Reducing the Number of Accidents in Iraq by Using Expert System

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Abstract

Traffic accidents problem is one of the serious problems that leads to economic losses and even to death of road user. Moreover, in Iraq there is a lack of experts of highway safety, and real experience is limited to few experts. There is also a lack in the distribution of those experts, in addition to the lack in the skilled staff of highway safety. Therefore, the development of a computer system that provides expert consultation in the domain of highway safety becomes a real need. This study has been intended to develop an expert system to suit the real situation of highway safety discussed above. The system consists of two phases. The first one is the diagnostic phase that presents some simple questions to the user to identify the problem, and then provide the user with answers about the probable causes. The second one is the remedy phase that includes the appropriate countermeasures for each probable cause. Thirteen accident patterns are identified by the developed system such as right angle collisions, rear end collisions, left-turn collisions, right-turn collisions..etc. The developed system is prepared by the aid of two groups of experts (operators and engineers), and specific references to handle this problem. The results from accident data demonstrate that Baghdad is the largest number of accidents among other Iraqi cities and Iraq has the highest number of fatalities comparing with the number of accidents among other countries. This system is believed to be a helpful and practical tool that assists novice, site engineers and operators in making quick and exact decision especially when an experienced engineer is not available. Evaluating results proved that the usefulness, credibility and efficiency of the system are quite promising.

Keywords: Traffic accidents, safety, expert system, countermeasures.

الخلاصة

مشكلة الحوادث المرورية واحده من المشاكل الخطيرة التي تقود الى خسائر اقتصاديه وحتى الى موت مستخدم الطريق. بالإضافة إلى ذلك في العراق هناك نقص في خبراء السلامة المرورية والخبرة الفعلية مقتصرة على عدد قليل من الخبراء وهناك أيضا نقص في توزيع أولئك الخبراء بالإضافة إلى نقص في كادر السلامة الماهر .لذلك فان تطوير برنامج حاسوبي الذي يوفر المشاورة مع الخبراء في مجال السلامة المرورية يصبح حاجة ضرورية.الدراسة الحالية تنوي الى تطوير نظام خبير لكي يتلائم مع الموقع الحقيقي للسلامة المرورية المناقشة أعلاه . النظام يتكون من طورين .الأول هو الطور التشخيصي الذي يعطي بعض الأسئلة البسيطة للمستخدم لتميز المشكلة و ثم بعد ذلك يجهز المستخدم بالأجوبة عن تلك الأسباب المحتملة. الطور الثاني هو طور المعالجة الذي يتضمن كل المعالجات المناسبة .ثلاثة عشر نموذج تميز بواسطة هذا النظام المطور كالتصادم بزاوية قائمة والتصادم من الخلف والتصادم نتيجة الاستدارة على اليسار والتصادم نتيجة الاستدارة على اليمين..الخ. النظام المطور حضر بمساعدة مجموعتين من الخبراء (المشغلين و المهندسين) ومصادر محددة لتوجيه مشكلة البحث .هذا النظام يؤمل له أن يكون أداة مساعدة وعملية لمساعدة المهندسين المبتدئين والمشغلين في صنع القرار السريع والدقيق وخصوصا عند عدم تواجد المهندسين المتمرسين في أعمال السلامة المرورية. ومن خلال البيانات التي تم الحصول عليها نلاحظ بان مدينة بغداد من اكبر المدن العراقية في عدد الحوادث و المصابين والقتلى.من جهة أخرى نلاحظ بان العراق من اكثر الدول من حيث عدد القتلى مقارنة بعدد حوادث الطرق. بالإضافة فان نظام تسجيل الحوادث في العراق يعاني من نقص كبير بالمعلومات. نتائج التدقيق للبرنامج أثبتت بان الأهمية والاعتمادية والكفاءة للنظام هي تمام كما متوقع.

الكلمات المفتاحية: الحوادث المرورية والسلامة ونظام الخبير والمعالجات.

1. Background

Safety is the primary goal of transportation engineering. The effort that public agencies put into reducing traffic accidents is highly justifiable.Traffic accidents place a huge financial burden on society. Two major factors usually play an important role in traffic accidents occurrence. The first is related to the driver, and the second is related to the roadway design. In addition, the vehicle has a significant role in traffic accidents due to different types to happen during driving (Abdel-Aty and Rowan, 1999; Ismail, 1988).

As the number of motor vehicle and vehicle-mile of travel increases throughout the world, the exposure of the population to traffic accidents also increases. The World Health Organization, road traffic injuries caused reported that 1.24 million deaths worldwide in the year 2010, slightly down from 1.26 million in 2000 (i.e. one person is killed every 25 seconds) (Wikipedia, 2015).

Actually, the traffic accidents could be described as a combination of an engineering problem, an education problem, and an enforcement problem. Obviously, one could consider it to be a social problem, because of its profound effect on society. It appears logical to consider the potential effect that may be realized through concentered efforts in these areas (Khisty and Lall, 1998).

The first step in accident prevention is to have accurate and detailed information about all circumstances surrounding past accidents. These data should include exact location and time; vehicle speed, paths, damage; light, weather, and road situation; and driver and vehicle condition.

In Iraq, the police department is the authority which is responsible for reporting the traffic accident, and they send after that a special report containing information that is needed by the department regions which are connected with the accident, in addition to the statistical organizations (Police Units, Amanat Baghdad, National Insurance Company (N.I.C), General Directorate of Traffic, General Corporation of Roads and Bridges, and Planning Corp, and others) (Al-Refaie, 2001).

