to a successful expert system.

In order to realize such a system, a strong cooperation between a domain specialist and a knowledge engineer. The expert must be capable of presenting knowledge and interpreting some information. The engineer is the one that transposes the information received in a presentation form specific to computerized systems, keeping in mind the three main modules of an expert system.

In specialized literature, in addition to these three specific components, also appear new ones, without which the expert system cannot be used: *the knowledge acquisition module, the user interface and the explanations engine*. Multi-expert systems are a more recent and promising approach that tends to be better than expert systems. They represent programs used to solve very complex problems, that include different opinions tied to the same problem, knowledge that has been acquired through various expertise. An expert system based on a multiple system has advantages, such as :

- 1) possibility to share experience, knowledge and resources ;
- 2) a greater credibility ;
- 3) a better reasoning thanks to observations made by other constituting agents.

The Architecture of an Expert System



There are two schemes of development for multi-expert systems. The first is the one in which the system is made of subsystems (agents) that tackle different aspects of the problem. The problem that needs to be solved in such systems is coordination and cooperation between systems. The second scheme is characterized by a single knowledge base containing information from multiple experts.

Hanachi (1996) proposed a specific technique of developing Expert Systems. This technique assumes the existence of two bases : one active and a deducting one that acts

like a cooperative informational system. This system retains data about development of projects and a set of rules that coordinates and controls different activities.

Solving and incorporating conflicting opinions represents a major problem for the presenting knowledge. Lietal (1995) suggests a fuzzy reasoning that combines experts' knowledge and takes into account their independence. This way of tackling the problem « identifies » input cases and finds the most suitable data to be used in that particular case.

Scientists observe nowadays an evolution towards frequent and complex interactions between different specialists in a limited domain, with the goal of exerting a high level activity.

Evaluation Criteria's for Multi-Expert Systems

The main reasons for which the multi-expert systems are selected in big and complex applications are : swiftness, safety, solution quality, efficiency, clarity, cost and adaptation to the domain.

Swiftness is one of the most important evaluation criteria's of these systems, especially when a multi-thread architecture is implemented.

The Safety that this type of systems offer ensures the continuity of it's functioning even if a module misses or doesn't correctly solve a sub-problem, it generates a failure or error. In this way a total failure is avoided and good reliability is ensured.

Solution Quality is high because knowledge is distributed on more than one module, so that the obtained solution is better than if it were integrated in a single module.

Efficiency takes into consideration expected times, which in case of distributing knowledge across more modules is bigger.

Clarity is given also by modularity, the system is visible and the quantity of information needed for a decision is reduced.

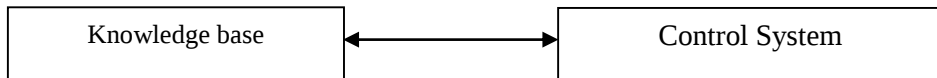
Adaptation to the problem's domain is taken into consideration, because experts trust more in systems that reflect their own abstraction and concept creation.

Costs of development are reduced more thanks to modularity that offers the possibility of knowledge acquisition at the same time from all the experts, as well as global validation of the prototype.

ORGANISATION OF AN EXPERT SYSTEM

The essential idea that stands behind the conception construction base of expert systems is that a human expert builds his own solution to the problem from basic pieces of knowledge, pieces that he has become familiar with before and that the expert selects and applies in a specific sequence. To provide a coherent solution to a given problem, knowledge needs to be formalized, represented in an adequate form to the inference processes, so that it can be manipulated according to a specific method of solving the

problem. As an immediate consequence of the concepts presented above, a valid concern is separating knowledge over domain, of the problem's data – **the knowledge base** – and the part responsible with organizing the inference processes that imply this knowledge – **the control system (inference engine)**, these actually being the main modules of an expert system.



The main components of an Expert System

These two components form the core of an Expert system around them, while other components realize it's complex functionality, such as :

- *Communication interface*
- *Knowledge acquisition component*
- *Explanation component*

The Knowledge Base, which is the system component responsible for storing information about the expertise domain and the problem to be solved, is composed of :

- *Facts base*
- *Rules base*
- *Agenda*

The control system is responsible for deployment of inference processes. He encodes one or more strategies of applying the rules.

