DEVELOPMENT OF AN EXPERT SYSTEM FOR THE QUANTIFICATION OF FAULT RATES IN TRAFFIC ACCIDENTS

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ABSTRACT

DEVELOPMENT OF AN EXPERT SYSTEM FOR THE QUANTIFICATION OF FAULT RATES IN TRAFFIC ACCIDENTS

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Traffic accidents which damage the safety of human beings are one of the most important problems due to their material losses and effects to human health. Although continuous improvements are made by the governments; losses of traffic accidents are still a significant issue all over the world. The usual studies realized so far are generally related with the accident prevention models. However, there has not been much research done concerning the situation after the traffic accidents happen. After occurrence of traffic accidents, determination of fault rates for each party involved in the accident is urgently important. The aim of this study is to develop an expert system that uses the knowledge of experts for determination of fault rates in traffic accidents. For this purpose, a detailed literature survey was performed to define the determinants influencing the fault rates of each party. In addition, required data, that is, expert-witness reports were taken from academicians. Classification of these data was done and critical factors affecting fault rates were determined. In light of the defined factors, flowcharts were developed for each type of traffic accident. Moreover questionnaire submitted to experts, was prepared to acquire knowledge of experts. The critical factors affecting fault rates were assessed with a quantitative way in questionnaire. The proposed Traffic Accident Expert System (TAES) is on the basis of the knowledge of experts. Quantification of fault rates can change from one expert to another. An expert system such as the one this thesis will propose will prevent these contradictions. In addition, the expert system quantifies fault rates faster and more consistent as well.

Key Words: Traffic Accidents, Knowledge Management, Expert Systems

ÖZ

TRAFİK KAZALARI KUSUR ORANLARININ BELİRLENMESİNE YÖNELİK BİR UZMAN SİSTEM GELİŞTİRİLMESİ

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Trafik kazaları maddi ve manevi kayıplarından dolayı insanların can güvenliğini tehdit eden en önemli sorunlardan birisini oluşturmaktadır. Hükümetler tarafından iyileştirmeler yapılmasına rağmen, tüm dünyada trafik kazaları halen günümüzde önemli bir husus olarak belirginleşmektedir. Şimdiye kadar yapılan çalışmalar genellikle kaza önleme modelleri ile ilgili olmakla birlikte, kazanın oluşmasından sonrasına yönelik fazla bir araştırma mevcut değildir. Trafik kazalarının oluşundan sonra kazaya karışan tarafların kusur oranlarının belirlenmesi acilen önemlidir. Bu kapsamda; bu çalışmanın amacı, trafik kazalarında kusur oranlarının tespiti için uzmanların bilgilerini kullanan bir uzman system geliştirilmesidir. Bu amaçla, tarafların kusur oranını etkileyen etmenleri tanımlayabilmek için detaylı bir literatür taraması yapılmıştır. Bu verilerin sınıflandırılması yapılarak, kusur oranlarını etkileyen kritik faktörler tespit edilmiştir. Belirlenen faktörlerin ışığında, her tip trafik kazası için akış şeması geliştirilmiştir. Ayrıca, uzmanların bilgilerine ulaşmak için hazırlanan anket aracılığıyla uzman görüşleri derlenmiştir. Kusur oranlarını etkileyen kritik faktörler ankette sayısal bir yaklaşımla değerlendirilmiştir. Önerilen bu uzman sistem uzmanların bilgilerine dayanmaktadır. Kusur oranlarının belirlenmesi bir uzmandan diğerine göre değişebilmektedir. Bu çalışma kapsamında önerilen uzman sistem, bu çelişkileri önleyecek mahiyettedir. Bununla birlikte geliştirilen bu uzman sistem, kusur oranlarını daha hızlı ve daha tutarlı belirleyebilme potansiyeline sahiptir.

Anahtar Sözcükler: Trafik Kazaları, Bilgi Yönetimi, Uzman Sistemler.

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To

My Family

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LIST OF ABBREVIATIONS

AI	Artificial intelligence
DATLCES	Dynamic and Automatic Traffic Light Control Expert System
ECMT	European Conference of Ministers of Transport
EU	European Union
FIPA	The Foundation for Intelligent Physical Agents
GIS	Geographic Information System
GPTT	General Plan for Traffic Training
IRTAD	International Road Traffic and Accident Database
KBS	Knowledge-based System
KBSLUA	Knowledge-based System Land Use Assessment
KM	Knowledge Management
KR	Knowledge Representation
MF-KBS	Multifunctional Knowledge-based System
OECD	Organization for Economic Cooperation and Development
SGD	Security General Directorate
TAES	Traffic Accident Expert System
WHO	World Health Organization

CHAPTER 1

INTRODUCTION

Traffic accidents which threaten the safety of human beings are one of the most important problems because of their material losses and effects to human health. Although improvements are made by governments, traffic accidents are still a significant issue all over the world. Most of the traffic accidents have been happening due to driving without proper care and attention, and inappropriate or excessive speed. The aim of this study is to develop an expert system that reflects the knowledge of experts for the determination of fault rates in traffic accidents.

The road traffic injury problem began with the car – and subsequently buses, trucks and other vehicles – that the problem escalated rapidly. By various accounts, the first injury crash was supposedly suffered by a cyclist in New York City on 30 May 1896, followed a few months later by the first fatality, a pedestrian in London. Despite the early concerns expressed over serious injury and loss of life, road traffic crashes have continued to this day to exact their toll. Though the exact number will never be known, the number of fatalities was conservatively estimated to have reached a cumulative total of 25 million by 1997 (Faith, 1997).

According to the "World report on traffic injury prevention, 2004", worldwide the number of people killed in road traffic crashes each year is estimated at almost 1,2 million, while the number injured could be as high as 50 million. This represents an average of 3287 persons dying each day around the world from road traffic injuries. Also, researchers state that the situation will become worse in the future. Without increased efforts and new initiatives, the total number of road traffic deaths worldwide and injuries worldwide is forecasted to rise by some 65% between 2000 and 2020 and in low-income and middle-income countries deaths are expected to increase by as much as 80%. The majority of such deaths are currently among "vulnerable road users" – pedestrians, pedal cyclists and motorcyclists. In high-income countries, deaths among car occupants continue to be predominant, but the risks per capita that vulnerable road users face are high (Murray CJL., and Lopez AD., 1996). Furthermore, on current trends, by 2020, road crash injury is likely to be the third leading cause of disability-adjusted life years lost (WHO, 2004). Table 1.1 shows the 10 leading causes of the global burden of diseases.

Table 1.1 The 10 leading causes of the global burden of disease

	1990		2020
Rank	Disease or injury	Rank	Disease or injury
1	Lower respiratory infections	1	Ischaemic heart disease
2	Diarrhoeal diseases	2	Unipolar major depression
3	Perinatal conditions	3	Road traffic injuries
4	Unipolar major depression	4	Cerebrovascular disease
5	Ischaemic heart disease	5	Chronic obstructive pulmonary disease
6	Cerebrovascular disease	6	Lower respiratory infections
7	Tuberculosis	7	Tuberculosis
8	Measles	8	War
9	Road traffic injuries	9	Diarrhoeal diseases
10	Congenital abnormalities	10	HIV

DALY: Disability-adjusted life year. A health-gap measure that combines information on the number of years lost from premature death with the loss of health from disability.

Every day around the world, almost 16000 people die from all types of injuries (WHO, 2004). Injuries represent 12% of the global burden of disease, the third most important cause of overall mortality and the main cause of death among 1–40 year-olds. The category of injuries worldwide is dominated by those incurred in road crashes. According to WHO's data, deaths from road traffic injuries account for around 25% of all deaths from injuries. Table 1.2 presents the leading causes of deaths by age group.

Table 1.2 Leading causes of the death by age group

Rank	0–4 years	5–14 years	15–29 years	30–44 years	45–59 years	≥60 years	All ages
1	Lower respiratory infections 1 890 008	Childhood cluster diseases 219 434	HIV/AIDS 707 277	HIV/AIDS 1 178 856	Ischaemic heart disease 1 043 978	Ischaemic heart disease 5 812 863	Ischaemic heart disease 7 153 056
2	Diarrhoeal diseases 1 577 891	Road traffic injuries 130 835	Road traffic injuries 302 208	Tuberculosis 390 004	Cerebrovascular disease 623 099	Cerebrovascular disease 4 685 722	Cerebrovascular disease 5 489 591
3	Low birth weight 1 149 168	Lower respiratory infections 127 782	Self-inflicted injuries 251 806	Road traffic injuries 285 457	Tuberculosis 400 704	Chronic obstructive pulmonary diseases 2 396 739	Lower respiratory infections 3 764 415
4	Malaria 1 098 446	HIV/AIDS 108 090	Tuberculosis 245 818	Ischaemic heart disease 231 340	HIV/AIDS 390 267	Lower respiratory infections 1 395 611	HIV/AIDS 2 818 762
5	Childhood cluster diseases 1 046 177	Drowning 86 327	Interpersonal violence 216 169	Self-inflicted injuries 230 490	Chronic obstructive pulmonary diseases 309 726	Trachea, bronchus, lung cancers 927 889	Chronic obstructive pulmonary diseases 2 743 509
6	Birth asphyxia and birth trauma 729 066	Malaria 76 257	Lower respiratory infections 92 522	Interpersonal violence 165 796	Trachea, bronchus, lung cancers 261 860	Diabetes mellitus 749 977	Diarrhoeal diseases 1 766 447
7	HIV/AIDS 370 706	Tropical cluster diseases 35 454	Fires 90 845	Cerebrovascular disease 124 417	Cirrhosis of the liver 250 208	Hypertensive heart disease 732 262	Childhood-cluster diseases 1 359 548
8	Congenital heart anomalies 223 569	Fires 33 046	Drowning 87 499	Cirrhosis of the liver 100 101	Road traffic injuries 221 776	Stomach cancer 605 395	Tuberculosis 1 605 063
9	Protein–energy malnutrition 138 197	Tuberculosis 32 762	War 71 680	Lower respiratory infections 98 232	Self-inflicted injuries 189 215	Tuberculosis 495 199	Trachea, bronchus, lung cancers 1 238 417
10	STDs excluding HIV 67 871	Protein–energy malnutrition 30 763	Hypertensive disorders 61 711	Poisonings 81 930	Stomach cancer 185 188	Colon and rectum cancers 476 902	Malaria 1 221 432
11	Meningitis 64 255	Meningitis 30 694	Maternal haemor-rhage 56 233	Fires 67 511	Liver cancer 180 117	Nephritis and nephrosis 440 708	Road traffic injuries 1 183 492
12	Drowning 57 287	Leukaemia 21 097	Ischaemic heart disease 53 870	Maternal haemorrhage 63 191	Diabetes mellitus 175 423	Alzheimer and other dementias 382 339	Low birth weight 1 149 172
13	Road traffic injuries 49 736	Falls 20 084	Poisoning 52 956	War 61 018	Lower respiratory infections 160 259	Liver cancer 367 503	Diabetes mellitus 982 175
14	Endocrine disorders 42 619	Violence 18 551	Childhood cluster diseases 48 101	Drowning 56 744	Breast cancer 147 489	Cirrhosis of the liver 366 417	Hypertensive heart disease 903 612
15	Tuberculosis 40 574	Poisonings 18 529	Abortion 43 782	Liver cancer 55 486	Hypertensive heart disease 129 634	Oesophagus cancer 318 112	Self-inflicted injuries 874 955

In 2002, the overall global road traffic injury mortality rate was 19.0 per 100 000 population (WHO, 2004). Low-income and middle-income countries had a rate slightly greater than the global average, while that for high-income countries was considerably lower. The vast majority – 90% – of road traffic deaths were in low-income and middle-income countries. Only 10% of road traffic deaths occurred in high-income countries. Table 1.3 displays estimated global road traffic injury-related deaths.

Table 1.3 Estimated global road traffic injury-related deaths

Estimated global road traffic injury-related deaths

	Number	Rate per 100 000 population	Proportion of total (%)
Low-income and middle-income countries	1 065 988	20.2	90
High-income countries	117 504	12.6	10
Total	1 183 492	19.0	100

According to WHO data for 2002, road traffic injuries accounted for 2.1% of all global deaths and ranked as the 11th leading cause of death. Furthermore, these road traffic deaths accounted for 23% of all injury deaths worldwide. Figure 1.1 shows distribution of global injury mortality by cause.

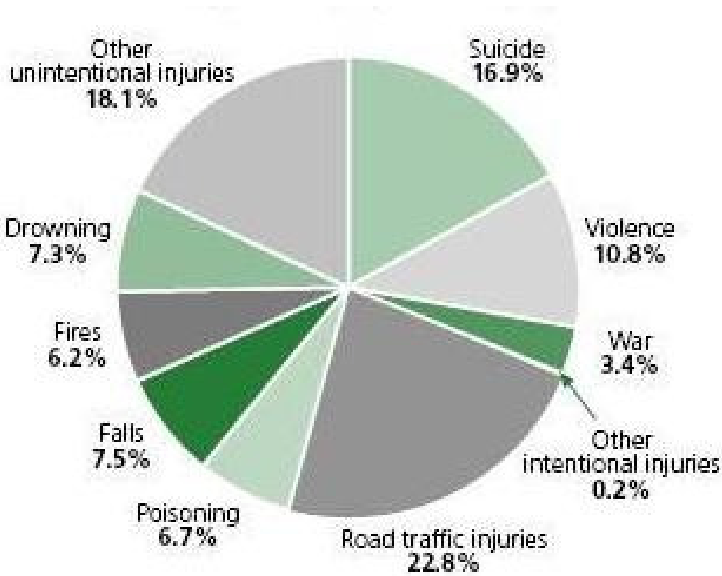


Figure 1.1 Distribution of global injury mortality by cause

Some cost quantification studies show that cost of global road crashes estimated at US$ 518 billion, with the costs in low-income countries – estimated at US$ 65 billion – exceeding the total annual amount received in development assistance (Jacobs G., Aeron-Thomas A., and Astrop A., 2000).

Over 50% of the global mortality due to road traffic injury occurs among young adults aged between 15 and 44 years, and the rates for this age group are higher in low-income and middle-income countries (WHO, 2004). Road traffic mortality rates are higher in men than in women in all regions regardless of income level, and also across all age groups. Figure 1.2 presents road traffic deaths by sex and age group.

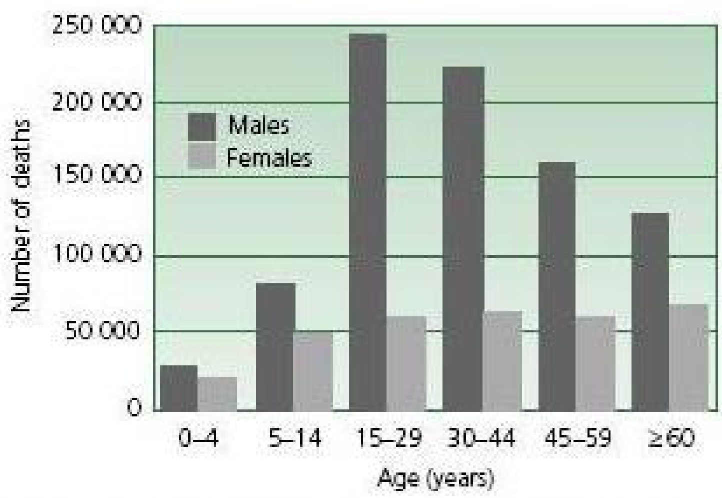


Figure 1.2 Road traffic deaths by sex and age group

The above mentioned statistics show the importance of traffic safety for human beings and economic resources. Many studies have been implemented for preventing road traffic accidents. Usually, these studies are related to parameters before road traffic accidents. That is to say, these are generally accident causation models and accident prevention techniques. There has not been much research done concerning the aftermath of road traffic accidents. Especially the studies relevant to after the accidents occur are statistical studies, giving some opinion about accidents by referencing statistics. However, this study focuses on assigning fault rates after the occurrence of traffic accidents. That is to say, it is urgently significant to determine responsible party involved in an accident after happening of a traffic accident. Therefore, the developed expert system determines the fault rates of each party involved in traffic accidents.

The investigation of urban traffic accidents is in responsibility of Security General Directorate Traffic Utilities Presidency in Turkey. When an urban traffic accident occurs, the first investigation is conducted by the police. However, the fact finding reports (accident reports) for traffic accidents with material damage can be investigated by vehicle drivers or parties involved in accident. The accident reports include date of accident, location, driver information, pedestrian information, road condition, weather condition etc. The criminal courts of first instance consider these reports to arrive at a conclusion. In fact, the criminal courts take into account the expert-witness reports in order to give a decision. There can be differences in quantification of fault rates in traffic accidents in expert-witness reports. That is to say, fault rates can change from one expert to another. This contradiction is related to some issues such as experience of experts, knowledge of experts about laws and regulations, insufficiency of data about accident etc. An expert system such as the one this thesis will propose will prevent these contradictions. In addition, the expert system quantifies the fault rates faster and more consistent as well.

The Traffic Accident Expert System based on the knowledge of experts is for the quantification of fault rates in traffic accidents. In order to overcome the problem of contradictions such an expert system is required. This expert system is expected to attain equality with experts or a committee of experts. That is to say, by using such an expert system, less time is spent and consistent appraisal results are produced. In fact, the responsibilities of different parties involved in traffic accidents need to be examined by fair and unbiased institutions.

At the initial step of this study, we divided accident types into five groups; they were accidents with the following: vehicle, pedestrian, fixed object, overturn, and two-wheeler users. When the obtained expert-witness reports were examined, it was concluded that **"vehicle - pedestrian"** and **"vehicle - vehicle"** accidents constitute most of the reports. Therefore these two types of accidents were selected for this study.

There are several types of "vehicle – pedestrian" and "vehicle – vehicle" accidents with respect to location where the accident happened. Some types of accidents include on a signalized intersection, on a zebra crossing, on a straight road, on a non signalized intersection. Also, vehicle accidents can be in different positions as followings: vehicles from opposing direction, overtaking, vehicles from one direction, vehicles from adjacent approaches, and on a path.

The required data was obtained from experts or academics. 146 reports were found to be related with the urban traffic accidents. The most common type of accident in urban traffic was “vehicle - pedestrian” among reports. 87 of 146 reports were related with “vehicle – pedestrian” type of accident. Also, 33 of 146 reports were related with “vehicle – vehicle” type of accident. Such reports showed that “vehicle – pedestrian” and “vehicle – vehicle” accidents were most occurring type of accidents in urban areas. In addition, 97 reports were found to be related with the rural traffic accidents. “Vehicle – vehicle” type of accident was the most occurring type among the reports in rural areas as well.

In this study, the reports received from experts were investigated. Also, laws and regulations related with road traffic were analyzed. While determining fault rates experience, knowledge and intuition have critical role. As mentioned before, this leads to contradictions among expert-witnesses. The Traffic Accident Expert System averts this problem by incorporating knowledge of experts in the form of rules.

After classification of the expert-witness reports and the accident types, the factors leading to the traffic accident were determined. All these factors were also classified for each type of traffic accident. In light of the identified or classified factors, flowcharts were developed for selected accident types. These flowcharts consist of scenarios causing traffic accidents. The questions are asked through the flowcharts. That is to say, some questions are conditional. In other words, the forthcoming question is depended on the question asked before.

A questionnaire was submitted to experts so as to develop a quantification system by considering flowcharts. This questionnaire has some produced scenarios with respect to types of urban and rural traffic accidents. The experts analyzed these scenarios by quantifying all of them. The results determined by experts were utilized in the expert system. There are different flowcharts developed by the researcher of this study in respect of accident types in the proposed expert system. The questions in questionnaire are organized by taking those flowcharts into consideration. At the end of the quantification, the expert system also prepares a report which explains the reasoning of assigned fault rates related to the concerned accident.

Within the context of this thesis, Chapter 2 presents the traffic accident statistics with the definitions and traffic accident investigation with the laws in Turkey. Chapter 3 outlines the literature review on expert systems with its applications. Chapter 4 discusses the knowledge acquisition and management process of Traffic Accident Expert System with literature review and selected type of traffic accident flowcharts. Also, the structure of the questionnaire is scrutinized in this chapter. Chapter 5 reviews the developed expert system in detail. Finally, Chapter 6 concludes the study and introduces research contributions, limitations, and future work.

CHAPTER 2

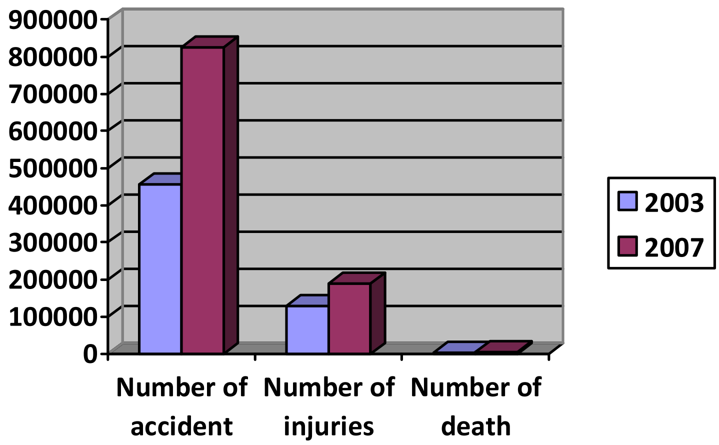
TRAFFIC ACCIDENTS IN TURKEY

This chapter presents the traffic accident statistics with the definitions and traffic accident investigation with the laws in Turkey. Also, current state of affairs and traffic safety in Turkey are introduced in this chapter.

Road transportation is usually chosen although there are different options presented to people in Turkey such as railway, sea, and airline. In addition, traffic accidents occur more commonly because of the fact that safety traffic conditions have not been supplied yet in Turkey. The main road safety problems today are extreme speed, drunk driving, not using a seatbelt, fatigue and distracted driving, and pedestrian safety etc. As a result of traffic accidents, deaths, injuries, and economic losses take place. Laws, media, education, drivers and pedestrians can provide consciousness or awareness about traffic accidents so as to achieve safety traffic conditions. Although necessary measures are taken into consideration, traffic accidents are still one of the most significant problems in Turkey.

The ratios of road transportation and road haulage are 95 per cent and 92 per cent respectively (Security General Directorate, 2007). Therefore, there is an important risk of traffic accidents in Turkey. While the number of accidents in Turkey in 2003 was 455.667; with 81 per cent rate of increase, this number reached to 825.583 in 2007 (See Table 2.1 in Appendix A). Furthermore, injury and death toll has increased since 2003 similar to number of traffic accidents. While being 128.689 in 2003; the number of injuries reached to 188.383 in 2007 with 46 per cent rate of increase. Alike death toll increased from 3966 to 5004. The given statistical data is shown in Table 2.1 in Appendix A. Also, Table 2.2 presents the traffic accident results in Turkey. Nevertheless, the number of deaths and the amount of economic loss do not show the truth.