In fact, reporting an accident is made if a person is killed or somebody injured and entered a hospital for medical treatment. If the accident causes a property damage, it needs to report a request from the person or region who is involved with accident, and they have right to request for a financial compensation (Al-Refaie, 2001 and Ali, 2001).

2. Nature of Traffic Accidents in Iraq

The number of accidents has declined from 25310 in 1990 to 6783 in 1999 despite increasing in vehicle numbers as shown in Table (1). The percentage of this decrement is about (8.1%) (Ali, 2001).

Referring to Table 1, there is a large difference between Iraq and other countries such as Jordan and Syria, in the number of accidents. The ratio of fatalities to accidents in Iraq was (32.8%) in 1995. In Jordan it was (1.6%) and in Syria was (8.8%), that is, the number of accidents in Iraq is more than that in Jordan by (20.5) times and in Syria by (3.7) times.

Table (1) Comparison among Iraq, Syria and Jordan in number of accidents injuries and fatalities (Madlum, 1997 and Ali, 2001).

Country / Year		1995	1996
Iraq	**No. of accident**	5223	5331
	No. of Injures	4232	4264
	No. of Fatalities	1717	1573
Syria	No. of accident	15649	14297
	No. of Injures	7897	8425
	No. of Fatalities	1524	1386
Jordan	No. of accident	28980	33784
	No. of Injures	13184	15375
	No. of Fatalities	469	552

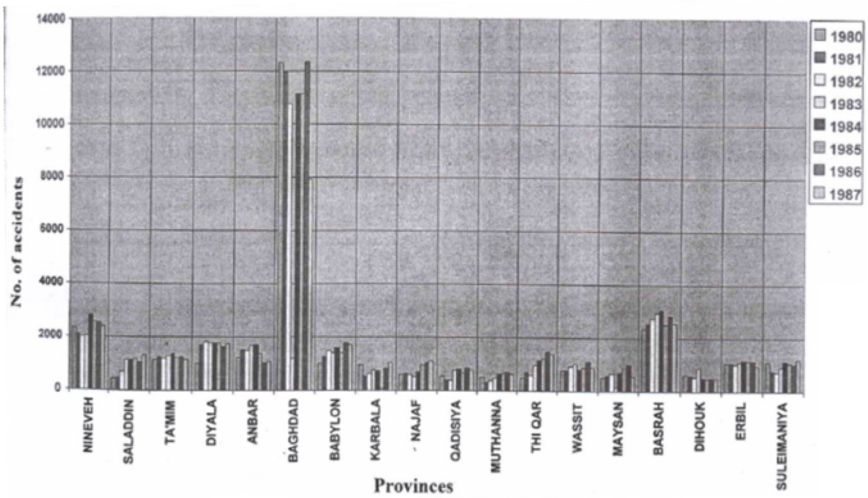
On the other hand, the comparison among Iraq and other countries is obviously from these percentages as below (Madlum, 1997):

- Iraq = fatal / accidents = 1/ 4
- Denmark = fatal / accidents =1/14
- France = fatal / accidents =1/16
- British = fatal / accidents =1/47
- Japan = fatal / accidents =1/57
- United States = fatal / accidents =1/57

Figure 1 Accidents distribute among different Iraqi provinces (Ali, 2001).

Thus, Iraq has the large number of fatal among other countries. In addition, According to the latest WHO data published in May 2014 road traffic accidents deaths in Iraq are 9,887 or 6.68% of total deaths. The age adjusted death rate is 41.41 per 100,000 of population ranks Iraq #2 in the world (Worldlife, 2015).

In fact, Baghdad has a large number of accidents than other cities (provinces) in Iraq as shown in Figures (1). Moreover, expressway is more than other ways in the number of accidents as shown in Figure (2).



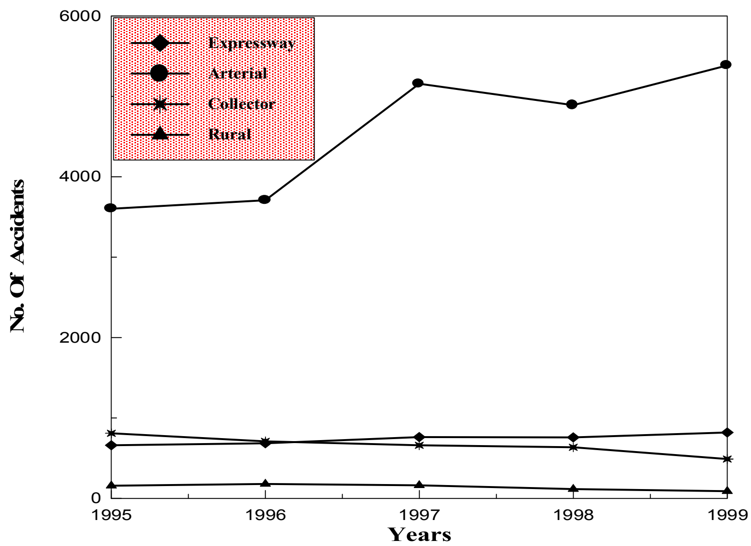


Figure (2) The number of accidents in different type of roads in Iraq (Ali, 2001).