2. SAFETY IN TRAFFIC

Automotive safety systems are of two types : active safety systems and passive safety systems. Active safety refers to technologies that assist the driver in preventing impact, while passive safety refers to the vehicle's parts (airbags, seatbelts, protection helmets, etc) which protect the vehicle's passengers during the impact.

The role of the active safety systems is that of assisting the driver in order to prevent any incident, helping him in the majority of cases in avoiding accidents. The passive systems kick in when an impact occurs.

A car relies mainly on the active systems, but when they fail or the driver has an accident, the passive systems kick in. They are called passive because they're only used in extreme cases.

Driver assistance, reducing the number of accidents, protecting the lives of traffic participants, preventive, defensive and ecologic driving are just a few of the aspects considered by car manufacturers when they launch a model and as well by the potential buyers. Safety has become a *lait-motif* in the XXIst century and the scientists constantly

investigate methods of reducing risk factors to which we are exposed to on public roads. Large amounts of money are invested in creating such systems that efficiencies the transport industry and that of car manufacturing.

Nowadays there is a large variety of technologies controlled by complex systems that respond in real time to unforeseen situations that take place while driving. These systems have the ability to respond faster than any reflex of the driver

In case of an accident, the safety devices can save people's lives. The most important systems that are equipped to a vehicle are: impact protection systems, also known as airbags (curtain, belt, frontal, side, knee-protection for driver, for scope, between passengers, anti-friction, for pedestrians etc.), *Vehicle Stability Control* (VSC) systems – that help the car to get back on the intended trajectory, Pretensioning Systems and Tension Limiters that are part of seatbelts, *WIL (Whiplash Injury Lesseging) chairs of reduction of wounds from shocks*, *Electronic Power Steering(EPS)* systems that increase the effort of vehicle steering, Anti-lock Braking System (ABS), which prevents wheels from being jammed while braking, Electronic Brake Distribution (EBD) systems which assists the ABS, Brake Assist (BA) systems which has the role of increasing brake pressure in case of emergency, etc..

In order to increase mobility in traffic, developing countermeasures for accidents, as well as making a solid base for automotive education, a new branch of psychology was created : traffic psychology. This branch studies the relation between the psychological processes and the traffic participants' behavior. To generate new knowledge in the domain, various factors are being studied, such as : attention, memory, experience, stress, level of ebriety, weariness, random activities (such as talking on the phone) si thus new ways of efficientising the automotive safety are being researched.

3. VEHICLE SAFETY TECHNOLOGIES

Standard equipment of vehicles includes technologies of maximizing safety, fuel economy, noxious gas level reduction, frontal suspensions that include silencers, MultiMode transmission geared with side buttons behind the steering wheel for changing gears, parking sensors or for automatic start of windshields, inner electrochromatic mirror, speed limiters, optimal gear switch indicator, Smart Entry & Push Start systems, Smart Key, technologies for enhancing comfort or smart storing compartments.

There are also technologies that come in aid of the driver. These are called „*Advanced Driver Assistance Systems* „, and use the vehicle's headlights, reflectors and other lights equipped, mirrors, braking systems, steering and suspension to avoid a collision.

From the Advanced Driver Assistance Systems category the following can be distinguished :

Automatic Parking is an automated manoeuvre for the car from a traffic lane to a parking spot in order to perform a sideways, perpendicular or at an angle parking and has the effect

of enhancing comfort and driving safety in tight spaces that require a lot of experience and patience.

The Global Positioning Systems (GPS) via satellite and radio waves – equipped with the TMS (Traffic Message Channel) system use outer space satellites as reference points for ground localization and offers to drivers live information from traffic.

ACC (Adaptive Cruise Control) maintains a constant speed and the optimal distance between other traffic participants through use of sensors or a radar, allowing the car to slow down when another vehicle is approaching and to accelerate to a preset speed when traffic is light again.

BSD (Blind Spot Detection) is a system that monitors what happens around the driven vehicle and warns the driver in case of a wrong framing / avoidance by.

The Lane Departure Warning System is a mechanism through which the driver is notified when he's leaving the assigned lane, which is a major cause of accidents.

The Collision Avoidance System informs the drivers when it detects an imminent danger, a collision with an obstacle.

The Intelligent Speed Adaptation is a system that constantly monitors the vehicle's speed as well as local limiting of speed on a public road and warns the driver when he passes the limit speed.

The Adaptive Light Control system assures optimal lighting on roads.