Table 2.2 Traffic accident results in Turkey



When these rates are compared with European Union (EU), the impact of danger can be comprehended. “The number of deaths per 100.000 vehicle” is considered as a significant piece of data in terms of traffic accidents. The situation in Turkey does not appear to be hopeful such that according to 2007 data, deaths per 100.000 vehicles is 14 in 2006 in 13 European Union Countries, while being 38 in Turkey (See Table 2.3).

Table 2.3 Comparison of traffic data

Country	Number of accident (injured)	Death Toll	Vehicles per 1000 people	Per 100.000 vehicles	Per 100.000 population
				Death	Death
GERMANY	341.980	5.091	666	9	6
AUSTRIA	39.468	730	645	14	9
FRANCE	58.215	4.709	609	13	8
POLAND	46.876	5.243	473	29	14
CZECH REPUBLIC	16.415	1.063	483	21	10
FINLAND	7.052	336	566	11	6
HOLLAND	25.308	730	533	8	4
SPAIN	99.797	4.104	649	14	9
SWEDEN	16.344	445	575	9	5
PORTUGAL	35.680	969	519	18	9
NORWAY	6.733	242	653	8	5
ENGLAND	258.404	3.172	565	10	5
SLOVENIA	11.731	263	581	23	13
AVERAGE OF 13 EUROPEAN UNION COUNTRIES			**578**	**14**	**8**
TURKEY	**107.013**	**5.004**	**184**	**38**	**7**
SWETZERLAND	27.088	370	685	7	5
KOREA	209.524	6.327	391	33	13
CANADA	151.321	2.925	624	15	9
JAPAN	886.864	7.272	648	9	6
NEW ZEALAND	7.425	391	755	13	9

In order to understand the quantum of damages after traffic accidents, the table shown in below gives statistics in detail. Table 2.4 discloses the number of fatal and injured traffic accidents with quantum of damages in 2007 in Turkey.

Table 2.4 Fatal, injured people in traffic accidents and quantum of damages

LOCATION	FATAL		INJURED		QUANTUM OF DAMAGES	
	Accident	Death	Accident	Injured	Accident	Damages (YTL)
Urban	1.042	1.219	62.491	96.081	601.925	988.492.982
Suburban	2.904	3.785	40.576	92.302	116.645	571.916.680
TOTAL	3.946	5.004	103.067	188.383	718.570	1.560.409.662

As it can be seen from the Table 2.4 fatalities in suburban areas are higher compared to urban areas. The first reason for this situation may be the speed limits which are much higher on suburban roads as compared with urban roads. In fact, most of the infringements occur on suburban or intercity roads because of dense traffic in urban roads. However, the injured and death toll is expected to decrease owing to construction of divided roads.

After occurrence of an accident the important issue is assigning fault rates or determining responsible party involved in the accident. Fault rates of traffic accidents are distributed among driver, pedestrian, vehicle, road, and passenger. The fault rates of each party of 2007 were published by Security General Directorate shown in Table 2.5 in Appendix A. In fact, the fault rates of traffic accidents and the factors of accidents are denoted as driver, pedestrian, vehicle, road and passenger.

In Turkey, records of traffic accidents have started to be arranged in two different forms dividing accidents including death, injury versus accidents including material loss since 2000. After this application, Security General Directorate has only assessed the accident data including death and injury. A literature review was done and some definitions are given below.

2.1. Definitions

Traffic Accident:

An event which can cause death, injury and material loss due to the crash of one or more vehicles moving on roads or highways (Traffic Accident Statistics, 2005).

The book named "Traffic Accident Statistics, 2005" also defines some concepts as given below.

Single vehicle accidents:

Traffic accidents in which only one vehicle is involved.

Accidents of two vehicles:

Traffic accidents in which only two vehicles are involved.

Material Loss:

Covers only the damage to the vehicles involved in an accident.

Persons killed:

Covers persons killed in the course of an accident or as a result of the accident.

Persons injured:

Covers persons not killed, but injured as a result of the accident.

2.2. Traffic Accident Investigations in Turkey

The police associated with Security General Directorate Traffic Utilities Presidency are authorized for investigating the traffic accidents and preparing the reports. These accident reports include following parts such as, location of accident, type of accident, weather condition, road and environment conditions, vehicles involved in accident, drivers involved in accident, information about passenger and pedestrian, infringements done by parties, and also summary of the accident with a simple drawing. When traffic accident occurs, depending on the severity of the traffic accident, the police are called. However, in some cases which are traffic accidents with material damage the police may not be called.

The legal decision process of quantification of fault rates in traffic accidents is explained below.

When a traffic accident has happened, the police come to the accident location and prepare the accident report. Subsequently this report is presented to the criminal court of first instance. The court then selects expert-witnesses for the duty of quantification of fault rates. Later, the court gives its decision by taking expert-witness reports account. However, the defendant has the right to make objection. This objection is made to Supreme Court. Also, a compensation case is valid in traffic accidents. As mentioned above, the courts consider the expert-witness reports while giving a decision.

2.3. Laws and Regulations Related with Traffic Accidents in Turkey

The Highway Traffic Law No. 2918 which was accepted in 1983. Later, however, some amendments were made in accordance with other laws. In addition, this law is composed of 135 items. Moreover, regulations related to this law were arranged. With the law amendment in Road Traffic Law No: 2918, (June 19, 1985), the use of a seatbelt was rendered obligatory to use safety belts, and this law was put into practice on June 18, 1986. In addition, with the Law No: 22078 dated on October 11 1994, which was issued in the Official Gazette, it was made obligatory for vehicles, manufactured in Turkey or imported into Turkey, to have rear seatbelts as of January 11, 1995. Provision concerning safety belts in the back seats of vans, trucks, lorries, tractors and intercity buses are applied to vehicles manufactured after August 1, 1998. It is also forbidden to transport children under 10 years old in the front passenger seat. In accordance with Article 150 of the Regulation of Road Traffic No: 2918, it is obligatory for drivers to use protective helmets and protective glasses, and for passengers to use protective helmets, on motorbikes and mopeds. In this thesis, Law No. 2918 is taken into account throughout preparing an accident report.

2.4. Current State of Affairs and National Diagnosis in Turkey

There are positive improvements in recent years about reducing risks of traffic accidents in order to achieve road safety. OECD/ECMT Transport Research Centre published a report on road safety performance in Turkey in 2006. According to that report, some strategies were executed so as to decrease risk of crashes in Turkey. These strategies are shown below.

Table 2.6 Strategies to decrease risk of crashes

Improved speed compliance / enforcement	From 20 November 1998, 450 radar equipments with video cameras have been used actively in speed enforcement. With this equipment it was intended to increase the perception of control on drivers by increasing the risk of being detected in order to reduce the number of accidents caused by high speed.
Reduced speed limits	No
New Regulation and enforcement related to : Drink driving, drunk pedestrians, driving under the influence of drugs	According to Article 48 of No 2918 of the Road Traffic Law (amended in 2003), it is forbidden to drive under the influence of alcohol or drugs.
Major infrastructure improvement programmes (fully controlled intersections, roundabouts, lighting, sealed shoulders, tactile edge line marking, etc.)	Construction of divided roads.
Enforcement of other road rules	Regular controls of infringements which have greatest effect upon the formation of accidents and leading to death: speeding, too close follow-up, faulty overtaking, alcohol and safety belt.
Regulation on vehicle inspection	Yes, ongoing
Emergency services	No

Table 2.4 Strategies to decrease risk of crashes (continued)

Graduated Licensing for novice drivers	With the EU harmonization process, a draft law is being discussed in Parliament to redefine conditions required for obtaining a driving licence. When the draft law is legalised, driving licence classes and conditions will be put into effect.
Education and information programmes	1. 2004 was announced as the Traffic Year. In this context; a number of road safety campaigns were launched: a) Tyres b) Seat Belt c) Fatigue d) Safe walk for children e) Extreme speed (Break yourself) f) Alcohol 2. Educational programmes on radios and TVs aimed at drivers and pedestrians have been organized. Seminars have been organized regarding the risks that drivers and pedestrians may face in traffic.
Safety equipment: enforcement of seat belt wearing/ helmet use	No recent changes.
Infrastructure improvements: Divided road (median barrier), roadside safety barriers, fewer obstacles further from roadway	Yes, ongoing

Table 2.4 Strategies to decrease risk of crashes (continued)

Regulation on active vehicle safety equipment	In order to prevent traffic accidents incurred by the intercity passenger buses, tachograph (displaying speed, how long the vehicle is used, calibration and intervention), installment of the lights, licence, registry and other traffic documents, insurance policies, certificate for using commercial vehicles are all examined. The technical examinations of the cars, as well as the drivers against intoxication, are checked in a computer based environment at the entrance and exit of the terminals. Those drivers who are problematic are disallowed, and the necessary legal transactions are made for those who have deficiencies. In order to prevent traffic accidents incurred by trucks, officials of the concerned bodies and institutions should take part in inspections including those mentioned above for the inspection of weights.

2.5. Traffic Safety in Turkey

When education level of drivers involved in accidents resulted in deaths and injuries between the years 2002-2005 is reviewed, it is seen that approximately 50 per cent of them are graduates of primary school. This ratio reflects the importance of relationship between education and accident (Prevention Activities against Traffic Accidents, 2008). Therefore the most significant issue in traffic safety is education. For this purpose Ministry of National Education prepared implementation, monitoring and inter-institutional coordination of General Plan for Traffic Training (GPTT) whereby pre-school, intra- and extramural traffic training are regulated were unsuccessful, although it was put into effect in 2001.

Another problem related with road safety in Turkey is motor vehicle driving courses which are not controlled effectively. In fact, training supplied at motor vehicle driving courses is not enough in training trainees as safe drivers in traffic. In addition to this situation, driving abilities of driving students are not fully evaluated in at driving tests.

An additional problem related to road safety is pedestrian control. According to statistics of the last decade obtained from Security General Directorate, approximately 21.7 percent of people who lost their lives due to traffic accidents are pedestrians (Prevention Activities against Traffic Accidents, 2008). Despite the fact that on average 30.9 percent of total pedestrian deaths occurs outside settlement areas, pedestrian control is not included in the control programs prepared by Security General Directorate for regional traffic units. Another factor threatening pedestrian safety is that vehicles are parked commonly on sidewalks, which was observed at all provinces covered in on-site audit and which forces pedestrians to use the traffic way instead of the sidewalks designated for pedestrians.

The last issue with regard to traffic safety in Turkey is the problem of traffic signals. It was detected that only in 2006, 11.154 accidents happened at locations where there were road-maintenance and repair works. Similarly, according to statistics for the same year, at 1.172 accidents, traffic lights were dysfunctional and 237 accidents occurred when ambient illumination was improper (Security General Directorate, 2006).

Road safety has received inadequate attention at national level in spite of increasing road traffic crashes. The reasons of the traffic accidents may include extreme speed, drink driving, lack of general awareness, non-use of seatbelt, fatigue and distracted driving, and pedestrian safety.

In conclusion, when the information given above is examined, it is understood that almost all of the state of affairs are concerned with before the occurrence of traffic accident or accident prevention activities. However, in this study, as stated previously, the purpose is related with after the happening of traffic accident. Although the prevention activities are important to avert traffic accident, the most important topic is to determine the responsible party or to assign fault rates after the traffic accidents happen. For this purpose, the proposed expert system is developed.

CHAPTER 3

EXPERT SYSTEMS

In this chapter, expert systems and artificial intelligence is outlined with literature review. Moreover, rule based expert systems are introduced. Finally, expert systems with applications are presented.

3.1. Definitions of Artificial Intelligence

In order to understand what is Artificial Intelligence (AI), first, it is important to understand its goal so that, to start with, “The goal of AI as a science is to make machines do things that would require intelligence if done by humans” (Boden, 1977). Another goal of AI is more modest: it is to produce computer programs that function more like people so that computers can be made more useful and so they can be made to do many things that people do and perhaps even faster and better than people can do them (Tveter, 1998).

When come to the definitions, Barr and Feigenbaum (1981) defines Artificial Intelligence: AI is the part of computer science concerned with designing intelligent computer systems, that is, systems that exhibit the characteristics we associate with intelligence in human behavior – understanding language, learning, reasoning, solving problems, and so on.

In other words, AI is concerned with programming computers to perform tasks that are presently done better by humans, because they involve such higher mental processes such as perceptual learning, memory organization and judgmental reasoning (Minsky, 1968).

3.2. Expert Systems

Expert systems (ES) are a very useful and successful application of AI. Generally, in solving any problem the first step is defining the problem area or domain to be solved. In this study, domain is quantification of fault rates in traffic accidents. Expert systems make extensive use of specialized knowledge to solve problems at the level of a human expert. An expert is generally defined as a person who has expertise in a certain area. That is to say, the expert has knowledge that is not known or available to most people. In order to quantify the fault rates of each party involved in a traffic accident, an expert system was developed in this study. Also, the expert system gives a report at the end of the determination of fault rates. In addition, the user can understand why such fault rates are assigned by the expert system when looking at the report.

3.2.1. Definitions of Expert Systems

As an expert system is a complicated system, Durkin (2002) and Negnevitsky (2002) categorized expert systems into seven types: (1) **rule-based systems;** (2) frame-based systems; (3) case-based reasoning systems; (4) fuzzy systems; (5) evolutionary computation systems; (6) neural network systems; and (7) hybrid systems, which combine more than one of the above systems. The selection of an appropriate type of expert system depends on the problem domain and its characteristics. In this thesis, the rule-based expert system was developed.

Professor Edward Feigenbaum (1977) of Stanford University defines an expert system as “an intelligent computer program that uses knowledge and inference procedures to solve problems that are difficult enough to require significant human expertise for their solution." That is, an expert system is a computer system that emulates the decision making ability of a human expert. In order to make it more clear, Figure 3.1 shows the basic function of an expert system.

More simply stated, an expert system is a computer system that simulates a human expert's knowledge through facts or rules. The system stores this knowledge so that it can draw logical conclusions, make decisions, learn from its mistakes, communicate with other experts, both man and machine, and also explain how it arrives at decisions (Castillo, 1991).

In addition to that, another definition of expert systems was done by Fenves in 1986. Expert systems originate from the branch of computer science called Artificial Intelligence (AI). The utility of this computer science technology to engineers is similar to algorithms (having been derived from numerical analysis) and software engineering (having been derived from computer languages, operating systems and database management systems).

Similarly, Jackson (1999) defines an expert system as a computer program that represents and reasons with knowledge of some specialist subject with a view to solving problems or giving advice.

Moreover, an expert system may completely fulfill a function that normally requires human expertise, or it may play the role of an assistant to a human decision maker.

Typical tasks for expert systems involve:

- the interpretation of data
- diagnosis of malfunctions
- structural analysis of complex objects

- configuration of complex objects
- planning sequences of actions

The basic function of an expert system is displayed in Figure 3.1 below.

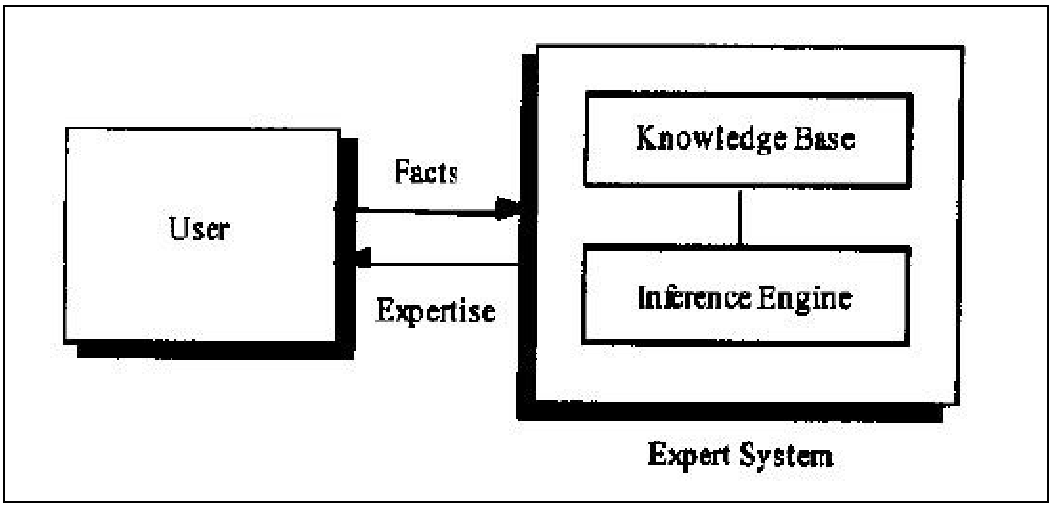


Figure 3.1 The basic function of an expert system (Giarratano and Riley, 2005)

When focused on the Figure 3.1, the user provides facts or other information to the expert system and takes expert advice or expertise in response. In fact, the expert systems consist of two main components. That is, the knowledge base contains the knowledge with which the inference engine draws conclusions. These conclusions are the expert system's responses to the user's queries for expertise. Since the expert system relies on inference, it must be able to explain its reasoning so that its reasoning can be checked.

3.2.2. Rule Based Expert Systems

Traffic Accident Expert System (TAES) employs rules to represent expert's knowledge. Rule-based programming is one of the most commonly used techniques for developing expert systems. A rule is composed of an IF portion and a THEN portion.

Firstly, the IF portion of a rule is a series of patterns which specify the facts. The process of matching facts to patterns is called pattern matching. The expert system tool provides a mechanism, called the inference engine, which automatically matches facts against patterns and determines which rules are applicable. Secondly, the THEN portion of a rule is the set of actions to be executed when the rule is applicable. The actions of applicable rules are executed when the inference engine is instructed to begin execution. The inference engine selects a rule and then the actions of the selected rule are executed (which may affect the list of applicable rules by adding or removing facts). The inference engine then selects another rule and executes its actions. This process continues until no applicable rules remain (Gary, 1997).

Thus, an expert system is an artificial intelligence program incorporating a knowledge base and an inference system. It is a highly specialized piece of software that attempts to duplicate the function of an expert in some field of expertise. Moreover, the program acts as an intelligent consultant or advisor in the domain of interest, capturing the knowledge of one or more experts. Non-experts can then make the expert system answer questions, solve problems, and make decisions in the domain (Roth, 1983).

Finally, Durkin (2002) stated that the most popular expert systems are rule-based expert systems. Rules can represent relations, recommendations, directives, strategies and heuristics. By considering the presented information about expert systems, a rule based expert system was developed in this study.

3.2.2.1. Rules as a Knowledge Representation Technique

Any rule consists of two parts: the IF part, called the antecedent (premise or condition) and the THEN part called the consequent (conclusion or action).

The basic syntax of a rule is:

IF <antecedent>
THEN <consequent>

In general, a rule can have multiple antecedents joined by the keywords AND (conjunction), OR (disjunction) or a combination of both.

IF the 'traffic light' is green
THEN the action is go
IF the 'traffic light' is red
THEN the action is stop

These statements represent in the IF – THEN forms are called production rules or just rules. The term 'rule' in AI, which is the most commonly used type of knowledge representation, can be defined as an IF-THEN structure that relates given information or facts in the IF part to some action in the THEN part. So, a rule provides some description of how to solve a problem.

3.2.2.2. Structure of Rule Based Expert System

In the early 1970s, a production system model was proposed, the foundation of the modern rule-based expert systems (Newell and Simon, 1972). The production model is based on the idea that humans solve problems by applying their knowledge (expressed as production rules) to a given problem represented by problem-specific information. The production rules are stored in the long-term memory and the problem-specific information or facts in the short term memory. Furthermore, the production system model and the basic structure of a rule-based expert system are shown in Figure 3.2 (Negnevitsky, 2004).

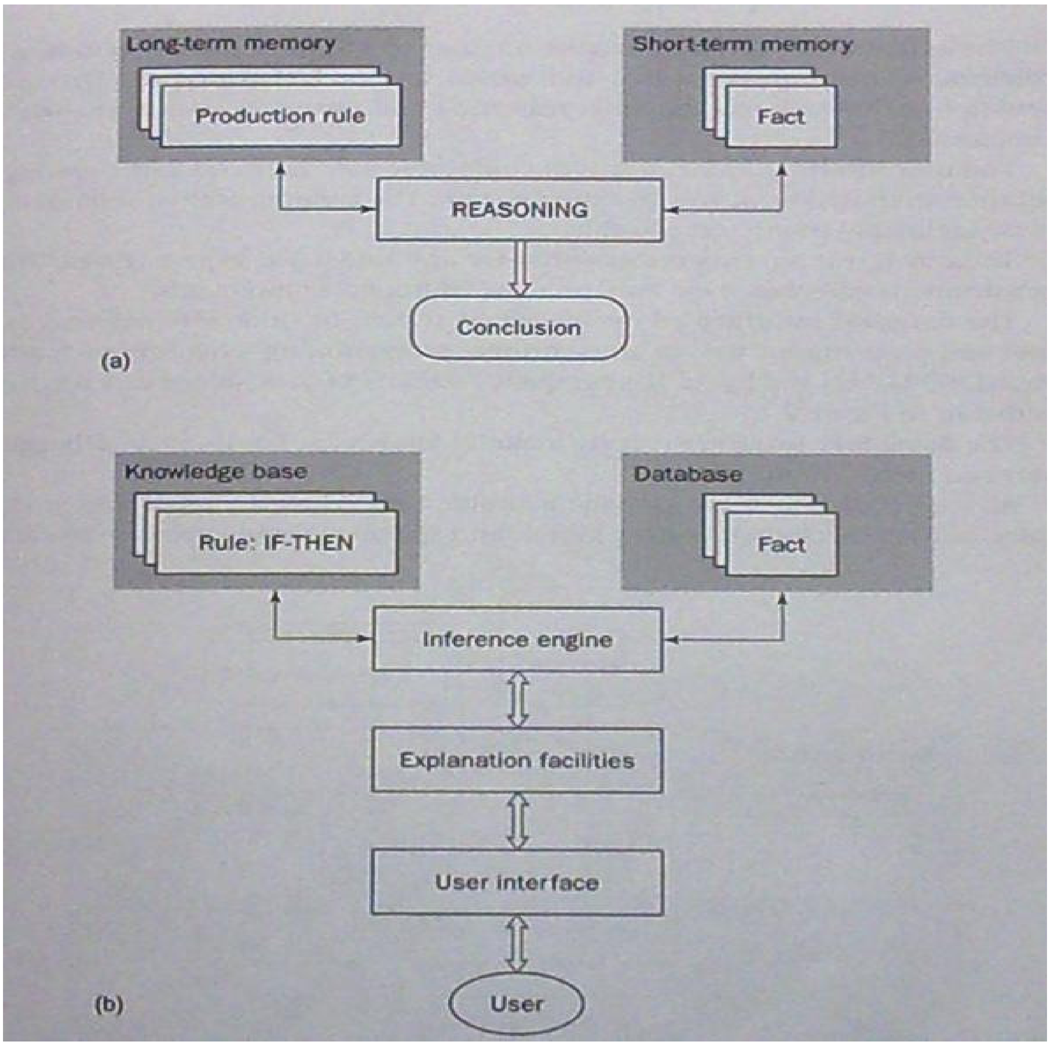


Figure 3.2 a) Production system model; b) Basic structure of a rule based expert system

A rule-based expert system has five components: the knowledge base, the database, the inference engine, the explanation facilities and the user interface.