As elsewhere, road accidents in Iraq are attributed to three major factors: human error, roadway conditions, and vehicle conditions as shown in Figure (3).

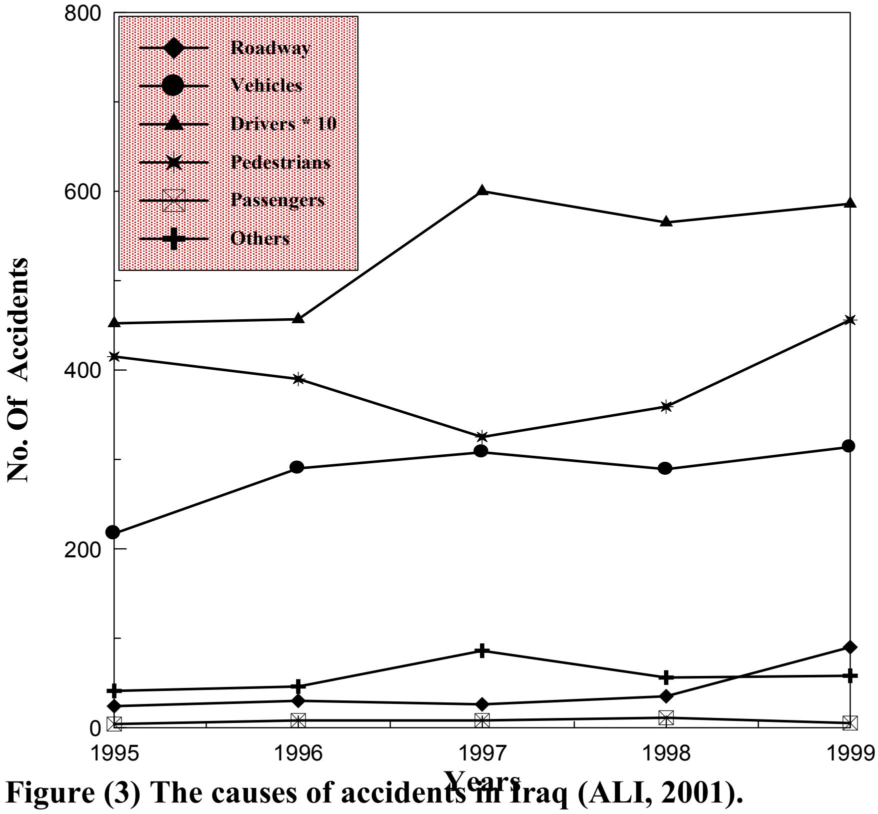


Figure (3) The causes of accidents in Iraq (ALI, 2001).

Secondary factors may include adverse weather conditions, such as frost, fog, rain and sand storm, high temperature during the summer season, and other related factors.

Human error is the major cause of auto accidents in Iraq. Ali (2001) indicated that more than 80% of the accidents are due to human error. Roads are full of irresponsible drivers who break traffic rules deliberately or ignorantly. Major traffic violations include speeding, improper overtaking, turning, and stopping, reckless driving and driving under the influence of alcohol.

Pedestrians are also at fault because many of them do not abide by traffic rules and regulations and do not follow the instructions necessary for their own safety.

Poor roadway conditions are to blame for about 10 % of traffic accidents in Iraq. Some accidents were attributed to mechanical failure caused by poorly maintained vehicles and oversize loads carried by vehicles. The percentage of accidents due to vehicle failure is more than (10%) of traffic accidents (Ali, 2001).

2. Deficiencies of Highway Safety in Iraq

According to different visits of traffic offices and interviews with traffic officers in Najaf and Baghdad, there are many deficiencies which increase from highway safety problem and make the mechanism of accident prevention in developing the country more difficult. These are:

- **The procedure of reporting traffic accidents:** the process of data collection concerning traffic accidents is the main factor that is followed by a series of accidents such as keeping and recording (reporting), and process of treatment and analysis. Without complete and detailed information about traffic accidents, the studies will not be detailed and accurate.At the present time, the value of information that is recorded during the time of accidents depends on the experience of the person who makes this report. The reports that officers make are inadequate. Also they do not give the actual causes of accidents. Therefore, a new procedure must be followed in recording the accidents so as to follow proper way to discover the actual causes of accidents.

- **Referencing Systems:** the accident location is not being identified accurately in the accident report because of absence of effective information that locates it.
- **Lower Safety Standards:** they exist on roads in general, but especially, at night due to poor visibility, and absence of signs, road markings, signals and other traffic controls.

3. General Countermeasures

The major countermeasures applied to combat Road Traffic accidents in Iraq during the last period were as follows (Hussein, 1988):

1- Establishment of the Traffic Police Department, and the Traffic Institute.
2- Improvement in the number and standards of driving schools.
3-Establishment of the road signs factory.
4-Enhancement and development of the traffic police equipment and increase in manpower.
5-Introduction of the compulsory front seatbelts legislation (1983).
6-Improvement of the drivers licensing procedures.