Pedestrian Protection System is implemented by Volvo that protects the pedestrians in case of an impact. This system contains a variety of sensors that identify pedestrian movement as well as video cameras mounted on the vehicle and in case it detects an immediate danger, the driver is warned both through sound and visual signals on the board computer. If the driver doesn't react immediately, the system automatically brakes and the exterior airbag opens.

The Traffic Sign Recognition represents a technology through which the vehicle can recognise traffic signs such as : speed limiters, warning indicators, orientation indicators etc.

Driver Drowsiness Detection is a safety technology that prevents accidents caused by alcohol consumption, driving under influence.

Speed Alert informs the driver both visually and through sound when the driver passes the legal speed limit on a certain road segment.

Wheel Speed Sensor – is a device used to read the rotation speed of a wheel and is used in the anti-blocking system for wheels when braking.

Real-time Traffic Information uses audio systems, the board computer, digital maps and other messages to assist the driver in choosing a more convenient road.

Extended Environmental Information – uses individual vehicle systems to transmit data regarding traffic situation on the entire road network.

Dynamic traffic management and Local Danger Warnings sends different messages to the driver and warns him when to be prudent and to fluidize traffic in case of incidents, blocks or bad weather.

Vehicular Communication Systems represent a technology being developed that is based on a communication network between vehicles and different communication nodes on the public roads. These have the purpose of mutual informing of drivers regarding traffic flow or other authorities warnings.

Emergency Call – is a system that is worked upon and is desired to the automatically generated after an accident occurs. This connects to the Emergency Services, allowing the vehicle passengers to communicate with the entrusted authorities and to also send data about the incident : the time it took place, the precise location where it happened, destination of the vehicle as well as other information about the car.

Other technologies and methods of enhancing automotive safety that are being developed include : limited access to certain public roads and estates, height-separated crossroads, median separators between road orientations in order to reduce frontal collisions (which produce the biggest damage and loss of lives), removing obstacles from the road, traffic banning for certain vulnerable participants and for some vehicles on certain road segments which might put them in danger, mounting devices for energy softening (guard rails, snow preventers, grass or sand areas), removal of automotive taxing cabins.

There are inventions related to auto safety that have been created, but have not yet been assembled with car series. A part of this category is the placement of the driver's seat in the middle.

4. CONCLUSION

In the process of choosing a vehicle, safety technologies should represent one of the most important aspects of which a buyer should take into account. In case of an event, safety systems can save people's lives.

Theodor Lădar affirms in his book "Patru roți și un singur creier" that „Safety does not start in ABS or airbag, it's where it ends”⁻¹. Therefore, with all the functional systems present on the vehicle, incidents can happen when the driver least expects it and it is vital for the driver to pay attention to everything that happens around and to act promptly. Automotive education is likewise very important for all traffic participants, regardless of moving on two or four wheels or as a pedestrian. An unforeseen situation can happen at any time in traffic and it can happen to even the most experienced driver to make a mistake in a moment of tension. For all auto-moto drivers there are schedules, programs

¹ Lădar Th., 2012, "Patru roti și un singur creier", p. 14

for defensive circulation, useful for any surprise they may have on the public roads.

Maintenance of vehicles is necessary for best functioning of all equipment's. Before leaving on a road it is important to check for tire pressure, steering and braking elements, fuel systems, spare wheel, liquid levels etc.

It is imperative to use only the authorized dealers for checkups and fixes and in case of incidents it is absolutely needed to repair the vehicle.

Both the driver and the other passengers must wear the seat belt at any time, including pregnant women and babies need to have special chairs mounted in the car. Also, driving assistance systems should never be disabled.

BIBLIOGRAPHY

IACOB Ionel, "Programare ORACLE 10g - Soluții informatice pentru dezvoltarea aplicațiilor economice utilizând PL/SQL și ORACLE DEVELOPER", Editura Universitară, 2012, București, România, ISBN: 978-606-591-313-4, 311p.

MOISE Maria, "Inteligența artificială și Sistemele Expert" - Ed. A IV-a revizuită și adăugită - Editura Pro Universitaria, 2010, București, România, ISBN: 978-973-129-706-4 , 578 p.

LADAR Theodor, "Patru roți și un singur creier" , v.0.1, 2012, București, România, ISBN: 978-973-0-13621-0, 231 p.

Auto - Moto Show from București

http://ec.europa.eu/health-eu/my_environment/road_safety/index_ro.htm