Firstly, the knowledge base contains the domain knowledge useful for problem solving. That is to say, in a rule based system, the knowledge base contains the domain knowledge needed to solve problems coded in the form of rules. In a rule-based expert system, the knowledge is represented as a set of rules.

Secondly, the database includes a set of facts used to match against the IF (condition) parts of rules stored in the knowledge base.

Thirdly, the inference engine carries out the reasoning whereby the expert system reaches a solution. In fact, inference engine is a critical component of a rule based expert system. It may use forward or backward chaining systems to determine a result. Forward chaining is the data-driven reasoning. The reasoning starts from the known data and proceeds forward with that data. Each time only the topmost rule is executed. When fired, the rule adds a new fact in the database. Any rule can be executed only once. The match-fire cycle stops when no further rules can be fired. Forward chaining is a technique for gathering information and then inferring from it whatever can be inferred. However, in forward chaining, many rules may be executed that have nothing to do with the established goal. The proposed expert system employs forward chaining in this study. On the other hand, backward chaining is the goal-driven reasoning. In backward chaining an expert system has the goal and the inference engine attempts to find the evidence to prove it. The knowledge base is searched to find rules that might have the desired solution. Such rules must have the goal in their THEN parts. If such a rule is found and its IF part matches data in the database, then the rule is fired and the goal is proved.

Fourthly, the explanation facilities enable the user to ask the expert system how a particular conclusion is reached and why a specific fact is needed.

Finally, the user interface is the means of communication between a user seeking a solution to the problem and an expert system. In fact, the user interface is the mechanism by which the user and the expert system communicate.

In short, these five components are essential for any rule-based expert system. They constitute its core. Rule-based expert systems have the advantages of natural knowledge representation, uniform structure, separation of knowledge from its processing, and coping with incomplete and uncertain knowledge.

3.2.3. What is an Expert System Shell?

An expert system shell can be considered as an expert system with the knowledge removed. Therefore, all the user has to do is to add the knowledge in the form of rules and provide relevant data to solve a problem.

3.2.4. Fundamental Characteristics of an Expert System

Fundamental characteristics of expert systems are identified in many books. In this section the characteristics which are compiled from the book of the writer Negnevitsky (2004) will be mentioned.

To start with, an expert system is built to perform at a human expert level in a narrow, specialized domain. Thus, the most important characteristic of an expert system is its high-quality performance. Experts use their practical experience and understanding of the problem to find short cuts to a solution. Because of that, experts use rules of thumb or heuristics. Like their human counterparts, expert systems should apply heuristic to guide the reasoning and thus reduce the search area for a solution.

A unique feature of an expert system is its explanation capability which enables expert system to review its own reasoning and explain its decisions. An explanation in expert systems in effect traces the rules fired during a problem-solving session. This is, of course, a simplification; however a real or human explanation is not yet possible because it requires basic understanding of the domain. Although a sequence of rules fired cannot be used to justify a conclusion, we can attach appropriate fundamental principles of the domain expressed as text to each rule, or at least each high-level rule, stored in the knowledge base.

In addition, expert systems employ symbolic reasoning when solving a problem. Symbols are used to represent different types of knowledge such as facts, concepts and rules. Unlike conventional programs, expert systems do not follow a prescribed sequence of steps. On the contrary, they permit inexact reasoning and can deal with incomplete, uncertain and fuzzy data. Although more conventional programs have been known to perform similar tasks in similar domains, expert systems are sufficiently different from such programs to form a distinct and identifiable class. Table 4.1 discloses the differences between expert systems and conventional programs and human experts.

Table 3.1 Comparison of expert systems with conventional systems and human experts (Negnevitsky, 2004)

Human experts	Expert systems	Conventional programs
Use knowledge in the form of rules of thumb or heuristic to solve problems in a narrow domain	Process knowledge expressed in the form of rules and use symbolic reasoning to solve problems in a **narrow domain**	Process data and use algorithms, a series of well-defined operations, to solve general numerical problems

Table 3.1 Comparison of expert systems with conventional systems and human experts (continued)

In a human brain, knowledge exist in a compiled form	Provide a **clear separation of knowledge from its processing**	Do not separate knowledge from the control structure to process this knowledge
Capable of explaining a line of reasoning and providing the details	**Trace the rules fired** during a problem-solving session and **explain how** a particular conclusion was reached and **why** specific data was needed	Do not explain how a particular result was obtained and why input data needed
Use inexact reasoning and can deal with incomplete, uncertain and fuzzy information	Permit **inexact reasoning** and can deal with incomplete, uncertain and fuzzy data	Work only on problems where data is complete and exact
Can make mistakes when information is incomplete or fuzzy	**Can make mistakes** when data is incomplete or fuzzy	Provide no solution at all, or a wrong one, when data is incomplete or fuzzy
Enhance the quality of problem solving via years of learning and practical training. This process is slow, inefficient and expensive	Enhance the quality of problem solving by adding new rules or adjusting old ones in the knowledge base. When new knowledge is acquired **changes are easy** to accomplish	Enhance the quality of problem solving by changing the problem code, which affects both the knowledge and its processing, making changes difficult

3.2.5. Development of Expert Systems

In fact, expert systems represent unwritten knowledge that must be extracted from an expert by extensive interviews. Besides, the process of building an expert system refers to the acquisition of knowledge from a human expert or other source and its coding in the expert system. The general stages in the development of an expert system are illustrated in Figure 3.3.

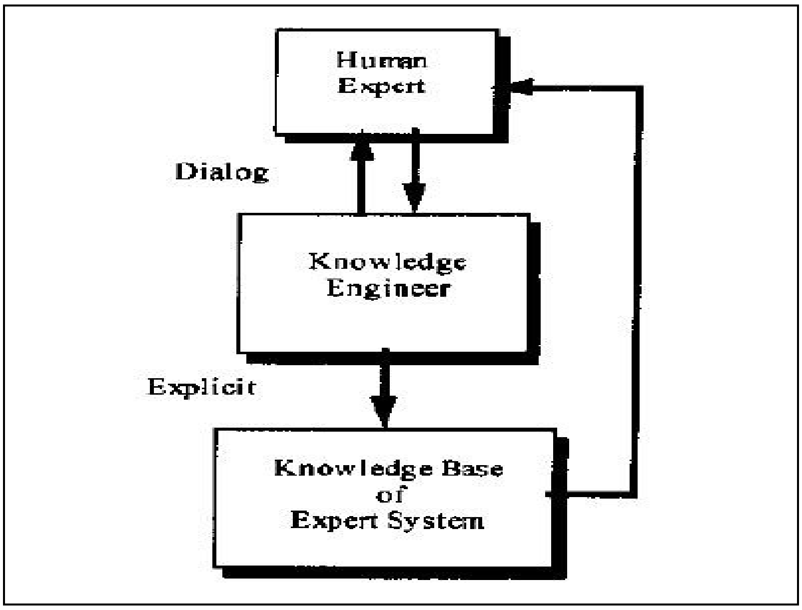


Figure 3.3 Development of an expert system (Giarratano and Riley, 2005)

Firstly, the knowledge engineer organizes a dialog with the human expert in order to acquire the expert's knowledge. Then, the knowledge engineer codes the knowledge clearly in the knowledge base. Afterward, the expert assesses the expert system and gives a critique to the knowledge engineer. This process is repeated until the system's performance is judged to be satisfactory by the expert. In the proposed expert system, the process is similar to the explanation above.

3.2.6. Fundamental Topics of an Expert System

The fundamental topics of an experts system are identified in many books and articles. The examples are (Buchanan, 1983), (Feigenbaum, 1977), and (Jackson, 1999).

3.2.6.1. Acquiring Knowledge

In fact, knowledge acquisition means that knowledge is elicited from experts in a specific domain. Also, the knowledge was organized and formalized with a goal of transforming it into a computer representation. Some suggestions and definitions were presented by the authors below.

Kidd (1987) says about knowledge acquisition, "As a process, it involves eliciting, analyzing and interpreting the knowledge that a human expert uses when solving a particular problem and then transforming this knowledge into a suitable machine representation." After the problem has been selected, the knowledge acquisition phase of expert system development begins. The main task here is to have the knowledge, which the expert uses to solve the problem displayed in a logical fashion so that it can be coded into the computer. This can be done by extraction of knowledge from domain experts.

Also, Buchanan (1983) defines knowledge acquisition as follow.

"Knowledge acquisition is the transfer and transformation of potential problem-solving expertise from some knowledge source to a program".

This transfer is usually accomplished by a series of lengthy and intensive interviews between a knowledge engineer and a domain expert. It is estimated that this form of labor produces between two and five units of knowledge per day. This rather low output has led researchers to look upon knowledge acquisition as the "bottleneck problem" of expert system applications (Feigenbaum, 1977).

Moreover, there are number of reasons why productivity is typically so poor (Jackson, 1999), some of which are;

- As specialists have their own jargon, and it is often difficult for experts to communicate their knowledge in everyday language.
- The facts and principles underlying many domains of interest cannot be characterized precisely in terms of a mathematical theory or a deterministic model whose properties are well understood.
- Experts need to know more than the mere facts or principles of a domain in order to solve problems. For example, they usually know which kinds of information are relevant to which kinds of judgment, how reliable different information sources are, and how to make hard problems easier by splitting them into sub problems which can be solved more or less independently. Eliciting this kind of knowledge, which is normally based on personal experience rather than formal training, is much more difficult than eliciting either particular facts or general principles.
- Human expertise, even in a relatively narrow domain, is often set in a broader context that involves a good deal of commonsense knowledge about the everyday world. Consider legal experts involved in litigation. It is difficult to delineate the amount and nature of general knowledge needed to deal with an arbitrary case.

3.2.6.2. Representing Knowledge

The knowledge of the experts may be represented in a number of ways. One common method of representing knowledge is in the form of IF - THEN type rules that is to say, production rules are used to represent knowledge. Production rules are designed for making inferences from knowledge using information in the working memory. In this thesis, IF-THEN type of knowledge representation technique was employed.

When looking at the definition of knowledge representation, Jackson (1999) defines it as: knowledge representation is a substantial subfield in its own right, which shares many concerns with both formal philosophy and cognitive psychology. It is concerned with the way in which information might be stored and associated in the human brain, usually from a logical, rather than a biological, perspective. In other words it is not typically concerned with the physical details of how knowledge is encoded, but rather with what the overall conceptual scheme might look like. Because of that, the main criteria for assessing a representation of knowledge are logical adequacy, heuristic power and notational convenience.

3.2.6.3. Controlling Reasoning

Reasoning is conducted by inference engine in the proposed expert system. That is to say, the expert system can achieve solution by reasoning. In fact, the inference engine links the rules given in the knowledge base with the facts provided in the database. In other words, the inference engine makes inferences by deciding which rules are satisfied by facts or objects, prioritizes the satisfied rules, and executes the rule with the highest priority. In a rule-based expert system, the domain knowledge is represented by a set of IF-THEN production rules and the data is represented by a set of facts about the current situation. Furthermore, the inference engine compares each rule stored in the knowledge base with facts contained in the database. When the IF part of the rule matches a fact, the rule is fired and its THEN part is executed.

3.2.6.4. Explaining Solutions

In the proposed expert system, the explanation facility explains the reasoning of the system to a user. That is, an expert system must be able to explain its reasoning and justify its advice, analysis or conclusion.

Explanations of expert system behavior are important for a number of reasons (Jackson, 1999), such as;

- Users of the system need to satisfy themselves that the program's conclusion are basically correct for their particular case
- Knowledge engineers need some way to satisfy themselves that knowledge is being applied properly even as the prototype is being built
- Domain experts need to see a trace of the way in which their knowledge is being applied in order to judge whether knowledge elicitation is proceeding successfully
- Programmers who maintain, debug and extend knowledge-based programs must have some window onto the program's behavior
- Managers of the expert system technology, who may end up being responsible for a program's decisions, need to satisfy themselves that a system's mode of reasoning is applicable to their domain.

3.3. Expert Systems with Applications

As there are many papers related to expert systems about all topics in journal of expert systems with applications. A literature review was done related to expert systems in this part of chapter.

A multifunctional knowledge-based system (MF-KBS) was constructed (Eduardo E. Morales and L. Enrique Sucar, 1998). The goal of this MF-KBS can be summarized as follows;

- A set of engineering components associated with models at different abstraction levels
- A set of different reasoning mechanism
- A configuration of a device specified by the user

Moreover, the MF-KBS is also able to produce followings;

- Different types of models (qualitative, quantitative, casual, probabilistic) for the device
- Capabilities to reason to each type of model, at different abstraction level, to support multiple tasks
- Capabilities to perform different tasks for the device, such as diagnosis, tutoring, consulting, reliability analysis, problem solving etc.

The MF-KBS has three main components which are; knowledge core, reasoning, mechanisms, knowledge operators. In this expert system, at the top of the architecture, there is a set of knowledge operators which are responsible for performing particular tasks using: (i) the knowledge core and (ii) the available reasoning mechanisms. The Figure 3.4 shows the components of this expert system below.

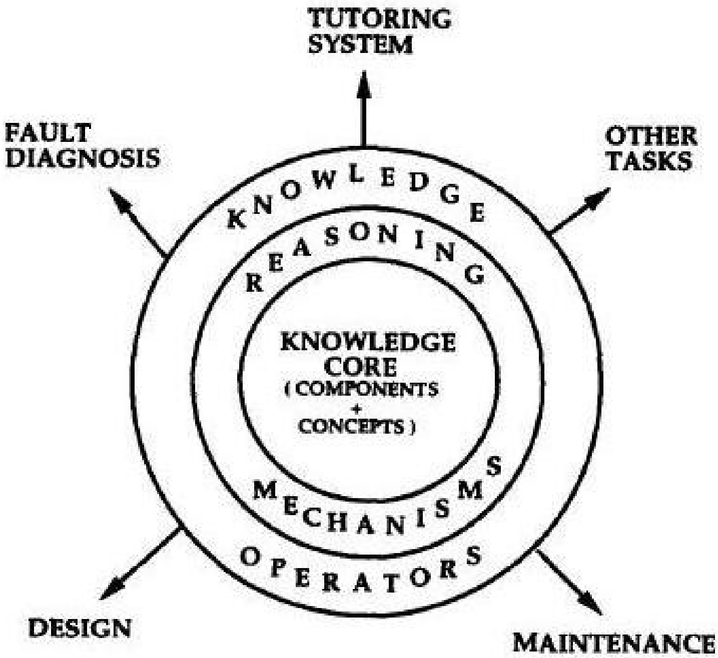


Figure 3.4 MF-KBS components

Besides that, another expert system with its application was developed (Tzai-Zang Lee, 2008). This expert system is a knowledge based system and it was applied in river land use assessment. That system was used to help the assessment of development plans for river land use. In this expert system, decision tables were used to acquire expert knowledge, and a forward chaining inference mechanism was utilized to derive assessment suggestions and assessment results. The framework of the KBS for land use assessment is shown below Figure 3.5.

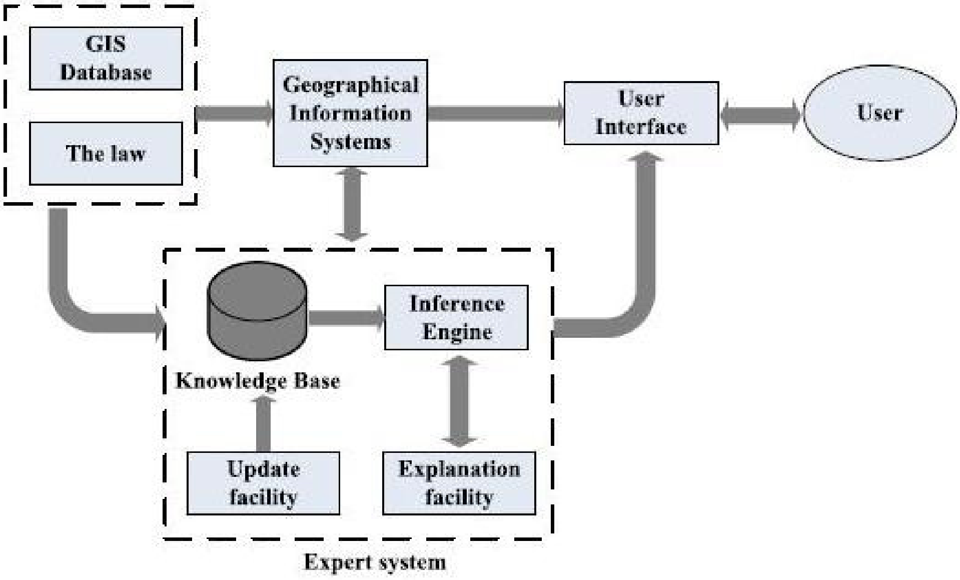


Figure 3.5 The framework of the KBS for land use assessment

This expert system includes five major components: (1) user interface, (2) knowledge base, (3) inference engine, (4) explanation facility, and (5) update facility. The user interface is designed to be media-rich and friendly to help users interact with the knowledge-based system land use assessment (KBSLUA). Moreover, a salient feature for the user interface is to utilize the GIS functions and databases to retrieve map information for users to better interact.

The other expert system with application is related to fuzzy logic (Hadjimichael, 2009). Michael Hadjimichael implemented this fuzzy expert system for aviation risk assessment. This risk assessment model is a fuzzy expert system, created by knowledge elicitation from the subject matter experts within the airline organization. The model represents risk as a hierarchical decomposition of contributing factors, whose interrelationships are represented by a fuzzy rule set. The decomposition of risk can help to identify those elements that contribute most significantly to the calculated risk. This risk model is knowledge-driven and nonprobabilistic.

Furthermore, an expert system for strategic control of accidents and insurers' risks in building construction projects was designed (Imriyas, 2009). The purpose of this study is to develop an effective WCI (workers' compensation insurance) premium-rating model for building projects, and to automate the model as an expert system. In which, a new WCI premium-rating model based on the findings of a literature review and a questionnaire survey was developed. A hybrid of interviews and past workers' compensation claims data analysis was pursued to develop the conceptual model of a fuzzy expert system to automate the proposed model. It was then prototyped and verified with Turing tests. The proposed expert system advocates real-time assessments of project hazards, safety, market conditions and insurers' internal factors for premium-rating. In addition to those, it also establishes an effective risk control strategy via a well-structured incentive system for contractors and clients. Its implementation in the insurance industry can curtail accidents in the construction industry, thereby minimizing insurers' financial risks.

Moreover, David Vallejo proposed a novel approach to detect and sanction the drivers' abnormal behaviors (Vallejo, 2009). The multi-agent system paradigm embodies this approach, together with the use of FIPA (The Foundation for Intelligent Physical Agents) standards. Traffic ontology formalizes the domain knowledge. Besides developing the architecture, a simulator is also presented for generating random situations in the crosswalk scene. This system involves a first approximation in relation to the control of drivers' abnormal behaviors in a crosswalk controlled by a traffic light, obtaining a high-scalable and flexible system which can be adapted to other domains. That paper suggests a multi-agent architecture composed of intelligent agents specialized in the different tasks that make up this system. Thus, important benefits are obtained due to the autonomy, the social ability, and the reactivity of the proposed agents. In addition, the use of ontologies to reliably represent the knowledge about drivers' behavior and to reason on, it is introduced. This way, monitoring and control of crosswalk scenes can be carried out without directly spending human resources.

Moreover, this system could be integrated into the penalty points system to semi-automatically penalize, for instance, to those drivers which ignore the obligation imposed by a red traffic light. The proposed intelligent surveillance system and cognitive surveillance system is disclosed below in Figure 3.6 and Figure 3.7 respectively.

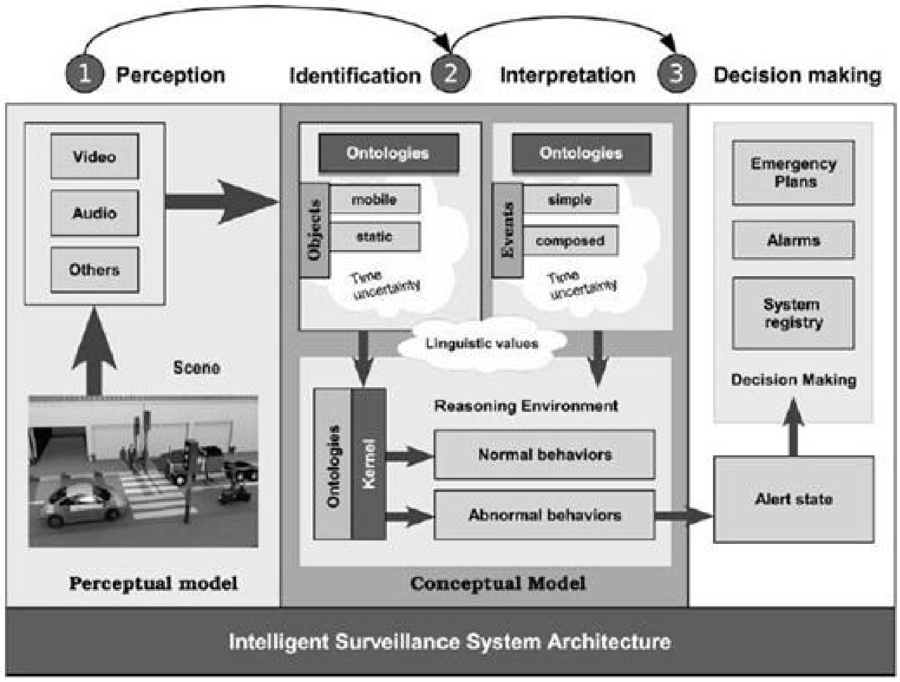


Figure 3.6 Conceptual architecture for an intelligent surveillance system

In this work, a novel approach to detect anomalous behaviors in a crosswalk has been proposed. The main advance of this work consists of dealing with the surveillance problem by defining the normality of the surveillance environment with high-level knowledge. The establishment of this system in a real world environment may involve a reduction of the number of accidents related to pedestrians in a crosswalk, due to the correction of drivers' abnormal behavior by semi-automatically sanctioning them.