At the present time, some countermeasures are suggested to help reduce the number of traffic accidents. First, developing and implementing a comprehensive transformation of the existing system to meet the needs of the future. Second, building safer roads compatible with geometric design standards, providing control devices and roadside safety features wherever they are wanted for existing and future roads. Third, introducing traffic safety education and licensing programs. Concerned authorities should educate the public by holding seminars and lectures on traffic laws and regulations. The most promising thing to do in Iraq is to try to influence the behavior by continuous education and training in the following aspects (Ben Said, 1998):

A. measures are directed to children: It seems easier to develop new behavior habit than to change incorrect one. Children must be taught at home, school, etc. Also, parents could be involved to educate their children regarding the most important traffic risks, encourage necessary behavior and train their children in actual traffic behavior in their way to and from school.
B. Measures directed to driving license applicants and holders: several studies have indicated that trained drivers have roughly half to four fifths the accidents of untrained groups. The drivers and pedestrians should be taught.
C. Forth, Enforcing traffic laws strictly by punishing all violators and intensifying road surveillance.

4. Typical Accident Categories

A summary of accidents can be used to identify safety problems that may exist at a particular site. It can also be used to identify the accident pattern at a site, from which possible causes of accidents may be identified leading to the identification of possible countermeasures (Garber and Hoel, 1997 and, Khisty and Lall, 1998). There are different ways in which an accident at a site can be summarized *by* (Garber and Hoel, 1997 and, Khisty and Lall, 1998):

a- Human factors
b- Environmental factors, and
c- Vehicle-related factors

The necessary information is usually obtained from accident reports.

5. Countermeasure

It is a specific activity or set of related activities designed to contribute to the solution of an identified safety problem at a signal location.Examples of countermeasure are (1) an advance warning sign installation, (2) a yield sign installation, or (3) a left-turn prohibition during peak traffic periods at an unsignalized intersection (Rowan *et. al*., 1980). The objective of countermeasure development is to: (NAASRA, 1988)

1- Determine the range of measures likely to influence the dominant accident types and road features.
2- Select countermeasures which, on the basis of professional judgment and experience, can be expected to reduce the number or severity of accidents of the type dominant at the location.
3- Check that adopted countermeasures do not have undesirable consequences, either in safety terms (e.g. lead to an increase in the number) or severity of another accident type or in traffic efficiency or environmental terms.
4- Be cost-effective.

6. Accident patterns

In this study, thirteen types of accidents are discussed. And also, all possible causes and countermeasure are discussed according to the available resources and opinions of the experts. Figure (4) indicates the stages of solving the problems and Figure (5) indicates the types of accidents as reported by Garber and Hoel(1997) and, Khisty and Lall, (1998).

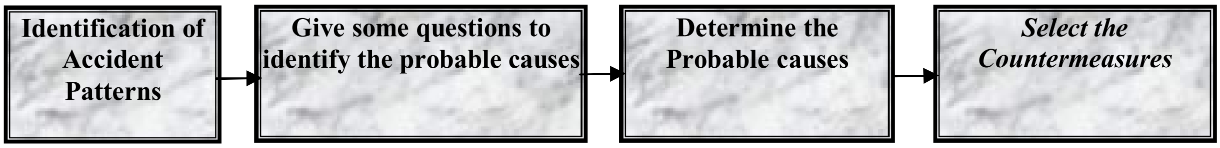


Figure (4) The stages of solving the problems.