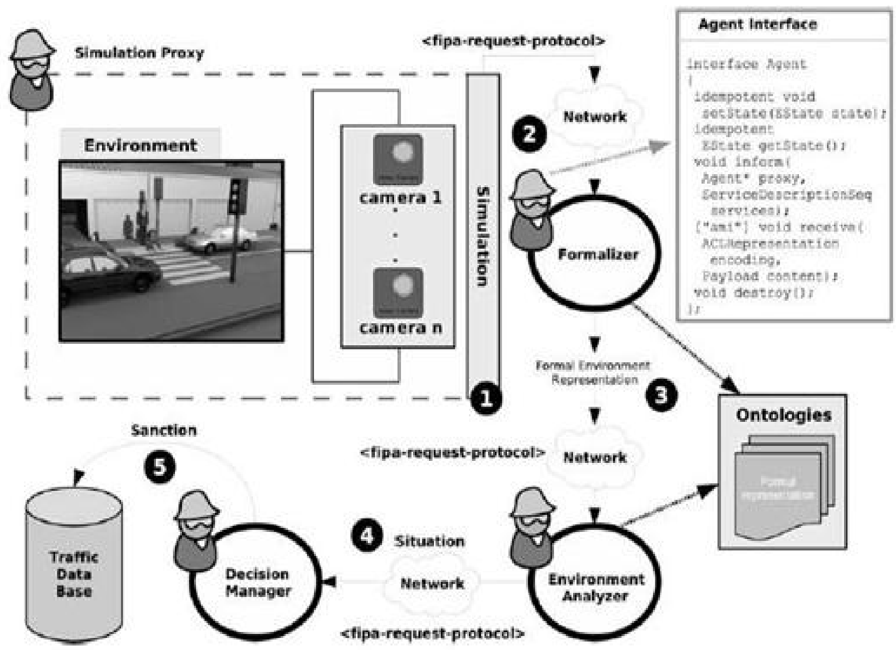


Figure 3.7 Multi-agent architecture of the cognitive surveillance system

In addition, W. Wen suggested a framework for a dynamic and automatic traffic light control expert system combined with a simulation model, which is composed of six sub models coded in Arena to help analyze the traffic problem (Wen, 2008). The model adopts interarrival time and interdeparture time to simulate the arrival and leaving number of cars on roads. In the experiment, each sub model represents a road that has three intersections. The simulation results physically prove the efficiency of the traffic system in an urban area. A framework for dynamic and automatic traffic light control expert systems is displayed below in Figure 3.8.

Furthermore, the Dynamic and Automatic Traffic Light Control Expert System (DATLCES) is composed of seven elements that are: a radio frequency identification (RFID) reader, an active RFID tag, a personal digital assistance (PDA), a wireless network, a database, a knowledge base, and finally a backend server.

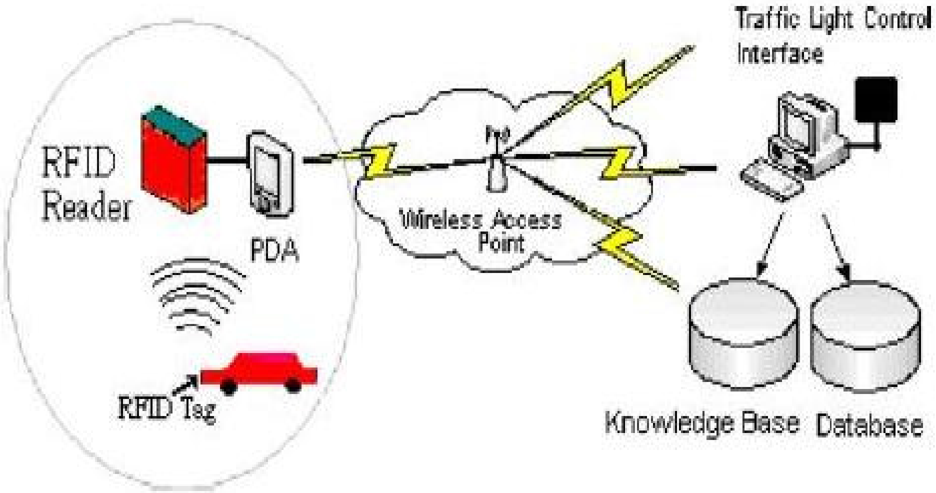


Figure 3.8 Dynamic and automatic traffic light control expert systems

In addition to all of these works, Evrim Bayam also presented a data mining application on traffic accident data (Bayam, 2005). The writer reviewed studies focusing on senior drivers based on the variables most examined. These variables are: the driver, vehicle, occupants and other road users, environmental and geographical conditions, roadway and accidents. In this meta-analysis, the crash model was used which is showed in Figure 3.9. An automobile crash is considered a system with the independent variables: driver; vehicle; environmental and geographical conditions; roadway; occupants and other road users. All these independent variables interact with each other. In the wake of these interactions, many driving scenarios occur. Then, one of these driving scenarios becomes a crash scenario, and subsequent accident information as a dependent variable emerges.

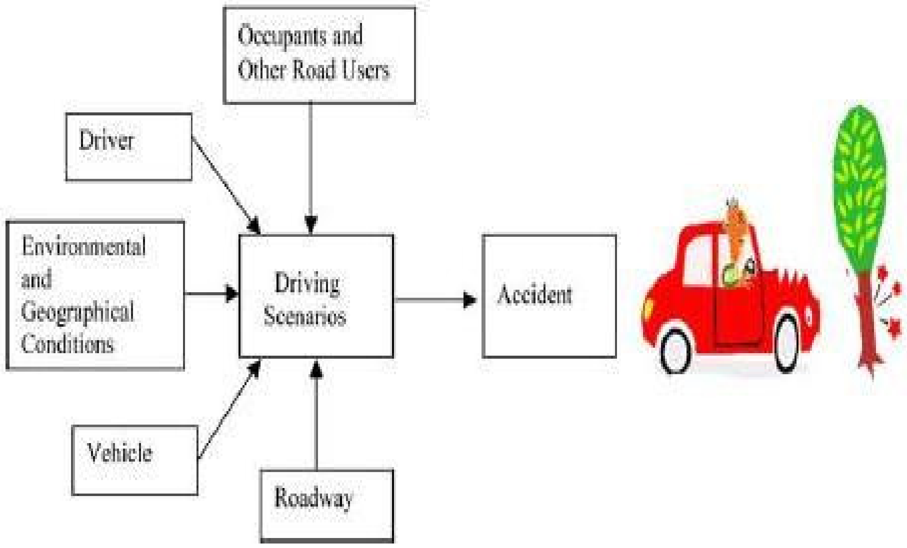


Figure 3.9 Automobile crash as a system

In this application, the ‘driver’ as an independent variable consists of a driver’s information such as age, sex and other relevant information. The ‘vehicle’ independent variable is composed of vehicle type and age of vehicle. The ‘environmental and geographical conditions’ are comprised of information about weather and lighting conditions, date and time of the day, and finally area type. The ‘roadway’ independent variable consists of road attributes such as road condition and road surface. The ‘occupants and other road users’ variable represents the type of occupants, the driver of the other vehicle, occupants of the other vehicle, and pedestrians. Moreover, what is included in the ‘other road users’ variable is age, gender and other characteristics of all other road users which have an impact on crash occurrence. The last variable is the ‘accident’ dependent variable comprised of data on accident type, severity, number of injuries, number of fatalities, point of impact, and reasons behind an accident.

CHAPTER 4

KNOWLEDGE MANAGEMENT IN TRAFFIC ACCIDENTS

This chapter reviews the knowledge acquisition and management process of the Traffic Accident Expert System with definitions and literature review. Also, the structure of traffic accident reports is scrutinized. Moreover, selected type of traffic accidents, that is, “vehicle – pedestrian” and “vehicle – vehicle” accidents and their flowcharts are introduced. Finally, the questionnaire and its quantification methodology are investigated.

4.1. Definitions and Literature Review

The definitions of Knowledge Management (KM) are defined in many articles and books. Although KM is a very popular approach since it has been applied over the past years, it is not fully understood. However, it is essential to understand KM deeply so as to execute this study. This can be achieved by understanding the two words composing KM, knowledge and management. Beginning with a simple dictionary definition, knowledge is defined as “the body of truths or facts accumulated by humankind in the course of time” (Macquarie Dictionary, 1997, p. 1186), where management is defined as “the act or manner of managing; handling, direction, or control” (Macquarie Dictionary, 1997, p. 1307). So that, the KM can be defined as managing or controlling the facts gathered in the course of time. However, this definition is not the appropriate one because neither knowledge nor management term is superficial. Because of that, a deeper terminology is needed.

In order to understand KM, first knowledge must be understood properly, which can be done by differentiating the terms data, information and knowledge from each other. In a book named “Decision Support Systems”, written by George M. Marakas, these three terms are defined as;

1. **Data.** Facts, measurements, or observations with or without context. An example of data without context is 60, 62, 66, and 72. The same data with context might be the height in inches of Laura, Samantha, John and Kristine, respectively. The validity and the effectiveness of data are determined primarily by the data’s accuracy.

2. **Information.** Data organized in such a manner as to be useful and relevant to a problem solver in making decisions. The key criterion in evaluating information is its usefulness. Information can also be thought of as an event rather than an entity. As such, information “occurs” when a decision maker understands some structured collection data.

3. **Knowledge.** The application of a combination of instincts, ideas, rules, procedures, and information to guide the actions, decisions of a problem solver within a particular problem context. In this sense knowledge is an interpretation made by the mind. Success in explaining the interactions of the problem context is a key element in evaluating the validity of knowledge.

In shortly, data can be generally defined as raw facts. When organized in some way, they become information; finally, knowledge is that information that has human meaning attached to it (Rowley, 2003). On the other hand, an alternative view is that knowledge has been ascertained from information through tests of proof (Lee & Bai, 2003).

When focused on the definition of knowledge, it is dictated as “fluid mix of framed experience, values, contextual information and expert insight that provides a framework for evaluating and incorporating new experiences and information” (Davenport and Prusak, 1998). Whereas, Applehans (1999) defined knowledge as “the ability to turn information into effective action” Another definition is Dixon’s (2000) definition which was “meaningful links people make in their minds between information and its application in action in a specific setting.” Also, Karl Wiig (1996) defined knowledge as “the insights, understandings, and practical know-how that we all possess – is the fundamental resource that allows us to function intelligently.”

As seen from these definitions, it is tricky to define knowledge so that some claim there is no universal definition for knowledge management (Goh, 2005). On the other hand, others tried to define knowledge management. For example, KM is defined as any process or practice of creating, acquiring, capturing, sharing and using knowledge, wherever it resides, to increase learning and performance in organizations (Scarborough, 1999).

In addition to these definitions, it is stated in a book named as “Tacit knowledge in Organizational Learning” written by Peter Busch in 2008 that some see KM as a process of codifying individual knowledge and placing this in databases or data warehouses. Others (e.g. Davenport and Prusak, 1998) see KM as trying to enable better access by employees to knowledge; or trying to change the knowledge environment by valuing knowledge as an asset (Rowley, 2003).

4.1.1. Definitions of Tacit and Explicit Knowledge

In their book "The Knowledge Creating Company", Nonaka and Takeuchi (1995) have built a whole theory about knowledge and its creation, on the basis of this distinction between tacit and explicit knowledge. Therefore, four modes of knowledge production are identified: (1) *socialization* which involves conversion from tacit knowledge to tacit knowledge, (2) *externalization* which involves conversion from tacit knowledge to explicit knowledge, (3) *combination* which involves conversion from explicit knowledge to explicit knowledge, and (4) *internalization* which involves conversion from explicit knowledge to tacit knowledge. It may, by virtue of its ability to convert tacit knowledge into explicit forms such as metaphors, analogies and models, have some utility in *externalization*. This utility is however restricted by its ability to support dialogue or collective reflection. A more explicit recognition of tacit knowledge and related human aspects, such as ideals, values, or emotions, is necessary for developing a richer conceptualization of knowledge management. In addition to these definitions written above, Polanyi (1966) proposed grouping knowledge as tacit and explicit. Explicit Knowledge can be denoted as tangible, which means that capturing, codification, and sharing occurs easily. It can be shared through discussions, by writing it down, and it can be stored in databases and in repositories as documents, notes, etc. Similarly, Nonaka and Takeuchi (1995) cited that the knowledge that can be documented, codified, transmitted and structured, and is conscious and externalized, is termed as explicit knowledge. In this study, laws, regulations, and traffic accident reports can be considered as explicit knowledge.

Also, some other writers defined tacit and explicit knowledge in books and their articles. When focused on the definitions of the tacit and explicit knowledge, for example, tacit knowledge is personal, context-specific, and difficult to codify and share. It is embedded in the human mind, behaviour and perceptions (Nonaka and Takeuchi, 1995). If somebody wants to achieve excellence in a business, he has to rule over the unstructured and intangible tacit knowledge (Haldin-Herrgard, 2000).

4.2. Knowledge Process for Traffic Accident Expert System

In order to investigate the traffic accidents, it is required to have experience about traffic accident laws and regulations. The major theme of Traffic Accident Expert System (TAES) is based on knowledge of experts in this study. The knowledge of experts could be defined as tacit knowledge. On the other hand, the police consider or show their knowledge through traffic accident reports in the investigation of a traffic accident. That is to say, the traffic accident report is explicit knowledge. After the occurrence of traffic accidents, the expert-witness reports are prepared by experts. Experts take into account their knowledge, laws and regulations published by governmental institutions while evaluating fault rates of the traffic accidents. Experts assign the fault rates of each party involved in an accident within the context of traffic accident report. In some cases, opinions of different experts may change with each other.

In short, the developed expert system has two types of knowledge, that is, tacit and explicit knowledge. First of all, explicit knowledge was achieved through laws and regulations about traffic accidents and road safety. Also, the traffic accident reports were used to obtain explicit knowledge. Secondly, the tacit knowledge was attained by the questionnaires consisting accident scenarios. Quantification of these scenarios was done by experts. The questionnaires were submitted to experts for the purpose of developing a quantification system. The questionnaires have some produced scenarios with respect to types of traffic accidents which the experts analyzed by quantifying all of them. The results determined by experts were utilized in the expert system. There are different flowcharts developed by the researcher of this study in respect of accident types in the proposed expert system. The questions in the questionnaire were organized by taking those flowcharts into consideration. At the end of the quantification, the expert system also prepares a report which explains the reasoning of assigned fault rates related with concerned accident. In this way, tacit knowledge of experts was acquired.

4.3. Knowledge Acquisition Process for Traffic Accident Expert System

The knowledge acquisition process for the proposed Traffic Accident Expert System was executed in several stages. Firstly, data collection and organization stage was done. That is to say, the traffic accident reports prepared by police and expert-witness reports prepared by academicians were required in the initial step of this study. Also, a review of the traffic accidents was done by analyzing related papers and books. Moreover, the identification of factors influencing traffic safety and severity of traffic accidents were defined. Afterwards the traffic accident expert-witness reports were classified in accordance with the type of traffic accident and location of traffic accidents in detail. Finally, in order to acquire tacit knowledge of experts the questionnaires consisting accident scenarios were prepared.

As mentioned before, at the initial step of this study, traffic accident types were divided into five groups such as; accidents with vehicle, with pedestrian, with fixed object, with overturn, and with two-wheeler users. The classification process of the expert-witness reports was done not only for urban traffic accidents but also for rural traffic accidents. When the obtained traffic accident expert-witness reports were examined in urban areas, it was concluded that "vehicle - pedestrian" and "vehicle - vehicle" type of traffic accidents constitute most of the reports. Therefore, these two types of accidents were selected for the urban areas within the context of this study. The required data was obtained from experts or academics. 146 reports were found to be related with the urban traffic accidents. The most common type of accidents in urban traffic was "vehicle -

pedestrian” among the reports. 87 of 146 reports were related with “vehicle - pedestrian” type of accidents. Also, 33 of 136 reports were related with “vehicle - vehicle” type of accidents. These reports show that “vehicle – pedestrian” and “vehicle – vehicle” accidents were most occurring type of accidents. The acquired reports are classified in Table 4.1.

Table 4.1 Distribution of urban traffic accidents

TYPES OF ACCIDENTS	Number of Accidents	Percentage distribution
Accidents with Pedestrian	87	59,6
Accidents with Vehicle	33	22,6
Overturn	4	2,7
Accidents with fixed object	5	3,4
Accidents with two-wheeler users	3	2,1
Other	14	9,6
TOTAL	146	100

As seen above, in urban areas pedestrian accidents represent approximately 60 percent of traffic accidents among such expert-witness reports. Especially, high density of traffic may lead to accidents with pedestrians. Also, integration of traffic into residential space plays an important role in increasing number of accidents. Moreover, not adhering to traffic rules in urban areas brings on fatalities or injuries. The percentage distribution of urban traffic accidents for the expert-witness reports examined are shown in Figure 4.1.

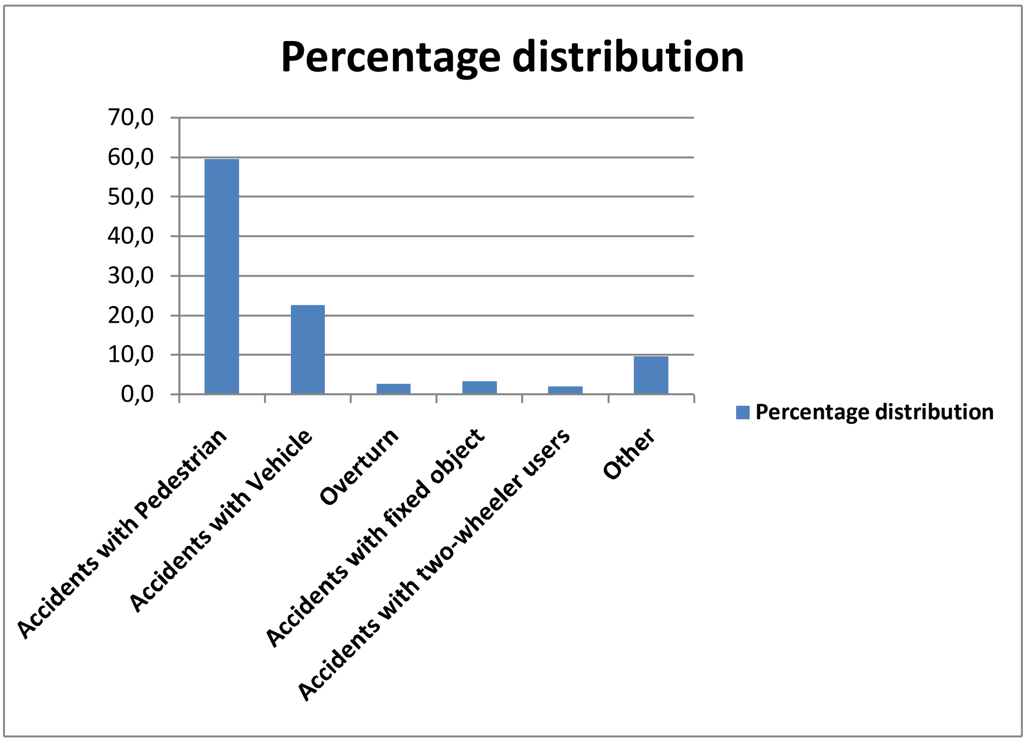


Figure 4.1 The distribution of accident types in urban areas for the expert-witness reports examined

Similarly, the rest of the expert-witness reports related with rural areas were classified. When these reports were examined, it was concluded that "vehicle – vehicle" type of traffic accidents also constitute most of the reports for rural traffic accidents. Therefore "vehicle – vehicle" accidents were selected for the rural areas within the context of this study. 97 reports were found to be related with the rural traffic accidents. 34 of 97 reports were related with "vehicle - vehicle" type of accidents. The acquired reports are classified in Table 4.2. According to the expert–witness reports, the general causes of traffic accidents can be ordered as follows: exceed speed limit, improper driving, following too closely, improper turning, inattention, and fatigue. The percentage distribution of rural traffic accidents examined is shown in Figure 4.2.

Table 4.2 Distribution of rural traffic accidents

TYPES OF ACCIDENTS	Number of Accidents	Percentage distribution
Accidents with Vehicle	34	35,1
Overturn or Out of way	32	33
Accidents with fixed object	8	8,2
Accidents with pedestrian	8	8,2
Accidents with two-wheeler users	1	1
Other	14	14,5
TOTAL	97	100

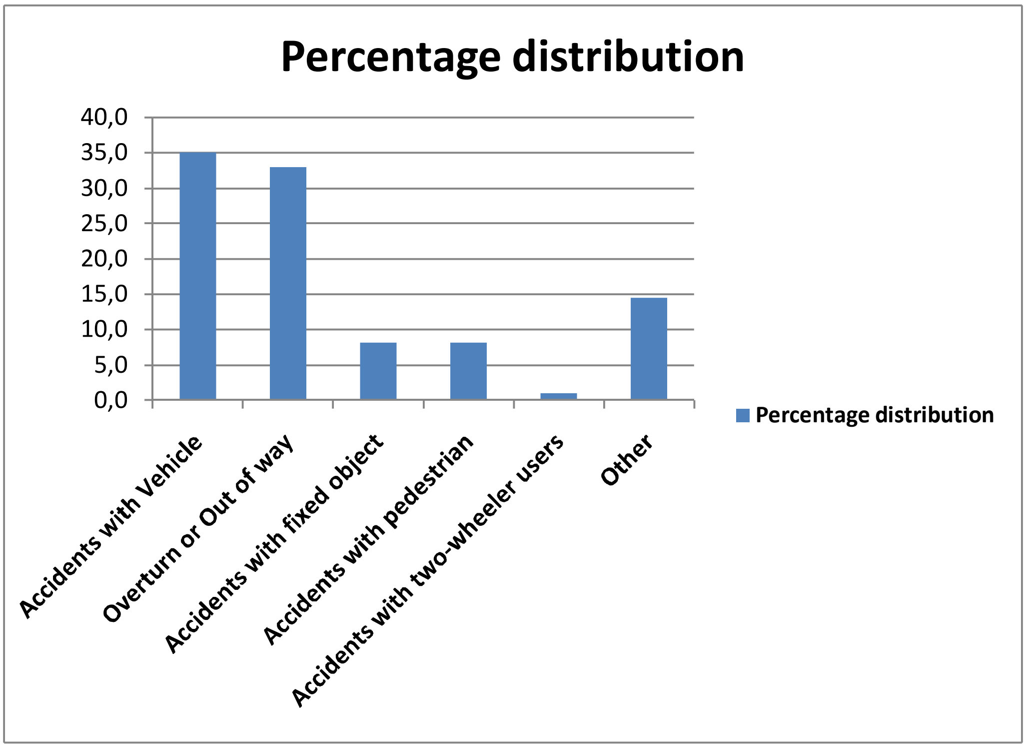


Figure 4.2 The distribution of accident types in rural areas for the expert-witness reports examined

Consequently, three types of traffic accidents were selected within the context of this study. Two of them are for urban areas; accidents with pedestrians on zebra crossings or intersections and on straight roads. Another one is for rural areas; head to head collision for "vehicle-vehicle" accidents.