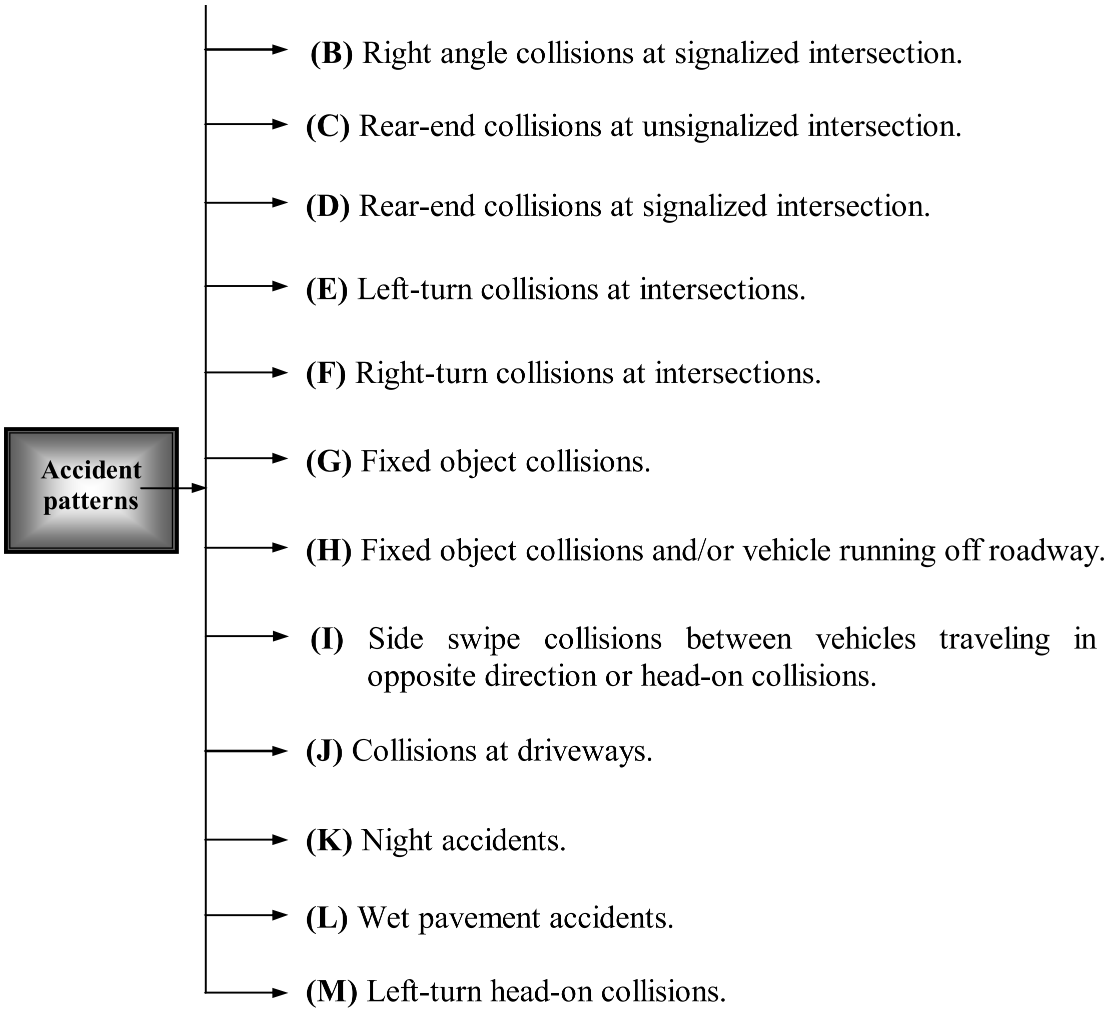


Figure (5) The accident patterns.

Figure 6 Left-turn accidents.

7. Expert system

Expert systems are computer programs that are constructed to do the kinds of activities that human experts can do, such as design, compose, plan, diagnose, interpret, summarize, audit and give advice. They are among the most useful and interesting application of artificial intelligence (Thielman and Giffith, 2000). Expert system technology is an attempt to mimic human experts in order to capture and preserve perishable expertise from one or several experts, and to transfer this expertise to the computer and then to other humans (Allwood, 1989).

The relationships between the Artificial Intelligence (AI) systems, knowledge-based expert systems (KBES), and expert system (ES) design are illustrated in Figure (7) (Liao, 2004).

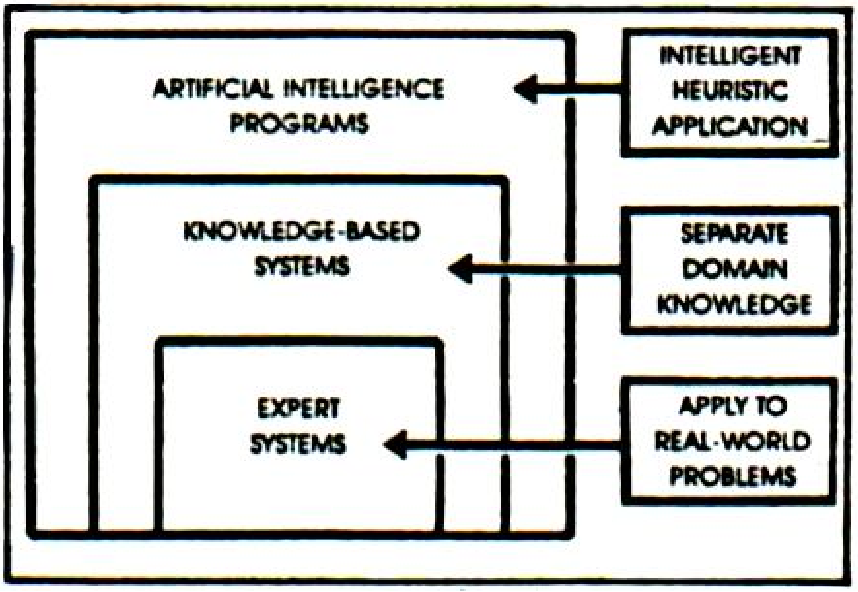


Figure (6) Expert system (ES) design (Clocksin and Mellish, 1984).

There is an analogy between an expert and an expert system, as shown in Figure (8).