All of the reports received from experts were investigated in detail. Also, laws and regulations related with road traffic safety were studied. While determining fault rates the experience, knowledge and intuition of the experts play the most critical role. The Traffic Accident Expert System (TAES) pretends the role of experts by incorporating the knowledge of experts in the form of rules.

4.3.1. Structure of Traffic Accident Reports

The general information about a traffic accident, that is, date and location are given in the first part of traffic accident reports. This kind of report includes general information about drivers, pedestrians, and involved vehicles. Moreover, information about weather condition, light condition, road character, road surface condition, total number of through lanes, median type, injury severity, point of impact, and vehicle movement before collision are presented. In addition to points given above, which rules are not evaded by drivers or pedestrians take part in these reports. Furthermore, the reports contain information and simple drawings about how the accidents have occurred. Mostly, there exists a special part in the report where the reporter writes the evaluation of the accident and the causes of the accident.

4.3.2. General Factors Considered for All Types of Traffic Accidents

In this study, the accident related information is provided by studying the available traffic accident reports and literature review. Some variables summarized from police investigation reports and literature review are shown in Table 4.3. New variables can be added to this table. Significant variables which will be employed to develop accident scenarios through flowcharts should be chosen among them for each type of traffic accident.

Table 4.3 Variables affecting traffic safety

Right of way	Invasion
Date	Alcoholic use
Time	Driver contributing circumstances
Type of road	Movement
Road surface	Direction
Road surface condition	Lane change
Median type	Foresight of the accident
Driver condition	Foresight distance
Location	Reactions
Major and minor street	Braking
Lane located	Braking line of left wheel
Daylight or darkness	Braking line of right wheel
Weather condition	Relative direction
Flash signal	Crash spot
Speed limit	Self reported speed
Gender of driver	Relative position
Age of driver	Crossing the middle of intersection
Education	Number lanes after turn
Type of vehicle	Lane after turn
Length of vehicle	Driver injury
Speeding	Passenger injury
Licensing	Driver death
Accident types	Passenger death

Subsequently, some of these variables were considered to be more important for all types of traffic accidents by the researcher and the supervisors of this study. These variables are shown in Table 4.4.

Table 4.4 Critical variables influencing traffic safety

Right of way	Weather condition
Date	Flash signal
Time	Alcoholic use
Type of road	Lane change
Median type	Speeding
Daylight or darkness	Licensing
Road surface condition	Foresight of the accident
Major and minor street	Braking
Location	Invasion

4.3.2.1. "Vehicle – Pedestrian" Type of Accidents in Urban Areas

Pedestrian crashes and the resulting deaths and injuries are a serious problem on our roadways. Pedestrians form a significant portion of all road user casualties in most countries. Despite all prevention efforts to protect pedestrians from the risk of accidents, such incidents are still quite common. The severity of "vehicle - pedestrian" accidents is generally very high because pedestrians are unprotected in case of collision. Therefore accidents involving pedestrians are more alarming type as they often result which serious injury or fatality.

Many pedestrian crashes are the result of unsafe motor vehicle driver and pedestrian behaviors. Certain roadway design features can contribute to unsafe behaviors by pedestrians and motorists. For example, excessively-wide streets encourage higher motorist speeds. High volume multilane roads with a lack of safe crossings at regular intervals can contribute to pedestrians crossing streets at unsafe locations, especially those who cannot or will not walk great distances to signalized locations.

In fact, pedestrians are generally exposed to the risk of traffic accident when crossing a road in urban areas. At intersections with traffic lights, pedestrian crossings can be possible when the lights are green for pedestrians. When the lights are red for pedestrians, a pedestrian may be exposed to traffic accident if he/she chooses to disregard regulations and attempts to cross the roads. At signalized intersections, critical factor leading to accident is not adhering to rules of traffic signal regulations.

In this study “vehicle – pedestrian” type of urban traffic accidents on zebra crossings or intersections and on straight roads were handled. General factors influencing these types of accidents can be detected by studying the available expert-witness reports. Table 4.5 discloses the factors not influencing the fault rates of traffic accidents in urban areas. These factors not having any fault weights while evaluating fault rates just give information about accident.

Table 4.5 General factors not having an effect on fault rates for “vehicle – pedestrian” type of traffic accidents

1	Whether the driver has driving licence or not.
2	Whether the driver used alcohol or not.
3	What was the date of the accident?
4	What was the time of the accident?
5	Whether the accident was in major street or not.
6	Whether the driver felt asleep or fatigue or not.
7	Whether the driver was driving without the proper care and attention or not.
8	Whether the road that accident occurred is one way or not.
9	Whether the road has one lane or not.
10	Whether the road is divided or not.

In addition, Table 4.6 discloses the factors influencing the occurrence and the severity of traffic accidents and traffic safety in urban areas. These factors have weights while evaluating the fault rates.

Table 4.6 The factors having weights for "vehicle – pedestrian" type of traffic accidents on zebra crossings or intersections and straight roads

1	Whether the weather condition was clear, rainy, cloudy, snowy or not.
2	Whether the road surface condition was dry, wet, snowy, icy or not.
3	Whether it was daytime or not.
4	Whether the type of road is access/collector or main arterial.
5	Whether the driver or pedestrian disregarded traffic signs, signals, road markings or not.
6	Whether the vehicle was on the road after the collision or not.
7	Whether the vehicle collided with a pedestrian on pavement or not.
8	Whether the vehicle was on the wrong direction or entering a roadway with a no vehicle entry sign or not.
9	Whether there was any visible sign on the road showing the zebra crossing or not.
10	Whether the zebra crossing was visible or not.
11	Whether the speed of vehicle was above legal limit or not.
12	Whether the pedestrian suddenly entered on the road without checking the traffic or not.
13	Whether there were any hazardous objects that cause the driver's maneuvers in wrong manner or not.
14	Whether there was any adjacent bus stop or not.
15	Whether there was any adjacent lay-by for vehicles or not.
16	Whether there were any parked vehicles on the rightmost lane or not.
17	Whether there was any right lane reserved for parked vehicles or not.
18	On which lane did the accident occur?
19	Whether the pedestrian was more than 20m from collision point or not.
20	Whether the vehicle stop within 10m distance from collision point or not.
21	Whether there was zebra crossing/pedestrian bridge/pedestrian subway within 100m distance or not.

4.3.2.1.1. Literature Review on "Vehicle – Pedestrian" Accidents in Urban Areas

In their studies, Zegeer and Stutts suggested the definition of pedestrian in detail. "Walking is a basic human activity, and almost everyone is a pedestrian at one time or another. Even though pedestrians are legitimate roadway users, they are frequently overlooked in the quest to build more sophisticated transportation systems. Whether building new infrastructure or renovating existing facilities, it should be assumed that people will walk, and plans should be made to accommodate pedestrians. Where people aren't walking, it is often because they are prevented or discouraged from doing so".

According to the writers, "pedestrian – motor vehicle" crash types include followings; (Zegeer and Stutts, 2004)

- Pedestrian darts out into traffic midblock,
- Pedestrian is struck from behind while walking or running along a road in the same direction as traffic,
- Vehicle turning at an intersection strikes a pedestrian,
- Pedestrian is struck by backing vehicle

The safety literature reveals a variety of risk factors that influence pedestrian crashes and severity. For example, pedestrian crash risk increases on wide roads (four lanes or more) with high motor vehicle speeds and/or volumes. Intersections are more difficult to cross when pedestrians encounter wide crossing distances, wide turning radii, multiple turn lanes, or traffic control that is confusing or complex. Other high-risk factors include drug/alcohol use by motorists and pedestrians, lack of nighttime roadway lighting, and the lack of walkways along roads. Older pedestrians are much more susceptible to serious or fatal injuries because of their frailty, while young children (particularly males aged 5 to 9) are more likely to be struck by a motor vehicle after darting into the street (Campbell, 2004).

Also, Ekman (1996) looked at the safety of pedestrians using pedestrian crossings (zebra crossings) and signalized crossings and compared them with crossing the road with no facilities. When looking at the accident rate per pedestrian crossing for different ages of pedestrians, the pedestrian (zebra) crossing had the highest accident rate for younger and older age groups and was only slightly lower than the signalized crossing for all other pedestrian ages. Ekman concluded that pedestrians had a false sense of 'protection' at the zebra and the signalized crossings.

In addition, pedestrian deaths occur primarily in urban areas as in expert-witness reports. Many pedestrians are killed on crosswalks, sidewalks, median strips, and traffic islands. Physical separations such as overpasses, underpasses, and barriers can reduce the problem. Increased illumination and improved signal timing at intersections also can be effective. Because traffic speeds affect the risk and severity of pedestrian crashes, reducing speeds can reduce pedestrian deaths (Retting, 2003).

Especially wide intersections and those with multiple turn lanes create a long wait for pedestrians. Sometimes, crossing prohibitions may be designated for one or more crosswalks to facilitate turning movements. If a crosswalk is closed, the pedestrian is left with three choices: cross illegally with no signal protection, walk a long distance around the intersection, or walk to another location to cross.

In order to decrease number of accidents and deaths, there are several objectives that transportation professionals should address to improve pedestrian safety and mobility;

- reduce the speed of motor vehicles
- reduce pedestrian risks at street crossing locations
- provide sidewalks and walkways separate from motor vehicle traffic
- improve awareness of and visibility between motor vehicles and pedestrians
- improve pedestrian and motorist behaviors

There are various types of "vehicle – pedestrian" accidents in respect to the location where the accidents occur. The most occurring types of accidents in urban areas are on zebra crossings or intersections and on straight roads. Therefore, these two types were selected within the context of this study.

4.3.2.1.2. "Vehicle – Pedestrian" Type of Traffic Accidents on Zebra Crossings or Intersections in Urban Areas

A zebra crossing is a type of pedestrian crossing used in many places around the world. Its distinguishing feature consists of alternating dark and light stripes on the road surface, from which it derives its name. A zebra crossing typically gives extra right of way to pedestrians. As stated previously, a flowchart was developed for zebra crossings by considering the factors influencing the severity of an accident. When focused on the flowchart for this type of traffic accident, the critical factor in zebra crossings is to obey the traffic posts, that is to say, pedestrians have right of way. Traffic accident flowchart for the zebra crossing accidents is shown in Figure 4.3. A numerical notation is used to depict questions in the flowchart. The numbers in the flowcharts refer to the number of questions which are shown in question lists.

When the developed flowchart is considered closely, the road and environment conditions will be noticed to take place at the top of flowchart. After knowing these conditions, the crash point on vehicle and the direction of pedestrian in reference to the vehicle is a critical issue while evaluating fault rates. The operation on the road which is materialized in two options: one way or two way. This is also effective on assigning fault rates. The road layout is considered to be divided or undivided in the flowchart. The weights assigned by experts in the questionnaire change in respect of road layout. There are four questions in the beginning of the flowchart. If the respondent answers these questions with a "YES", the system directly goes to result. That is to say, when the vehicle is going in the wrong direction or collides with a pedestrian on a median or sidewalk, 100% fault rate is assigned to the driver by the system. Also, if one of the parties violates the traffic lights, the 100% fault rate is assigned to the infringer party. When continued throughout flowchart, lane count on the road divides flowchart into two sub parts. In flowchart, the forthcoming questions change in respect of lane count. In addition, there are three options for the speed of the vehicle such as, above legal limit, below legal limit, and unknown. If the speed of the vehicle is unknown, three questions come after that to judge the speed. Such questions can be seen in the flowchart. Moreover, another topic taken into account while developing the flowchart is that whether the pedestrian is before the zebra crossing or not at the moment of the accident. The questions in the yellow boxes are also considered when the number of lanes are two or more.

The question list and flowchart for "vehicle – pedestrian" type of accidents on zebra crossings are given in Table 4.7 and Figure 4.3 respectively.

Table 4.7 The question list for zebra crossing

Number	Questions	Response Yes/No/U
1	Is the road that accident occurred one way?	
2	Is the road divided?	
3	Was the vehicle on the wrong direction or entering a roadway with a no vehicle entry sign?	
4	Did the vehicle collide with a pedestrian on median or side walk or shoulder or lay-by?	
5	Did the driver violate traffic lights?	
6	Did the pedestrian violate traffic lights?	
7	Is the road one lane?	
8	Did the accident occur before/at/after the center of the lane referenced to the vehicle?	
9	Was the speed of the vehicle above legal limit?	
10	How far was the pedestrian from collision point? (Less than 20m - more than 20m)	
11	Was the vehicle on the road after the collision?	
12	Did the vehicle stop within 10m distance from collision point?	
13	Did the accident occur on which lane referenced to the vehicle?	
14	Was the pedestrian before zebra crossing?	
15	Was there any vehicle on the other lanes?	
16	Did the driver take precaution with steering maneuvers to avoid collision?	
17	Was there any visible sign on the road showing the zebra crossing?	

Table 4.7 The question list for zebra crossing (continued)

18	Did the pedestrian suddenly enter on the road without checking the vehicular traffic?	
19	Were there any hazardous objects that cause the driver's maneuver in wrong manner?	
20	Was there any adjacent bus stop?	
21	Was there any adjacent lay-by for vehicles?	
22	Was there any parked vehicle on the rightmost lane?	
23	Was there any (right) lane reserved for parked vehicles?	

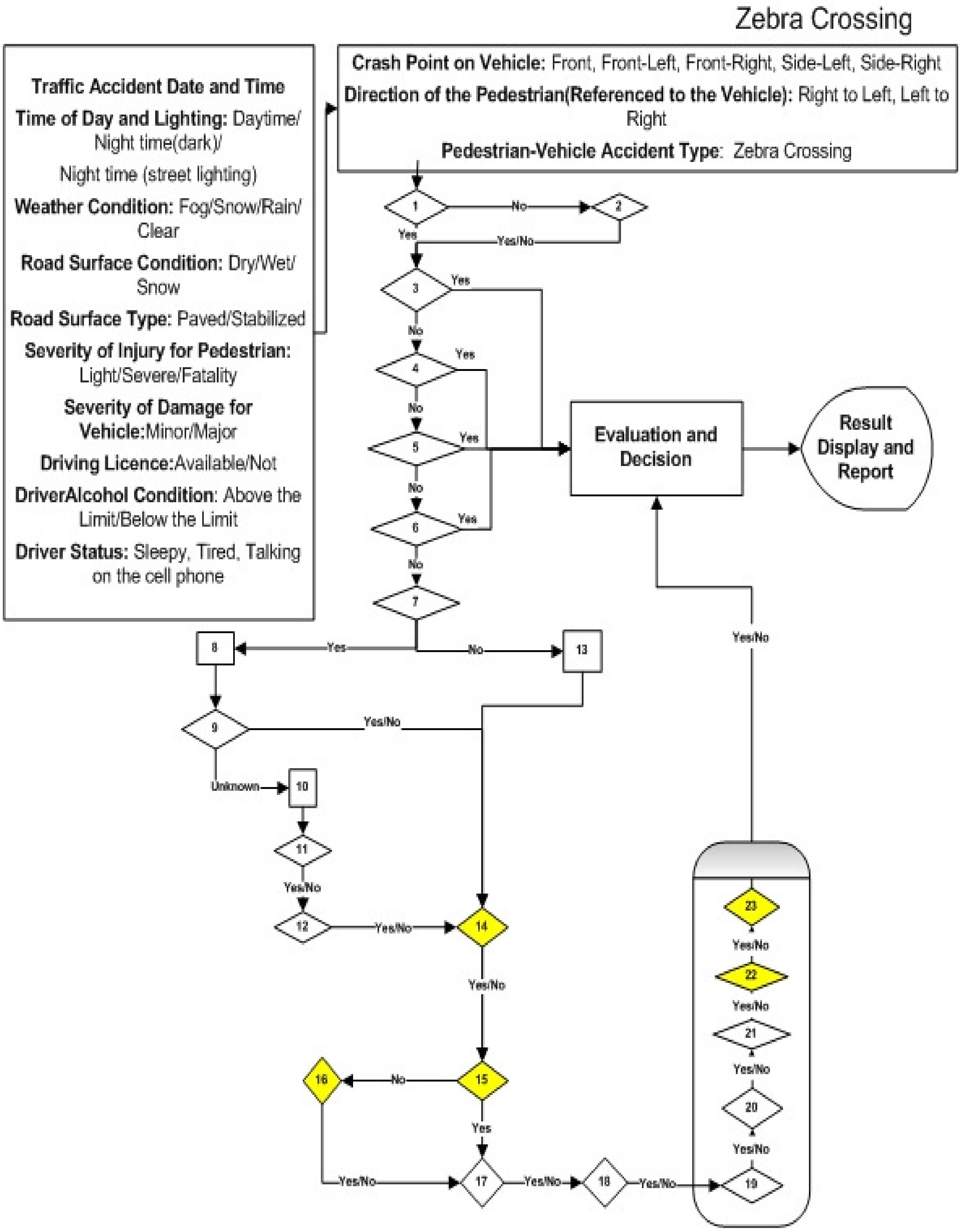


Figure 4.3 Flowchart for “vehicle – pedestrian” type of accidents on zebra crossings

Furthermore, the questions those come after the given above take the following factors into consideration; whether the pedestrian suddenly enters the road without checking the vehicular traffic or not, whether there is an adjacent bus stop or not, whether there is a lay by or not, and whether there are any hazardous objects that cause the drivers maneuver in wrong manner or not. Subsequently, system evaluates the answers to the questions in a quantitative approach. Finally, the fault rates of each party are determined.

Although there are only two sides, driver or pedestrian, to assign fault rates for all questions in the flowchart, two questions have three choices to assign fault rates as driver, pedestrian and road fault. These questions are; "were there any hazardous objects that cause the drivers maneuver in wrong manner?" and "was there any parked vehicle on the right most lane that adversely effects the sight of the driver?"

In this study, general factors for "vehicle – pedestrian" type of urban traffic accidents on zebra crossings are shown above in Table 3.5 disclosing the factors affecting severity of traffic accidents. Therefore, quantification of fault rates depends on some of those factors. In fact, traffic accidents happen when some these factors are violated. In order to determine fault rates, a questionnaire was prepared in light of a developed flowchart. The example cases from the questionnaire for each type of accident considered accidents are presented in Appendix B, C, and D. The acquired results from experts are used in the expert system which is developed for quantification of fault rates of traffic accidents.

4.3.2.1.3. "Vehicle – Pedestrian" Type of Traffic Accidents on Straight Roads in Urban Areas

Similarly to other types of pedestrian accidents in urban areas, the critical factor is to obey traffic posts in straight roadways. In fact, the significant factor different from zebra crossings in this kind of accidents is "whether there was zebra crossing/pedestrian bridge/pedestrian subway within a 100m distance or not" due to the Article 138 of the Regulation of Road Traffic No: 2918. If the answer given to this question is "YES", the fault rate of the pedestrian is increased due to the fact that pedestrian violates the related rules. Traffic accident flowchart for the straight road accidents is shown in Figure 4.4. Subsequently, a questionnaire was prepared to obtain experts' knowledge like on things such as zebra crossing types of urban traffic accidents. The results obtained from the questionnaire were used in the expert system.

Pedestrians should be aware of that there is high risk of accidents in urban areas. Especially on straight roads, the critical factor leading to accident is not adhering to traffic signs and not paying proper attention to the traffic rules and regulations.

The question list and flowchart for "vehicle – pedestrian" type of accidents on straight roads are given in Table 4.8 and Figure 4.4 respectively.

Table 4.8 The question list for straight roads

Number	Questions	Response Yes/No/U
1	Is the road that accident occurred one way?	
2	Is the road divided?	
3	Was the vehicle on the wrong direction or entering a roadway with a no vehicle entry sign?	

Table 4.8 The question list for straight roads (continued)

4	Did the vehicle collide with a pedestrian on median or side walk or shoulder or lay-by?	
5	Did the driver violate traffic lights?	
6	Did the pedestrian violate traffic lights?	
7	Is the road one lane?	
8	Did the accident occur before/at/after the center of the lane referenced to the vehicle?	
9	Was the speed of the vehicle above legal limit?	
10	How far was the pedestrian from collision point? (Less than 20m - more than 20m)	
11	Was the vehicle on the road after the collision?	
12	Did the vehicle stop within 10m distance from collision point?	
13	Did the accident occur on which lane referenced to the vehicle?	
14	Was there any vehicle on the other lanes?	
15	Did the driver take precaution with steering maneuvers to avoid collision?	
16	Was there zebra crossing/pedestrian bridge/pedestrian subway within 100m distance to collision point?	
17	Did the pedestrian suddenly enter on the road without checking the vehicular traffic?	
18	Were there any hazardous objects that cause the driver's maneuver in wrong manner?	
19	Was there any adjacent bus stop?	
20	Was there any adjacent lay-by for vehicles?	
21	Was there any parked vehicle on the rightmost lane?	
22	Was there any (right) lane reserved for parked vehicles?	

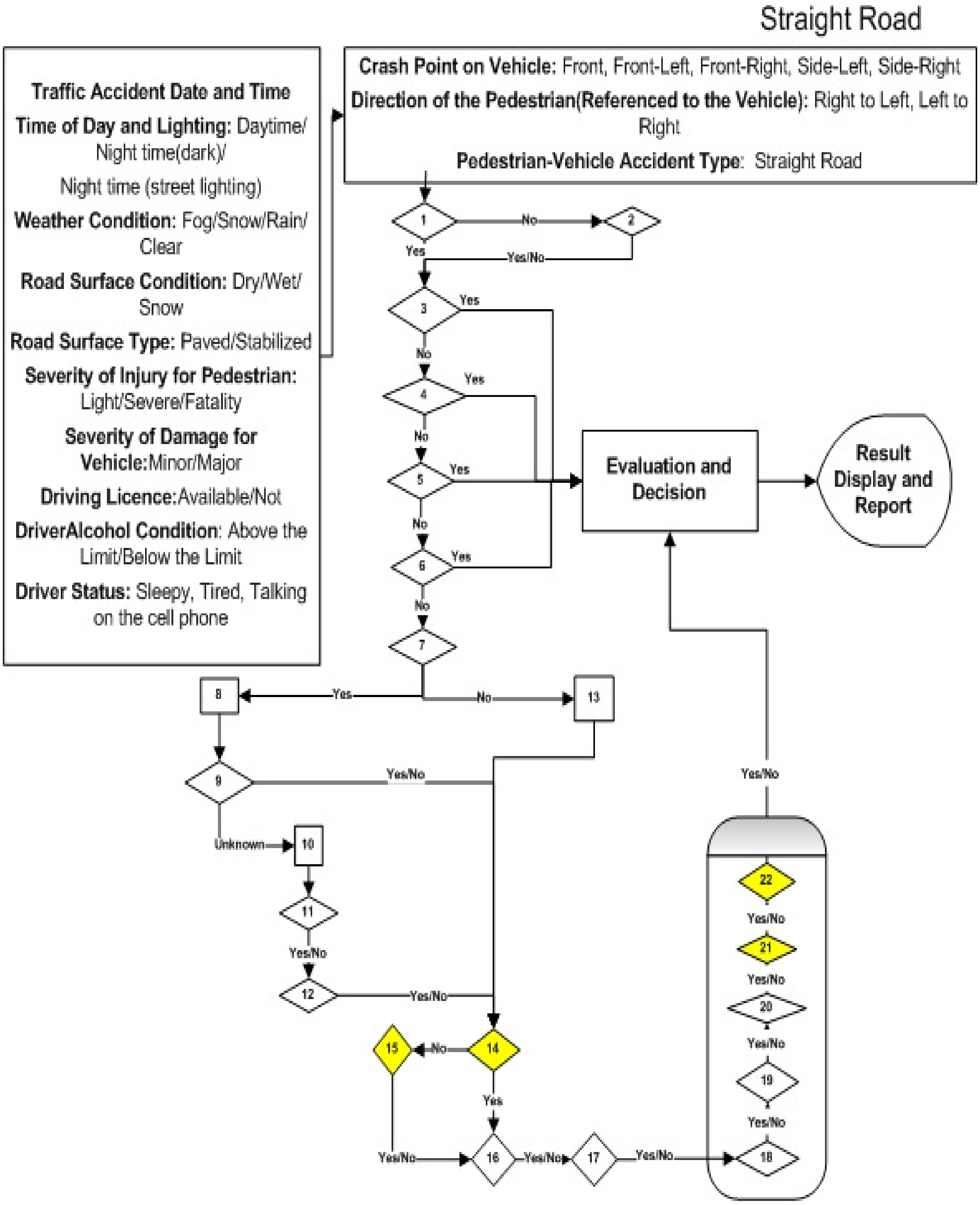


Figure 4.4 Flowchart for “vehicle - pedestrian” type of accidents on straight roads

Finally, in order to develop a quantification system for the "vehicle – pedestrian" type of accident in urban areas, the knowledge of experts should be converted into touchable data. This process was performed with a questionnaire form that was submitted to experts. This questionnaire contains some developed scenarios related with the types of "vehicle – pedestrian" accidents. The experts analyzed these scenarios by quantifying each of them. The acquired results from experts are used in the expert system which is developed for quantification of fault rates of urban "vehicle – pedestrian" accidents.

4.3.2.2. "Vehicle – Vehicle" Type of Accidents in Rural Areas

Traffic accidents in rural areas lead to deaths and injuries as well. When looking at the expert-witness reports in rural areas, 34 of 97 reports or 35.1 % are "vehicle – vehicle" type of traffic accidents. For this reason this issue should be considered in detail. So, the factors affecting the severity on this type of traffic accidents were identified as well. In this study, general factors for "vehicle – vehicle" type of traffic accidents on rural roads can be detected studying the available expert-witness reports. The factors not influencing the fault rates of traffic accidents in rural areas are presented in Table 4.9. These factors not having any fault weights while evaluating fault rates just give information about accident.

Table 4.9 General factors not having an effect on fault rates for "vehicle – vehicle" type of traffic accidents

1	Whether the drivers have driving license or not.
2	Whether the drivers used alcohol or not.
3	What was the date of accident?

Table 4.9 General factors not having an effect on fault rates for "vehicle – vehicle" type of traffic accidents (continued)

4	What was the time of accident?
5	Whether the drivers felt asleep or fatigue or not.
6	Whether the drivers were driving without the proper care and attention or not.
7	Whether the road that accident occurred is one way or not.
8	Whether the road has one lane or not.
9	Whether the road is divided or not.

In addition, Table 4.10 discloses the factors influencing the occurrence and the severity of traffic accidents and traffic safety in urban areas. These factors have weights while evaluating the fault rates.

Table 4.10 The factors having weights for head to head collision for "vehicle – vehicle" type of traffic accidents

1	Whether the weather condition was clear, rainy, cloudy, snowy or not.
2	What was the type of road?
3	Whether the road surface condition was dry, wet, snowy, icy or not.
4	Whether it was daytime or not.
5	Whether the drivers disregarded traffic signs, signals, road markings or not.
6	Whether the drivers adhered to rules of overtaking or not.
7	Whether the drivers overtook in an overtaking prohibited zone or not.
8	Whether the vehicles were on the wrong direction or entering a roadway with a no vehicle entry sign or not.
9	Whether the speed of vehicles were above legal limit or not.
10	On which lane did the traffic accident occur?
11	Whether the vehicles had proper light equipment or not.
12	Whether the crash point was on right lane or left lane.

When looking at the factors shown above, there are some differences between "vehicle – pedestrian" and "vehicle – vehicle" type of traffic accidents. Especially, the question, "on which lane is the crash point?" has critical importance for this type of accidents.

4.3.2.2.1. Head to Head Collisions for "Vehicle-Vehicle" Traffic Accidents in Rural Areas

"Vehicle – vehicle" type of traffic accidents are one of the most frequent type of accident on rural roads. Hence, a flowchart for the "vehicle – vehicle" type of traffic accidents was developed. The proposed flowchart can be seen in Figure 4.5. When the flowchart is examined carefully, the first critical issue is the number of lanes. The flowchart is separated into two sub parts as two lanes and more than two lanes. In this study, the road layout is assumed to be undivided and the operation is two way. The questions differ for the road having two lanes and the road having more than two lanes. The questions can be seen throughout the flowchart. In addition, the crash points on vehicles are significant while assigning fault rates. The speed of the vehicles also has importance on fault rates. Finally, the system assesses the answers to the questions in a quantitative approach. Subsequently, the fault rates of each party are determined.

The question list and flowchart for head to head collision for "vehicle – vehicle" traffic accidents are given in Table 4.11 and Figure 4.5 respectively.

Table 4.11 The question list for "vehicle - vehicle" collision

Number	Questions	Response Yes/No/U
1	Did the accident occur on the left lane/right lane/on the middle of the road referenced to the vehicle A's direction?	
2	Did the driver B take precaution to avoid collision?	
3	Did the driver A take precaution to avoid collision?	
4	Crash point is on right/left lane referenced to the vehicle A's direction?	
5	Did the accident occur on the lanes adjacent to or next to middle lane marking?	
6	Did the accident occur on the vehicle A's direction?	
7	Did the accident occur on the vehicle B's direction?	
8	Crash point on vehicles: front-middle/front-left/front-right/side-left/side-right.	
9	Was the speed of the vehicle A above legal limit?	
10	Was the speed of the vehicle B above legal limit?	
11	Did the vehicle A have proper light equipment?	
12	Did the vehicle B have proper light equipment?	

In conclusion, a questionnaire was prepared so as to acquire expert's knowledge whereby fault rates of each party involved in such kinds of traffic accidents were determined. The expert system employs all these quantification results to deduce the responsible party after the traffic accident.

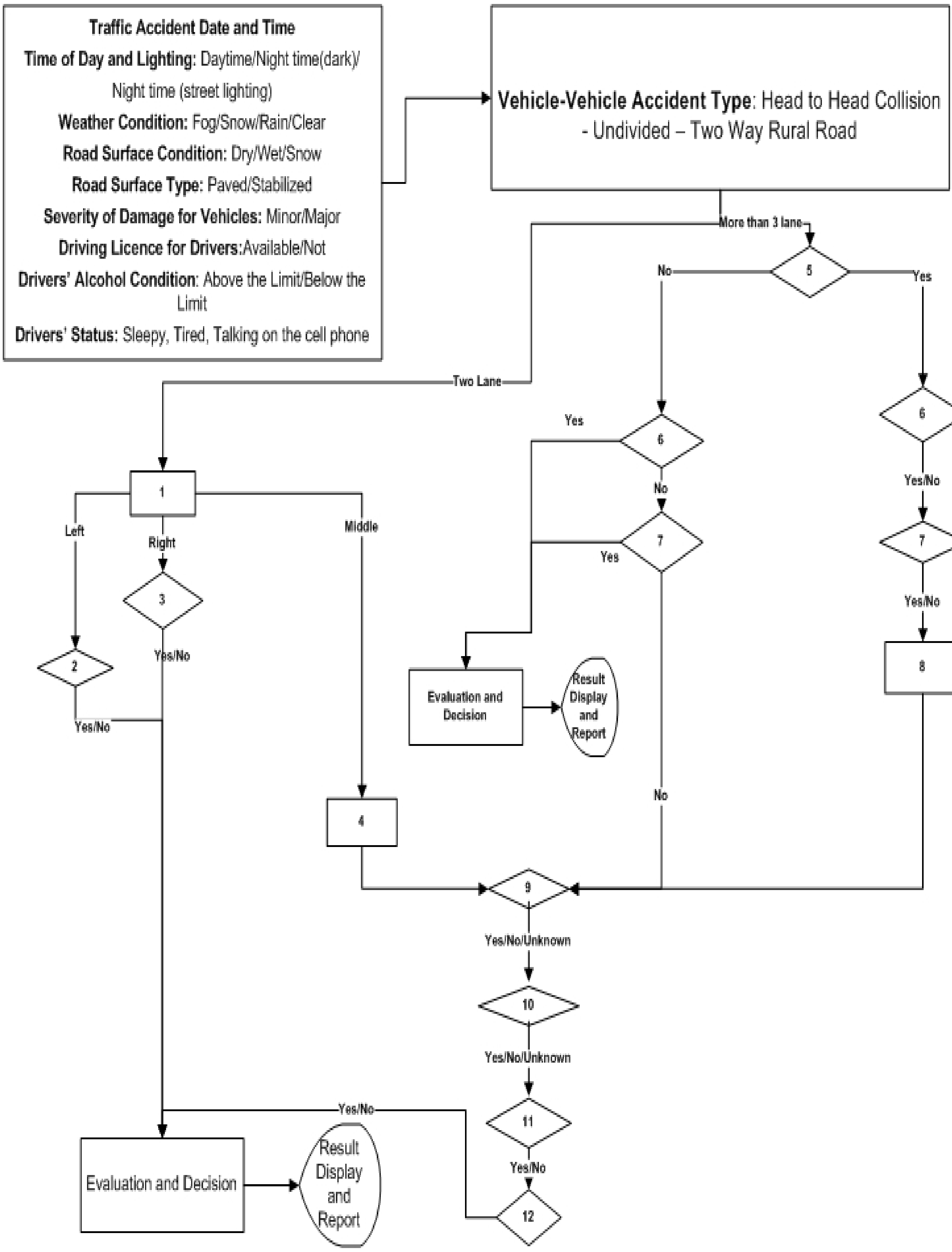


Figure 4.5 Flowchart for head to head collision for “vehicle – vehicle” accidents in rural areas

4.4. The Questionnaire

As introduced before, a questionnaire was prepared for the purpose of acquiring expert's knowledge. As stated previously three types of traffic accidents were investigated in this thesis such as, accidents with pedestrians on zebra crossings or intersections in urban areas, accidents with pedestrians on straight roads in urban areas, and finally accidents with vehicle to vehicle in rural areas. The questionnaire has three parts, that is, each part corresponds to each type of traffic accident. These three parts are the following:

- accidents with pedestrians on zebra crossings or intersections in urban areas
- accidents with pedestrians on straight roads in urban areas
- accidents with vehicle to vehicle in rural areas

4.4.1. The First Part of the Questionnaire

This part includes the questions related to accidents with pedestrians on zebra crossings or intersections in urban areas. The questions were asked to the experts through the developed flowcharts. There are many accident scenarios in the questionnaire. Firstly, the questionnaire covers the information about road and environmental conditions and their scenarios. Secondly, the questionnaire has 18 cases to be considered. These cases are separated from each other in respect of layout, total number of through lanes, operation, and signal control. Each case has accident scenarios in accordance with type of road conditions. These scenarios were developed by taking into account the factors influencing the fault rates of parties involved in a traffic accident. Also, each scenario has two answers as "Yes" and "No". Each answer has a weight in order to adjust fault rates as well. An example of one case from first part of the questionnaire related to accidents with pedestrians on zebra crossings or intersections is added to the end of this study. The example case is shown in Appendix B.

4.4.2. The Second Part of the Questionnaire

The second part covers the questions related to accidents with pedestrian on straight roads in urban areas. The necessary or related questions were asked to the experts through the developed flowcharts. This part also includes many of the accident scenarios included in the questionnaire. Similar to the first part, the second part of the questionnaire contains the information about road and environmental conditions and their scenarios. In addition, the second part of the questionnaire has 18 cases to be taken into account as well. Similar to zebra crossings, these cases are separated from each other in respect of layout, total number of through lanes, operation, and signal control. Each case has also accident scenarios in accordance with type of road conditions. Each scenario has two answers as “Yes” and “No” like first part of the questionnaire. Each answer has a weight in order to adjust fault rates as well. An example of one case from second part of the questionnaire related to accidents with pedestrians on straight roads is added to the end of this study. The example case is disclosed in Appendix C.

4.4.3. The Third Part of the Questionnaire

The third part is totally different from the first two parts of the questionnaire. That is to say, this part includes the questions related to accidents of “vehicle – vehicle” type head to head collision in rural areas. There are 12 cases depending on type of road, operation, and layout. The questions were asked to the experts through the developed flowchart for the “vehicle – vehicle” type of traffic accidents. Also, there are a number of accident scenarios in the questionnaire.

Firstly, the questionnaire includes the information about road and environmental conditions and their scenarios. These scenarios were developed by considering the factors influencing the fault rates of parties involved in a traffic accident. In addition, similarly to other parts, each scenario has two answers as “Yes” and “No”. Finally, each answer has a weight in order to adjust the fault rates as well. An example of one case from third part of the questionnaire related to accidents with vehicle to vehicle on straight roads in urban areas is added to the end of this study. The example case is presented in Appendix D.

4.4.4. The Quantification Methodology in Questionnaire

The importance of factors is rated over 100 in all the three parts of questionnaire. However, before the expert system is conducted, for the “vehicle – pedestrian” type of traffic accidents on zebra crossings, the fault rates are assumed 70 % and 30 % corresponding driver and pedestrian respectively. The reason for this, on zebra crossings pedestrians have already right of way to across. Experts judge these rates on the average when there are no other information other than there the accident is “vehicle - pedestrian” accident at a zebra crossing. The drivers are assumed to be faultier than pedestrians on zebra crossings. However, for the “vehicle - pedestrian” type of traffic accidents on straight roads, the fault rates are assumed 40% and 60% corresponding driver and pedestrian respectively. This is the rating of experts on the average when there are no other information other than the accident is “vehicle - pedestrian” accident on straight roads. On the other hand, for the “vehicle – vehicle” type of traffic accidents, the fault rates are assumed to 50% and 50% corresponding to driver A and driver B respectively. The respondents of the questionnaire, experts, were asked to give positive or negative weight to the factors in the scenarios. Each scenario has positive and negative weight for the parties involved in an accident. In fact, if one party is faultier than the other one, the faultier party takes positive weight, that is to say, fault rate of it is increased. If on the same scenario, at the same situation, the other party takes negative weight, that is, fault rate for this party is decreased. The examples given below explain the methodology executed.

Example 1.

Accident occured on the rightmost lane referenced to the vehicle's direction	Yes	**-2**	**Driver**
		2	**Pedestrian**

Example 2.

Accident occured on the leftmost lane referenced to the vehicle's direction	Yes	**2**	**Driver**
		-2	**Pedestrian**

This scenario is taken from "vehicle – pedestrian" type of accidents on zebra crossings. The road is undivided and two way. This scenario is for the direction of pedestrian referenced to the vehicle is right to left. When focused on the weighted values for the driver and pedestrian, for the first example, if the accident occurred on the rightmost lane referenced to the vehicle's direction the fault rate of driver is decreased by 2 points out of 70, that is, decreased 2%. However the fault rates of pedestrian is increased by 2%. The opposite condition is valid for the example 2.

Similar to the scenario shown above, the questionnaire consists of many scenarios. The obtained data in questionnaire from the experts was used to form a database so as to determine the fault rates. In order to clarify the quantification methodology of the questionnaire, an examined part of the questionnaire from a "vehicle – pedestrian" type of accident on zebra crossings in urban areas is given in the following section.

4.4.4.1. An Example of Quantification

The questionnaire results of "vehicle – pedestrian" type of accident on zebra crossings in urban areas are introduced in this part of the chapter. Each scenario has weights for driver and pedestrian. The final fault rates are determined by considering all the answers to the questions in the questionnaire. That is to say, fault values of driver and pedestrian are accumulated separately. An example quantification of an accident scenario is shown below.

		Driver	Pedestrian
Type of Road	Access road	3	-3
Time of day and Lighting	Night time(dark)	1	-1
Weather condition	Rainy or Snowy	2	-2
Road surface type	Paved		
Road surface condition	Wet	1	-1
Sign Control	Sign	1	-1
Control (marking)	Visible marking	1	-1
Is the zebra adjacent to bus stop	Yes	1	-1
Is there a lay-by for bus stop	No		

Layout	Undivided
Total number of through lanes	Four lane
Operation	Two way
Signal Control	No Signal

Did the vehicle collide with pedestrian on median or side walk or shoulder or lay-by?	No		Driver
			Pedestrian

Was the vehicle on the wrong direction or entering a roadway with a no vehicle entry sign?	No		Driver
			Pedestrian

Was the pedestrian before zebra crossing?	Yes	-2	Driver
		2	Pedestrian

Direction of pedestrian referenced to the vehicle is Right to Left	Yes	2	Driver
		-2	Pedestrian
Crash point on vehicle is Front-Left	Yes		

Did the accident occur on the left lane referenced to the vehicle's direction	Yes	2	Driver
		-2	Pedestrian

Was the speed of the vehicle above legal limit?	Yes	5	Driver
		-5	Pedestrian

Did the pedestrian suddenly enter the road without checking the vehicular traffic?	Yes	-5	Driver
		5	Pedestrian

Was there any vehicle on the adjacent lanes?	No	3	Driver
		-3	Pedestrian
Did the driver take precaution with steering maneuvers to avoid collision?	No		

Were there any hazardous objects that cause the driver's maneuver in wrong manner?	No		Driver
			Pedestrian

The fault rates are quantified as below,

Fault rate of driver = 70 + ∑ adjustment on fault rates of driver

Fault rate of pedestrian = 30 + ∑ adjustment on fault rates of pedestrian = 100 – fault rate of driver

For the example above,

Fault rate of driver = 70 + 3+1+2+1+1+1+1+(-2)+2+2+5+(-5)+3 = 85 %

Fault rate of pedestrian = 30 +(-3)-1-2-1-1-1-1+2-2-2-5+5-3 = 15 %

In conclusion, fault rates of driver and pedestrian are determined by considering the answers to the questions through developed flowcharts for each type of traffic accidents. As seen above, each factor has weight and some have a value 0 for driver and pedestrian. The final fault rates of driver and pedestrian are calculated by accumulating the each fault value for each question.

4.4.5. The Assumptions in Questionnaire

As stated previously, this study covers three types of traffic accidents as followings: “vehicle – pedestrian” accidents on zebra crossings, “vehicle – pedestrian” accidents on straight roads in urban areas, and also “vehicle – vehicle” accidents in rural areas. These three types are selected due to the fact that these are frequent types according to expert-witness reports. The rest of the accident types are not considered in this study. Also, it is thought that there is one vehicle and one pedestrian involved in a single accident for “vehicle – pedestrian” type. The fault rates are assigned by considering this assumption. Also, in the beginning, the fault rates of the driver and pedestrian are assumed

70% and 30% respectively for zebra crossings due to the fact that rating of experts on the average. Also, pedestrians already have the right of way on zebra crossings. However, for the “vehicle - pedestrian” type of traffic accidents on straight roads, the fault rates are assumed 40% and 60% corresponding driver and pedestrian respectively. This is the rating of experts on the average when there are no other information other than the accident is “vehicle - pedestrian” on straight roads. In addition, it is assumed that there are two vehicles involved in accident for “vehicle – vehicle” type of traffic accident. The accidents including more than two vehicles are not considered in this questionnaire. The fault rates of drivers are assumed to equal, that is, 50% and 50% respectively because of experts’ rating.

CHAPTER 5

THE TRAFFIC ACCIDENT EXPERT SYSTEM (TAES)

Traffic Accident Expert System is a rule based expert system. The knowledge process of this system was introduced before. In addition, the knowledge is represented as a set of rules. The proposed expert system employs forward chaining in this study. That is to say, the expert system is a data driven expert system, there is no goal to be achieved for a conclusion. In this expert system, each answer to each question has a weight or value of fault. Lastly, all these faults are accumulated and the final fault rates are calculated in expert system.

There are many questions asked to user whereby conclusion is determined. All the answers to the questions identify the responsible party involved in traffic accident. As mentioned in previous chapters, flowcharts were developed for each type of traffic accidents. That is to say, the proposed expert system follows the flowchart through answers. Therefore, some of the questions are conditional. The expert system asks the conditional questions if necessary. For example, the expert system asks to user “Did the vehicle collide with pedestrian on median or sidewalk or shoulder or lay-by?” If the user answers with “YES”, the expert system does not ask any other question to the user. However, if the user answers as “NO” the expert system asks the question to the user through flowchart as “Was the vehicle on the wrong direction or entering a roadway with a no vehicle entry sign?”