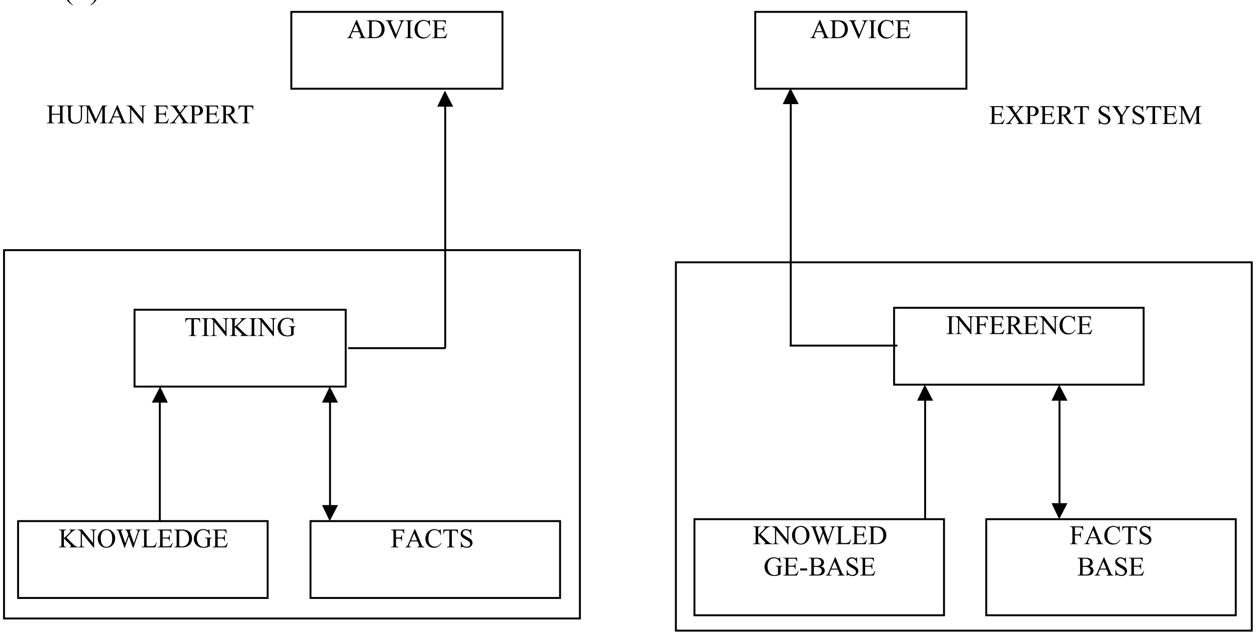


Figure (8) An analogy between human expert and expert system (Al-Zubadi, 2000).

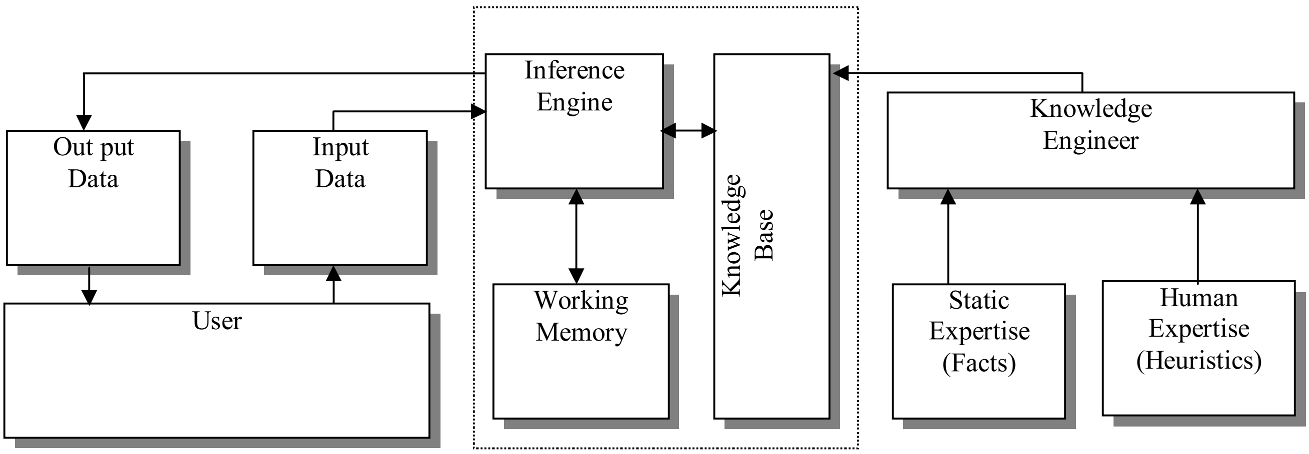


Figure (9) Expert system Architecture (Ajam, 1999).

Several humans participate in the development and use of an expert system (Cohn and Bouslby, 1988). End users benefit from the output of the expert system in some manner to aid in performing their jobs. End users can be classified as:

1- A non-expert seeking direct advice. In such a case the ES acts as a consultant.
2- A student who wants to learn. In such a case the ES acts as instructor.
3- An ES builder who wants to improve the knowledge base. In such a case the ES acts as a partner.

Choosing the right expert or experts is, of course, essential. Not only do they provide knowledge but also credibility, improved acceptance among users and sponsors and mouth-to-mouth marketing of the systems (Herland and Schddersson, 2000).

Another important factor to build expert system is the knowledge engineer who is able to link the team in such a way that other members can make their contribution.

The knowledge engineer must be able to convert the capacity for intelligent action into appropriate forms that can be utilized by the system (Beerel, 1997).

One of the most serious problems that faces the expert systems is the domain selection. If experts disagree, or a specialist in the domain is not available, then the domain is unsuitable. Domains where the nature of the problem changes rapidly are also unsuitable. Within a particular domain there are certain tasks that are not amenable to computerization.

In addition, knowledge acquisition is the extraction of knowledge from one or more domain experts and from the other sources, and then its transfer to the knowledge base. There are several formal methods of knowledge acquisition as listed below:(Allwood 1989 and Hart, 1989).

- **Introspection**: This is where the expert acts as an expert and knowledge engineer by examining his/her own thinking processes. The expert builds a system, which he/she believes that it effectively replicates his/her thinking processes. In this way, many excellent systems do benefit from the involvement of an experienced knowledge engineer.
- **Interviewing:**Hearing experienced engineers through making interviews for a couple of hours and taking notes most often follows up this technique. The questionnaires are then taken to provide knowledge and system to simulate the way of the expert about the same problems. The expert is then giving the

opportunity to verify whether the systems do an accurate reflection of his knowledge.