5.1. Developing the Expert System with C# and Visual Studio .Net

C# programming language and visual studio .Net developing environment were used for the development of the TAES. C# is an object oriented programming language. The .Net development environment enables creating interactive visual user interfaces. Also, C# language enables compact, well designed, and object oriented structured programming.

5.2. The Visualization of the Expert System

In this part of this chapter, the visualization of the proposed expert system is scrutinized. The modules or displays are shown with their explanations in detail.

5.2.1. Selection of the Traffic Accident Type

The expert system investigate two types of traffic accidents such as, “vehicle – pedestrian” and “vehicle – vehicle”. In the first module of the program, the user should choose the type of accident which will be analyzed. Figure 5.1 shows the first module of the program.

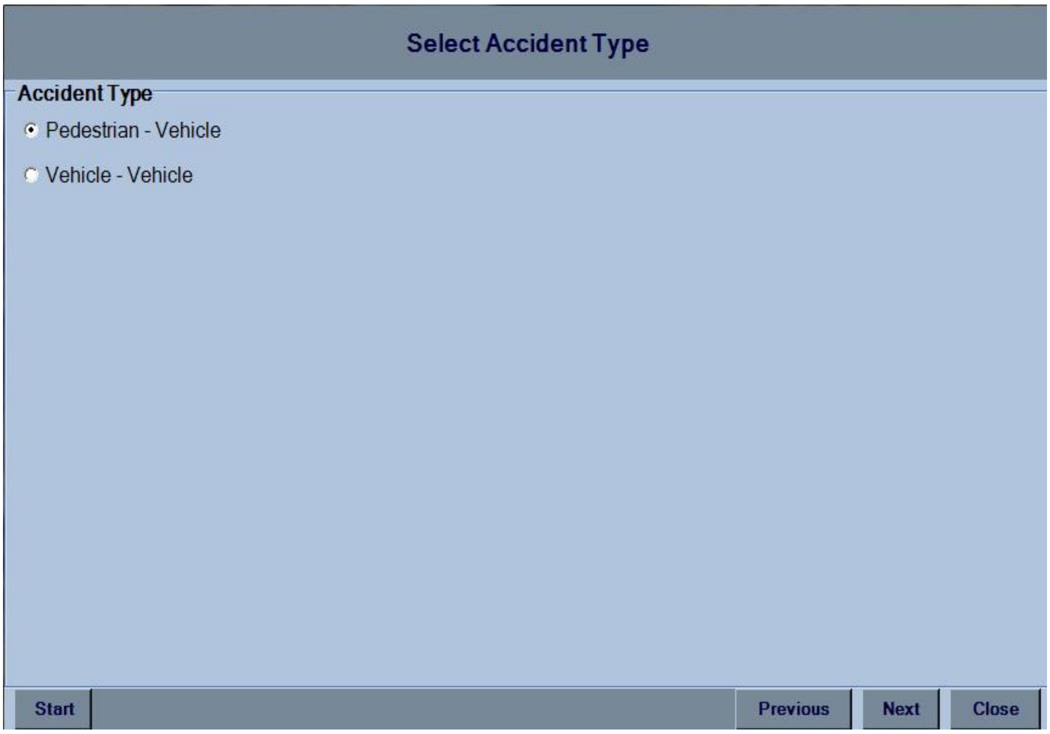


Figure 5.1 Selection of the accident type

5.2.2. Accident Information

After selecting accident type, in the second module of the program, information input about traffic accident takes place. Especially, the system asks to the user the location, accident date and time, the direction of the vehicle and also, the speed limit on the road. Figure 5.2 discloses the accident information module.

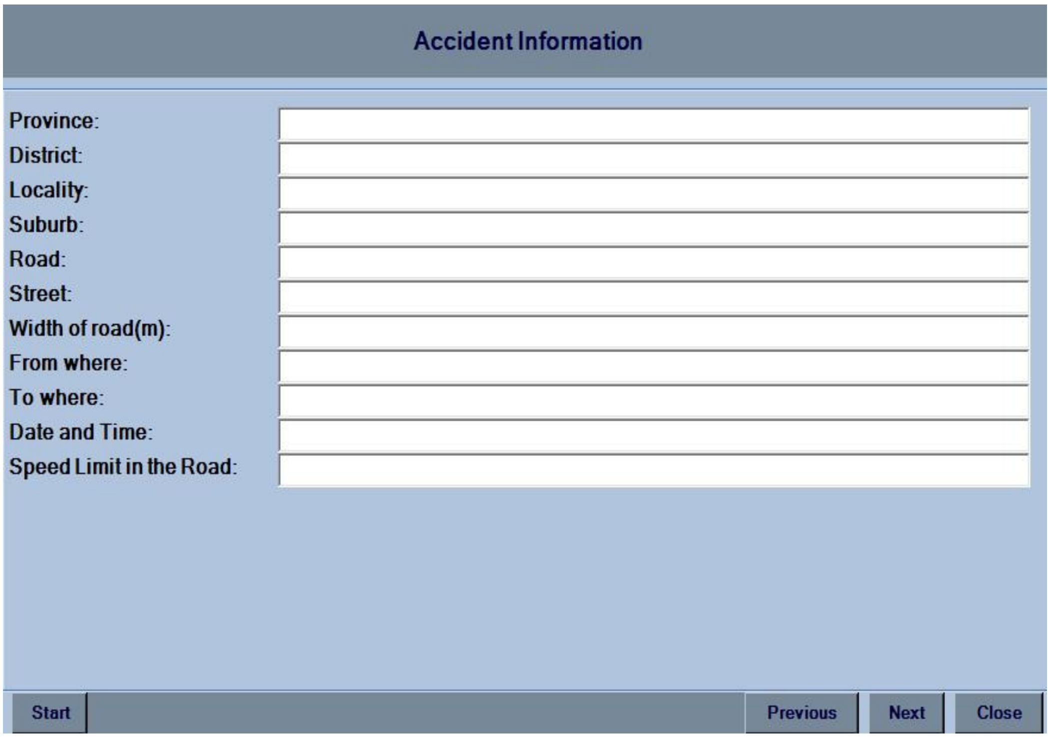


Figure 5.2 Accident information

5.2.3. Selection of the Traffic Accident Type for Pedestrians

When the type of accident is selected in first module, the other selection is done for pedestrians as on which location. That is to say, the expert system considers two types of pedestrian accidents such as, on zebra crossings or intersections and on straight roads. The third module of the program defines the type of pedestrian accidents. In fact, the system asks the user to choose accident type for pedestrians. Figure 5.3 presents the selection of traffic accident types for pedestrians.

Figure 5.3 Selection of traffic accident type for pedestrians

5.2.4. Pedestrian Information

The fourth module of the system asks the user information about the pedestrian. The user should enter the name, address, citizenship number, telephone number and direction of the pedestrian with reference to the vehicle's direction. Figure 5.4 visualizes the pedestrian information module.

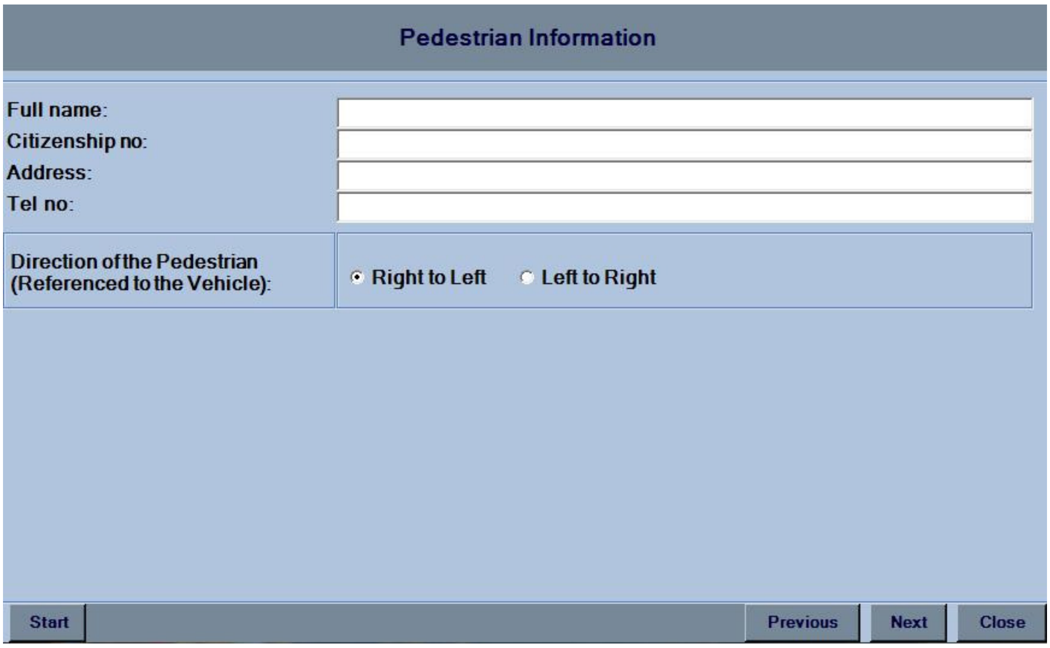


Figure 5.4 Pedestrian information

5.2.5. Driver and Vehicle Information

The fifth module of the program includes information about driver and vehicle. The user should enter the name, address, telephone number, citizenship number, licence number and class. Also, the user should enter the driver alcohol condition and driver speed at the accident moment. If the speed of the driver is not known, there is a choice that the user can select the speed of vehicle is unknown. In addition, this part of program consists of vehicle make and model, plate number and crash point on vehicle as well. Figure 5.5 shows the driver and vehicle information.

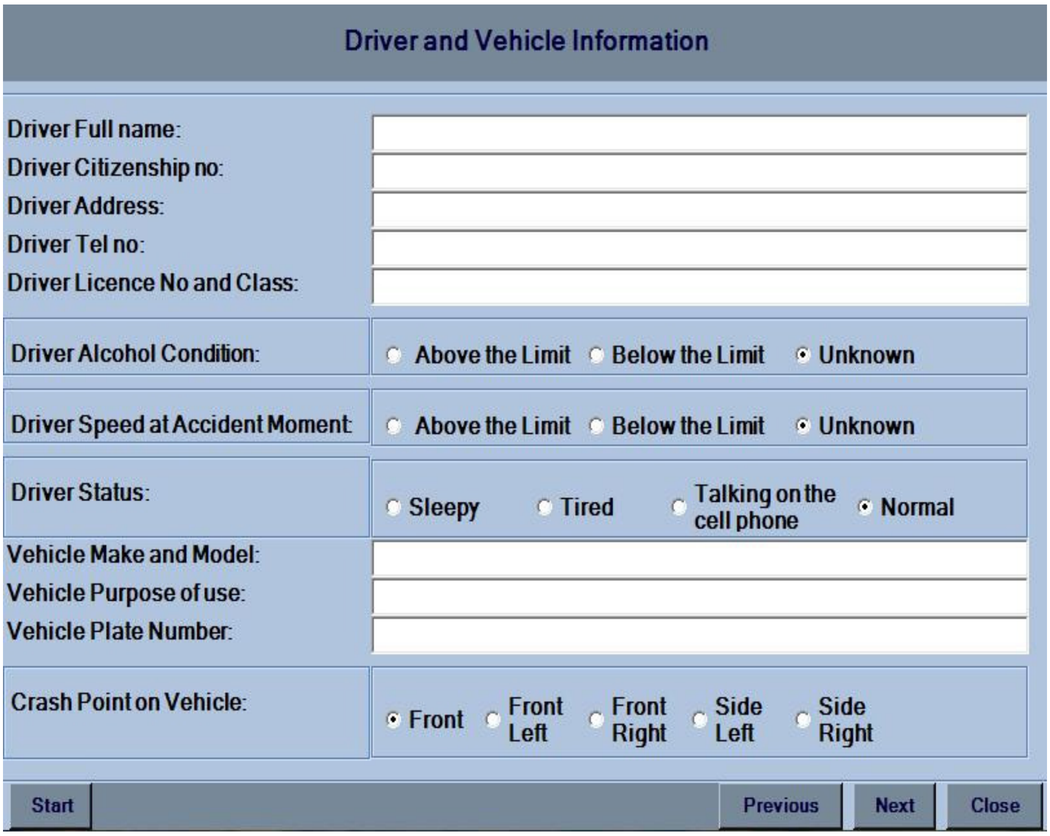


Figure 5.5 Driver and vehicle information

5.2.6. Result of the Accident

The sixth module of the program asks the user about the result of the accident. The user should define the severity of the damage for pedestrian as, light injury, severe injury, and fatality. Also, the user should identify the severity damage to the vehicle such as, negligible, minor, and major. The Figure 5.6 visualizes the results of the accidents in respect of injury severity.

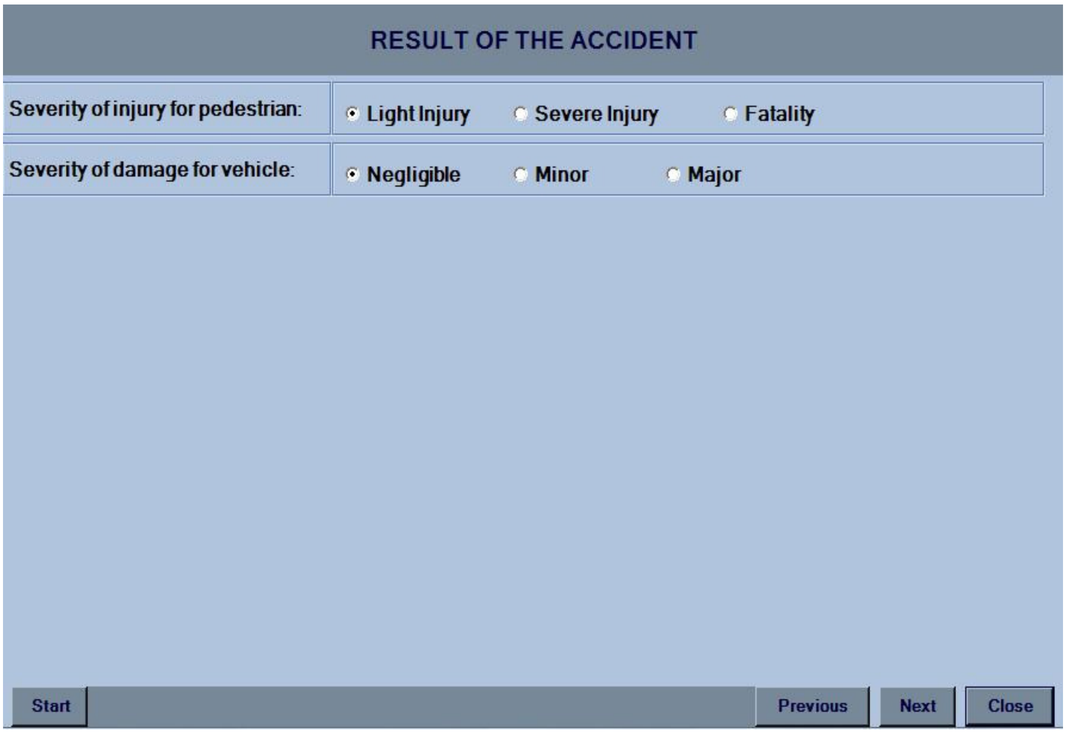


Figure 5.6 Result of the accident

5.2.7. Road and Environment Conditions

In this module of the expert system, the user should choose the road and environment conditions. The layout of the road can be chosen as divided or undivided. Also, the total number of lanes can be selected as one lane, two lanes, three or four lanes, and more than four lanes as well. In addition, the operation type of the road is defined as one way or two way. If there are traffic signals on the road, the user can select the signal button. Moreover, three types of roads are introduced within the context of this expert system. These roads are access road, collector road and main arterial. Furthermore, the time of the day is an important issue while evaluating fault rates. This issue is considered as three choices such as, daytime, night time (street lighting), and night time (dark). In addition to the factors taken into account above, weather condition of the accident day influences the accident severity and fault rates. Clear, foggy, and rainy or snowy choices are presented. Two types of road surfaces, stabilized and paved are introduced. Another issue considered in this module is road surface condition. Dry, wet, and snowy or icy can be selected. Finally, whether there is a lay by for bus stop or not is a critical point which should be considered. All the road and environment conditions are selected by user. Figure 5.7 visualizes the road and environment conditions.

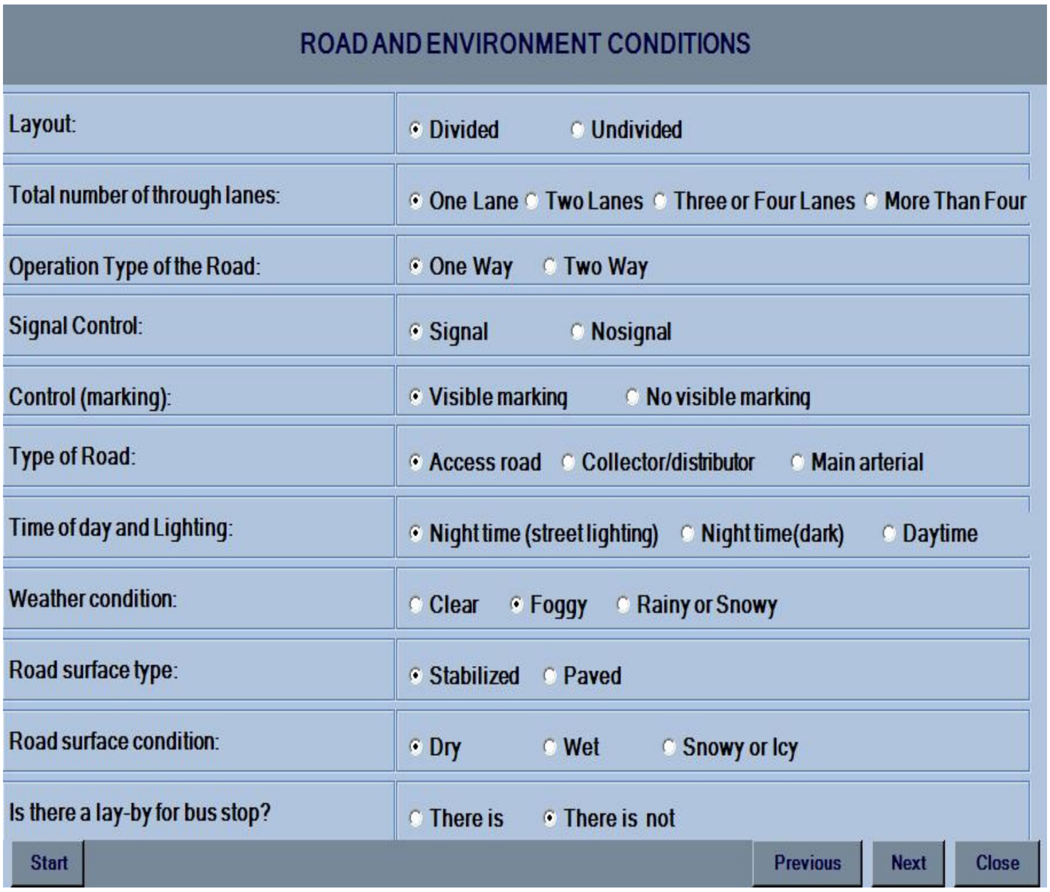


Figure 5.7 Road and environment conditions

5.2.8. Questions

The system asks the questions to the user through flowcharts which were developed for each type of traffic accident. In fact, as stated previously, there are some conditional questions in the program. The system asks the forthcoming question by considering previous question. The user has basically two options and for some questions three options to select. These are Yes, No, and for some cases Unknown. The Figure 5.8 presents the one of the questions module.

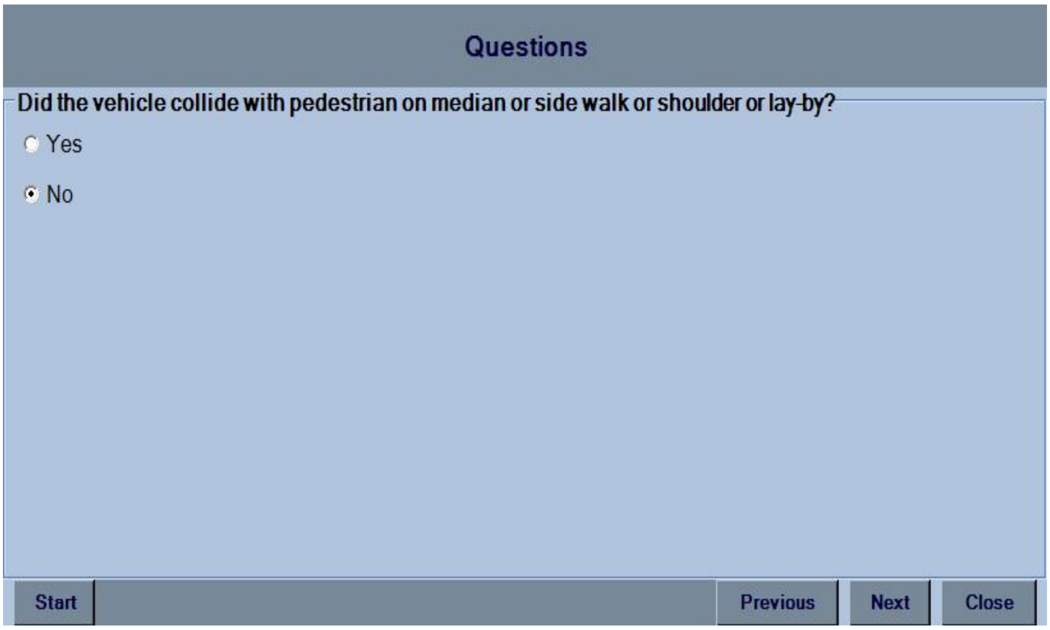


Figure 5.8 One of the questions

5.2.9. Final and Reporting

This is the last part of the computer program. In this part, the user can see the results of the accident scenario. In fact, there is a report button on the bottom right of this display. When this button is pressed by the user, the report is recorded and opened a Microsoft Word document. In this report, the system quantifies the fault rates of each part involved in an accident. Moreover, this report covers all the information about accident, road and environment conditions, driver and pedestrian information as well. This report in its conclusion section includes the driver and pedestrian faults in respect of laws and regulations. Figure 5.9 shows the final and reporting display of the system.