- **Observation:**Here the expert is placed under close observation while he/she works, the process most often involves the use of video camera or tape recording in order to analyze what he/she is doing and saying.
- **Induction:** This is the process of converting a set of examples into rules for software programs, which can handle this procedure.
- **Prototypic**:This is an extension of interviewing technique, where the questionnaire works with the experienced engineer in building a system; both parties contribute to the system design. The user of the system tests the knowledge base to include all the possible, suitable and specific decisions. The experienced engineer aims at getting the structure right by modifying the system while interacting with this expert. The prototypic method has the advantage of maximizing the interplay between the questionnaire and the experienced engineer, of amending the system route and achieving some visible result very quickly. Prototypic also facilitates the monitoring of the project and the ability to revise the system objectives at certain suitable stages.

After the development of an expert system using Visual Basic Language, it must be used and evaluated to make the modifications that may appear necessary, changing in coding structure, if required, to make it more understandable (i.e., evaluating the quality of an expert system to determine the level of expertise and accuracy that can be expected from it (Prerau, 1990 and Allwood, 1989).

The development of a diagnostic and advisory expert system in the domain of highway accident is presented. The system is intended to identify the accident patterns, clarify its probable cause, and provide the user with practical advice to remedy it. The developed system is saved on floppy disks, so it is easy to be handled, and can be used in many locations.

The limitations of the developed system could be summarized as following:

1. This system discusses thirteen patterns of accidents only.
2. Human errors comprise drivers, pedestrians and passengers in the system the driver only were discussed.
3. General countermeasures are suggested for each probable cause according to written resources and opinions of experts, and the cost of each countermeasure is not considered.
4. The probability of each probable cause is not discussed in the system.

The following phases are required to achieve this task (Prerau, 1990, Allwood 1989, and Hart 1990):

1- Knowledge elicitation.
2- Knowledge analysis and representation.
3- Coding and testing.

7.1 Knowledge Elicitation

It can be defined as the process of extracting domain knowledge base (facts, rules, heuristics, and procedures from the experts and other sources. The following phases are required to achieve these tasks.

1- From textbooks, papers, manuals and journals, basic information was gathered to recognize the research problem generally. This step is necessary to establish a preliminary background about the subject “highway safety”. Certain efforts were exerted to characterize the real experts and to determine where they usually present and whether they participated in conference and other scientific and practical activities.

2- Holding unstructured interviews to collect more information regarding them and the subject of the research, i.e., assigning further references and experts.
3- Structural (focused) interviews are the last step of this stage in which the knowledge approximately got acceptable. During these interviews, the questions were oriented directly to reach the required knowledge through documenting the question and the answers on paper, and using questionnaire form. According to need, these interviews might be repeated with the same experts to satisfy some inquires proceeding from previous interviews or from interviewing other experts.

The interviews were held with engineers working in the safety,design supervision, planning of the road and the police officers as shown in Table (2). For the purpose of success and acceptability, it is important to subject the system to vigorous testing prior to hand over to users. This stage has been done through representing a prototype and running it. Therefore, the re-running could treat mistakes and errors. Further improvement could be also added for interface by the same time.

7.2 Using the developed system

This stage consists of four parallel activities:

1- Technical testing of the system: This includes stability hardware operation system/software compatibility, invalid input handling, and output formats. This part presents no differences from traditional practices.
2- End user validation: This ensures that the system solves the real kind of problems and presents the conclusions in a way that end users understand. It also ensures that the user-interface enables the user to describe his problem in a way that is intuitive and obvious.
3- Knowledge verification: This ensures that the knowledge is correct and the expert system makes correct inferences.
4- Prototype interfaces: This ensures that interfaces are accepted by end users (or by any other prospective users).

The evaluation process consists of evaluation lists submitted to (18) users who have different level of experience. Some of them were previously involved in the elicitation session of the system. Table (2) indicated the numbers of evaluators, years of experience, factors that are discussed. From Table (2), there are two factors for each evaluation element. There are Relative Important factor (RI) and Quality Level (QL). Another factor, Evaluation Index (EI) is also included. The average (EI) is (84.00). It is a very good indication for the system because it is a first version that deals with highway safety problems by using the expert system technology. The (EI) is believed to be in higher level than above if the recommendations and proposal studies will be done. Some of the screens from the developed system have been demonstrated in Figure (A-1) (see the appendix).

Table (2) List of experts involved in developing the system.

No. of Experts	Position	Years of Exp.	Academic qualification	Method of Knowledge Acquisition		
				Unstructured Interviews	Structured Interviews	Questionnaire Form
1.	A law expert in road accident	30	Higher diploma in Accidents	X	X	X
2.	Traffic officer /director of computer center	28	Ph.D.	X	X	X
3.	Traffic officer /director of planning and follow-up department	25	Higher diploma	X	X	
4.	Traffic officer	25	Higher diploma		X	
5.	Traffic officer /commander of traffic police (Thi-Qar)	27	B.Sc.			X
6.	Traffic officer/ commander of traffic police (Najaf)	24	B.Sc.			X
7.	Traffic officer	32	B.Sc.	X		
8.	University Prof.	30	Ph.D.	X	X	X
9.	University Prof.	30	M.Sc.		X	X
10.	University Assist Prof.	12	Ph.D.			X
11.	University Assist Prof.	10	Ph.D.		X	
12.	University Assist Prof.	10	Ph.D.		X	
13.	University lecture	10	Ph.D.	X	X	X
14.	University lecture	8	Ph.D.		X	X
15.	Studies department	20	(B.Sc.)		X	X
16.	Design department	21	B.Sc.	X		X
17.	Design department	18	B.Sc.			X
18.	Design department	15	B.Sc.			X

8. Conclusions and recommendations

The following conclusions can be drawn from the research fieldwork and the developed system:

1. During the stage of system design, it was noticed that there is a lack in the highway safety measures because there is no Iraqi highway safety manual contains the suitable remedies according to the Iraqi traffic and climatic factors. The developed system may provide the first step to this manual.
2. The developed system is a cornerstone to solve the safety problem in Iraq because it depends mainly on academic and experiential experiences.
3. The expert system was validated by the officers in response to the statement "is the knowledge of seat belt usage useful to recognize the seat belt usage ". The officers responded with strong agreement during system design, development and testing.
4. The absence of good recording system at the roads of Iraq. Thus, inaccurate data lead to false analysis of the accident cause. Finally the study will be uncorrected according to these data and the problem will stay as it is. Also, the police officer that records the accident at the accident scene does not use the report form; therefore, necessary information was absent.
5. Providing expert knowledge on the type of accident and its probable causes and countermeasures for less experienced and inexperienced engineers especially when experts are not available or very hard to be.
6. The interaction between the officers and engineers is required for getting adequate results and adopting new technology regarding highway safety.
7. Expanding the study to discuss other accident patterns such as pedestrian accidents, cyclists, and using the same preceding patterns in the other locations such as interchanges.
8. Developing the system to include detection phase which depends on the data to identify the locations of high frequency accidents and then go to the diagnostic and remedy phase.

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Appendix A

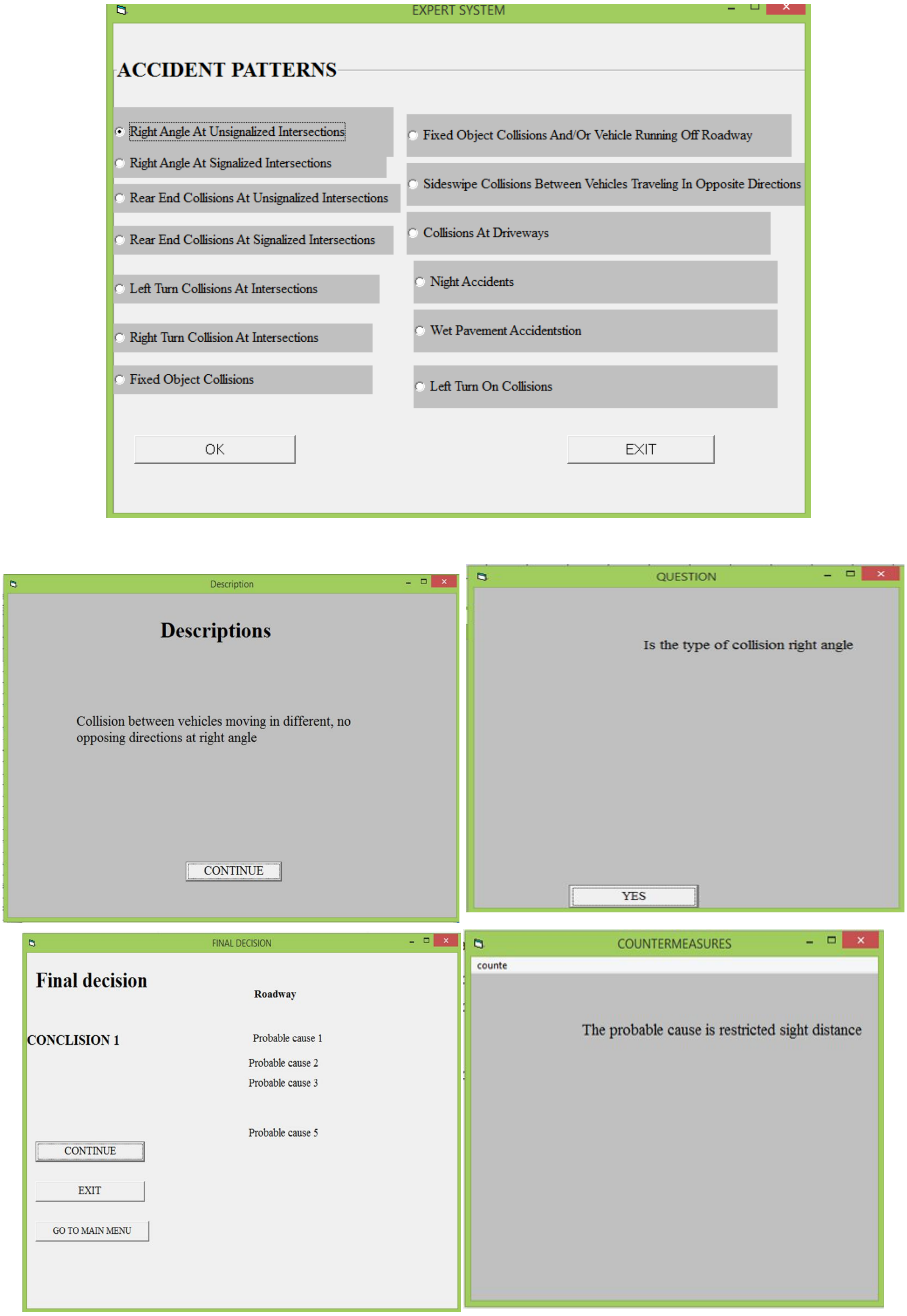

Figure A-1 Screens from the developed system.