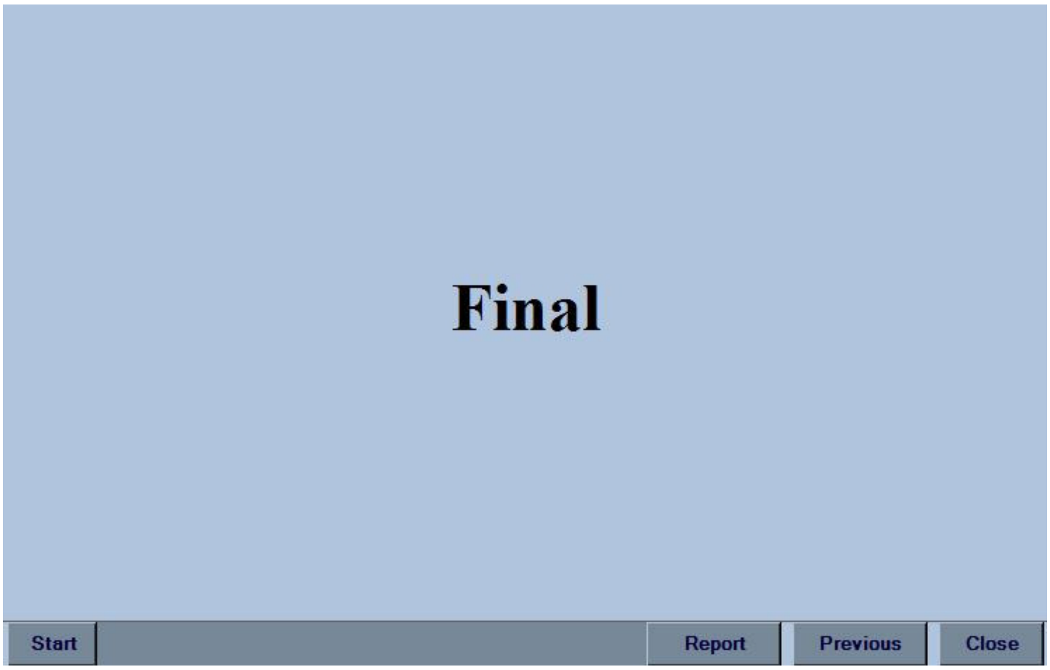


Figure 5.9 Final and reporting display

5.3. The Reporting System in Expert System

When the fault rates are determined, the explanation of how this result is achieved is executed by explanation facility in the expert system. That is to say, the proposed expert system prepares a report explaining why these results are assigned. The report includes general information about traffic accident such as, location, time, weather condition, road environmental conditions and etc. Also, the report contains laws related to accident types and violations. The real case studies of the "vehicle – pedestrian" type of traffic accidents are applied to the expert system. The reports and the comparison of the fault rates between expert system reports and real expert-witness reports for these cases are introduced in next part of this chapter.

5.4. Verification of Fault Rates with TAES

In this part of this chapter, the expert system was tested with real accident cases and it is understood that results are quite consistent. The comparison of fault rates with expert-witness reports and the proposed expert system is shown in Table 5.1. There are ten different accidents compared. An example of accident report given by the expert system is disclosed in Appendix E. Many real accident cases from expert-witness reports were tried in the expert system and similar results were obtained.

Table 5.1 The comparison of the fault rates

		Expert witness reports	TAES(Traffic Accident Expert System)
ACCIDENT 1	Driver	40	40
	Pedestrian	60	60
ACCIDENT 2	Driver	15	20
	Pedestrian	85	80
ACCIDENT 3	Driver	40	45
	Pedestrian	60	55
ACCIDENT 4	Driver	40	40
	Pedestrian	60	60
ACCIDENT 5	Driver	40	40
	Pedestrian	60	60
ACCIDENT 6	Driver	40	20
	Pedestrian	60	80
ACCIDENT 7	Driver	50	55
	Pedestrian	50	45
ACCIDENT 8	Driver	25	35
	Pedestrian	75	65
ACCIDENT 9	Driver	15	20
	Pedestrian	85	80
ACCIDENT 10	Driver	60	70
	Pedestrian	40	30

For the first real accident case, the experts were assigned 37.5% for driver and 62.5% for pedestrian. When looked at the expert system results it is seen that results are 35% and 65% for driver and pedestrian respectively. That is to say, the results are quite similar.

Also, for the second case, the experts were assigned 12.5% for driver and 87.5% for pedestrian. When focused on the expert system results, 18% and 82% for driver and pedestrian respectively. It is understood that results are similar. This shows the consistency of the proposed expert system.

To sum up, as it can be understood from the above the result fault rates of the expert system are similar with experts. Finally, the Traffic Accident Expert System is fruitful for the quantification of fault rates.

CHAPTER 6

CONCLUSION AND RECOMMENDATIONS

In this chapter, general conclusions are presented. Also, this chapter reviews the most important results in the Traffic Accident Expert System. Finally, ideas for possible future research in this field are discussed.

The usual studies are mostly related with accident prevention models. However, after the traffic accidents happen, assigning fault rates has critical importance. For this purpose, the main theme of this study is to develop an expert system for the quantification of fault rates in traffic accidents.

In the previous chapters and in the attachments, the results obtained from the research were discussed. A detailed literature review was performed to define the determinants influencing the fault rates after the occurrence of traffic accidents. The critical factors influencing fault rates were evaluated within a quantitative approach in questionnaires. Flowcharts were developed for each type of traffic accidents in view of defined factors. Also, knowledge acquisition process for the proposed expert system was introduced as well.

The Traffic Accident Expert System was tested with real cases. In previous chapter, the fault rates assigned by TAES and experts were compared. It was seen that TAES's results are acceptable. TAES is based on the knowledge of experts. The most powerful specialty of TAES is the preparation of accident report. The accident report is prepared on the basis of traffic laws and regulations. It can be concluded that TAES is a favorable tool for quantification of fault rates in traffic accidents.

In conclusion, the main contribution of this expert system is that quantification of fault rates for each party involved in traffic accidents is more consistent and faster. In fact, contradictions while assigning fault rates are prevented by this system. Moreover, the explanation facility of this expert system, that is to say, report is an important feature of the proposed expert system.

As a future work, the proposed expert system may be implemented for the other types of traffic accidents which were not considered within the context of this study. Also, the cases which consider more than two vehicles involved in traffic accidents can be taken into account.

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APPENDIX A

TRAFFIC ACCIDENT STATISTICS

Table 2.1 Traffic accident results in Turkey

ACCIDENT AND VICTIMS OF ACCIDENTS			2003	2007
ACCIDENT	POLICE, SGD	**URBAN**	373.531	665.458
		SUBURB	48.771	83.998
		TOTAL	422.302	749.456
	GENDARMERIE	TOTAL	33.365	76.127
	SUM TOTAL		455.667	825.583
DEATH	POLICE, SGD	**URBAN**	973	1.219
		SUBURB	1.845	2.240
		TOTAL	2.818	3.459
	GENDARMERIE	TOTAL	1.148	1.545
	SUM TOTAL		3.966	5.004
INJURED PERSONS	POLICE, SGD	**URBAN**	59.355	96.081
		SUBURB	35.969	53.050
		TOTAL	95.324	149.140
	GENDARMERIE	TOTAL	33.365	39.243
	SUM TOTAL		128.689	188.383
ECONOMIC LOSS YTL	POLICE, SGD	**URBAN**	326.826.637	988.492.982
		SUBURB	141.508.999	358.251.470
		TOTAL	468.335.636	1.346.744.452
	GENDARMERIE	TOTAL	66.873.083	213.665.210
	SUM TOTAL		535.208.719	1.560.409.662

Table 2.5 Fault Rates of Traffic Accidents in 2007

Factor of accident	URBAN		SUBURB		TOTAL	
	Number of fault	%	Number of fault	%	Number of fault	%
Driver	733.701	98.23	174.637	98.06	908.338	98.19
Pedestrian	12.288	1.65	1.651	0.92	13.939	1.51
Vehicle	247	0.03	993	0.57	1.240	0.13
Road	384	0.05	418	0.23	802	0.09
Passenger	329	0.04	393	0.22	722	0.08
TOTAL	746.949	100,00	178.092	100,00	925.041	100,00

APPENDIX B

AN EXAMPLE CASE (5) FROM FIRST PART OF THE QUESTIONNAIRE

ROAD AND ENVIRONMENT CONDITIONS

		Driver	Pedestrian
Type of Road	Access road		
Type of Road	Collector/distributor		
Type of Road	Main arterial		

Time of day and Lighting	Night time (street lighting)		
Time of day and Lighting	Night time(dark)		
Time of day and Lighting	Daytime		

Weather condition	Clear		
Weather condition	Foggy		
Weather condition	Rainy or Snowy		

Road surface type	Stabilized		
Road surface type	Paved		

Road surface condition	Dry		
Road surface condition	Wet		
Road surface condition	Snowy or Icy		

Sign Control	Sign		
Sign Control	No sign		

Control (marking)	Visible marking		
Control (marking)	No visible marking		

Was the zebra adjacent to bus stop?	Yes		
Was there a lay-by for bus stop?	Yes		

Was the zebra adjacent to bus stop?	Yes		
Was there a lay-by for bus stop?	No		

Was the zebra adjacent to bus stop?	No		
Was there a lay-by for bus stop?	No		

Was the rightmost lane reserved for parked vehicles?	Yes		
Was there any parked vehicle on the rightmost lane?	Yes		

Was the rightmost lane reserved for parked vehicles?	Yes		
Was there any parked vehicle on the rightmost lane?	No		

Was the rightmost lane reserved for parked vehicles?	No		
Was there any parked vehicle on the rightmost lane?	Yes		

Was the rightmost lane reserved for parked vehicles?	No		
Was there any parked vehicle on the rightmost lane?	No		

ACCIDENT DATE & TIME

Type of Accident:	Vehicle – Pedestrian
Location:	Zebra Crossing on Urban Roads or Intersections

ROAD AND ENVIRONMENT CONDITIONS

Layout	Divided
Total number of through lanes	Three and more lane
Operation	One way
Signal Control	Signal

RESULT OF THE ACCIDENT

Severity of injury for pedestrian	Fatality
Severity of damage for vehicle	Minor

		Expert	
Did the vehicle collide with pedestrian on median or side walk or shoulder or lay-by?	Yes		Driver
			Pedestrian
Was the vehicle on the wrong direction or entering a roadway with a no vehicle entry sign?	Yes		Driver
			Pedestrian
Was the pedestrian before zebra crossing?	Yes		Driver
			Pedestrian
Did the driver violate traffic lights?	Yes		Driver
			Pedestrian
Did the pedestrian violate traffic lights?	Yes		Driver
			Pedestrian
Was the direction of pedestrian referenced to the vehicle Right to Left?	Yes		Driver
			Pedestrian
Was the crash point on vehicle Front-Middle?	Yes		

Was the direction of pedestrian referenced to the vehicle Right to Left?	Yes		Driver
			Pedestrian
Was the crash point on vehicle Front-Left?	Yes		

Was the direction of pedestrian referenced to the vehicle Right to Left?	Yes		Driver
			Pedestrian
Was the crash point on vehicle Front-Right?	Yes		

Was the direction of pedestrian referenced to the vehicle Right to Left?	Yes		Driver
			Pedestrian
Was the crash point on vehicle Side-Left?	Yes		

Was the direction of pedestrian referenced to the vehicle Right to Left?	Yes		Driver
			Pedestrian
Was the crash point on vehicle Side-Right?	Yes		

Was the direction of pedestrian referenced to the vehicle Left to Right?	Yes		Driver
			Pedestrian
Was the crash point on vehicle Front-Middle?	Yes		

Was the direction of pedestrian referenced to the vehicle Left to Right?	Yes		Driver
			Pedestrian
Was the crash point on vehicle Front-Left?	Yes		

Was the direction of pedestrian referenced to the vehicle Left to Right?	Yes		Driver
			Pedestrian
Was the crash point on vehicle Front-Right?	Yes		

Was the direction of pedestrian referenced to the vehicle Left to Right?	Yes		Driver
			Pedestrian
Was the crash point on vehicle Side-Left?	Yes		

Was the direction of pedestrian referenced to the vehicle Left to Right?	Yes		Driver
			Pedestrian
Was the crash point on vehicle Side-Right?	Yes		

Did the accident occur on the rightmost lane referenced to the vehicle's direction?	Yes		Driver
			Pedestrian

Did the accident occur on the middle lane referenced to the vehicle's direction?	Yes		Driver
			Pedestrian

Did the accident occur on the leftmost lane referenced to the vehicle's direction?	Yes		Driver
			Pedestrian

Was the speed of the vehicle above legal limit?	Yes		Driver
			Pedestrian

Was the speed of the vehicle below legal limit?	No		Driver
			Pedestrian

Did the pedestrian suddenly enter the road without checking the vehicular traffic?	Yes		Driver
			Pedestrian

Was the speed of the vehicle above legal limit?	Unknown		Driver
			Pedestrian
Was the pedestrian more than 20m from collision point?	Yes		

Was the speed of the vehicle above legal limit?	Unknown		Driver
			Pedestrian
Was the vehicle on the road after the collision?	No		
Was the pedestrian more than 20m from collision point?	Yes		

Was the speed of the vehicle above legal limit?	Unknown		Driver
			Pedestrian
Did the vehicle stop within 10m distance from collision point?	No		
Was the vehicle on the road after the collision?	No		
Was the pedestrian more than 20m from collision point?	Yes		

Was there any vehicle on the adjacent lanes?	No		Driver
			Pedestrian
Did the driver take precaution with steering maneuvers to avoid collision?	No		

Was there any vehicle on the adjacent lanes?	No		Driver
			Pedestrian
Did the driver take precaution with steering maneuvers to avoid collision?	Yes		

			Object
Were there any hazardous objects that cause the driver's maneuver in wrong manner?	Yes		Driver
			Pedestrian

APPENDIX C

AN EXAMPLE CASE (16) FROM SECOND PART OF THE QUESTIONNAIRE

ROAD AND ENVIRONMENT CONDITIONS

		Driver	Pedestrian
Type of Road	Access road		
Type of Road	Collector/distributor		
Type of Road	Main arterial		

Time of day and Lighting	Night time (street lighting)		
Time of day and Lighting	Night time(dark)		
Time of day and Lighting	Daytime		

Weather condition	Clear		
Weather condition	Foggy		
Weather condition	Rainy or Snowy		

Road surface type	Stabilized		
Road surface type	Paved		

Road surface condition	Dry		
Road surface condition	Wet		
Road surface condition	Snowy or Icy		

Sign Control	Sign		
Sign Control	No sign		

Control (marking)	Visible marking		
Control (marking)	No visible marking		

Was the zebra adjacent to bus stop?	Yes		
Was there a lay-by for bus stop?	Yes		

Was the zebra adjacent to bus stop?	Yes		
Was there a lay-by for bus stop?	No		

Was the zebra adjacent to bus stop?	No		
Was there a lay-by for bus stop?	No		

Was the rightmost lane reserved for parked vehicles?	Yes		
Was there any parked vehicle on the rightmost lane?	Yes		

Was the rightmost lane reserved for parked vehicles?	Yes		
Was there any parked vehicle on the rightmost lane?	No		

Was the rightmost lane reserved for parked vehicles?	No		
Was there any parked vehicle on the rightmost lane?	Yes		

Was the rightmost lane reserved for parked vehicles?	No		
Was there any parked vehicle on the rightmost lane?	No		

ACCIDENT DATE & TIME

Type of Accident:	Vehicle - Pedestrian
Location:	Straight Roads

ROAD AND ENVIRONMENT CONDITIONS

Layout	Undivided
Total number of through lanes	Four lane
Operation	Two way
Signal Control	No signal

RESULT OF THE ACCIDENT

Severity of injury for pedestrian	Fatality
Severity of damage for vehicle	Minor

		Expert	
Did the vehicle collide with pedestrian on median or side walk or shoulder or lay-by?	Yes		Driver
			Pedestrian

Was the vehicle on the wrong direction or entering a roadway with a no vehicle entry sign?	Yes		Driver
			Pedestrian

Were there any zebra crossing / pedestrian bridge / pedestrian subway within 100m distance?	Yes		Driver
			Pedestrian

Was the direction of pedestrian referenced to the vehicle Right to Left?	Yes		Driver
			Pedestrian
Was the crash point on vehicle Front-Middle?	Yes		

Was the direction of pedestrian referenced to the vehicle Right to Left?	Yes		Driver
			Pedestrian
Was the crash point on vehicle Front-Left?	Yes		

Was the direction of pedestrian referenced to the vehicle Right to Left?	Yes		Driver
			Pedestrian
Was the Crash point on vehicle Front-Right?	Yes		

Was the direction of pedestrian referenced to the vehicle Right to Left?	Yes		Driver
			Pedestrian
Was the crash point on vehicle Side-Left?	Yes		

Was the direction of pedestrian referenced to the vehicle Right to Left?	Yes		Driver
			Pedestrian
Was the crash point on vehicle Side-Right?	Yes		

Was the direction of pedestrian referenced to the vehicle Left to Right?	Yes		Driver
			Pedestrian
Was the crash point on vehicle Front-Middle?	Yes		

Was the direction of pedestrian referenced to the vehicle Left to Right?	Yes		Driver
			Pedestrian
Was the crash point on vehicle Front-Left?	Yes		

Was the direction of pedestrian referenced to the vehicle Left to Right?	Yes		Driver
			Pedestrian
Was the crash point on vehicle Front-Right?	Yes		

Was the direction of pedestrian referenced to the vehicle Left to Right?	Yes		Driver
			Pedestrian
Was the crash point on vehicle Side-Left?	Yes		

Was the direction of pedestrian referenced to the vehicle Left to Right?	Yes		Driver
			Pedestrian
Was the crash point on vehicle Side-Right?	Yes		

Did the accident occur on the right lane referenced to the vehicle's direction?	Yes		Driver
			Pedestrian

Did the accident occur on the left lane referenced to the vehicle's direction?	Yes		Driver
			Pedestrian

Was the speed of the vehicle above legal limit?	Yes		Driver
			Pedestrian

Was the speed of the vehicle below legal limit?	No		Driver
			Pedestrian

Did the pedestrian suddenly enter the road without checking the vehicular traffic?	Yes		Driver
			Pedestrian

Was the speed of the vehicle above legal limit?	Unknown		Driver
			Pedestrian
Was the pedestrian more than 20m from collision point?	Yes		

Was the speed of the vehicle above legal limit?	Unknown		Driver
			Pedestrian
Was the vehicle on the road after the collision?	No		
Was the pedestrian more than 20m from collision point?	Yes		

Was the speed of the vehicle above legal limit?	Unknown		Driver
			Pedestrian
Did the vehicle stop within 10m distance from collision point?	No		
Was the vehicle on the road after the collision?	No		
Was the pedestrian more than 20m from collision point?	Yes		

Was there any vehicle on the adjacent lanes?	No		Driver
			Pedestrian
Did the driver take precaution with steering maneuvers to avoid collision?	No		

Was there any vehicle on the adjacent lanes?	No		Driver
			Pedestrian
Did the driver take precaution with steering maneuvers to avoid collision?	Yes		

			Object
Were there any hazardous objects that cause the driver's maneuver in wrong manner?	Yes		Driver
			Pedestrian

APPENDIX D

AN EXAMPLE CASE (9) FROM THIRD PART OF THE QUESTIONNAIRE

ROAD AND ENVIRONMENT CONDITIONS

		Driver	Pedestrian
Type of Road	Access road		
Type of Road	Collector/distributor		
Type of Road	Main arterial		

Time of day and Lighting	Night time (street lighting)		
Time of day and Lighting	Night time(dark)		
Time of day and Lighting	Daytime		

Weather condition	Clear		
Weather condition	Foggy		

Weather condition	Rainy or Snowy		

Road surface type	Stabilized		
Road surface type	Paved		

Road surface condition	Dry		
Road surface condition	Wet		
Road surface condition	Snowy or Icy		

ACCIDENT DATE & TIME

Type of Accident:	Vehicle - Vehicle
Location:	Head to head on rural roads

ROAD AND ENVIRONMENT CONDITIONS

Layout	Undivided
Total number of through lanes	Five or Six or more lane
Operation	Two way
Overtaking condition for vehicle A	Not prohibited
Overtaking condition for vehicle B	Not prohibited

RESULT OF THE ACCIDENT

Severity of damage for vehicle A	Major
Severity of damage for vehicle B	Major

		Expert	
Did the accident occur on the lanes adjacent to or next to middle lane marking?	No		Driver A
			Driver B
Did the accident occur on the lane on vehicle A's direction?	Yes		

Did the accident occur on the lanes adjacent to or next to middle lane marking?	No		Driver A
			Driver B
Did the accident occur on the lane on vehicle B's direction?	Yes		

Did the accident occur on the lanes adjacent to or next to middle lane marking?	**Yes**

Was the Crash point on the lane on vehicle A's direction?	**Yes**

Was the Crash point on vehicle A Front-Left?	Yes		Driver A
			Driver B
Was the crash point on vehicle B Front-Left?	Yes		

Was the crash point on vehicle A Front?	Yes		Driver A
			Driver B
Was the crash point on vehicle B Side-Left?	Yes		

Was the crash point on vehicle A Side-Left?	Yes		Driver A
			Driver B
Was the crash point on vehicle B Front?	Yes		

Was the crash point on vehicle A Front?	Yes		Driver A
			Driver B
Was the crash point on vehicle B Front?	Yes		

Was the crash point on vehicle A Front-Right?	Yes		Driver A
			Driver B
Was the crash point on vehicle B Front-Right?	Yes		

Was the crash point on the lane on vehicle B's direction?	**Yes**

Was the crash point on vehicle A Front-Left?	Yes		Driver A
			Driver B
Was the crash point on vehicle B Front-Left?	Yes		

Was the crash point on vehicle A Front?	Yes		Driver A
			Driver B
Was the crash point on vehicle B Side-Left?	Yes		

Was the crash point on vehicle A Side-Left?	Yes		Driver A
			Driver B
Was the crash point on vehicle B Front?	Yes		

Was the crash point on vehicle A Front?	Yes		Driver A
			Driver B
Was the crash point on vehicle B Front?	Yes		

Was the crash point on vehicle A Front-Right?	Yes		Driver A
			Driver B
Was the crash point on vehicle B Front-Right?	Yes		

Was the speed of the vehicle A above legal limit?	Yes		Driver A
			Driver B

Was the speed of the vehicle B below legal limit?	Yes		Driver A
			Driver B

Did the vehicle A have proper light equipment?	No		Driver A
			Driver B

Did the vehicle B have proper light equipment?	No		Driver A
			Driver B

APPENDIX E

AN EXAMPLE OF ACCIDENT REPORT

1. ACCIDENT DETAILS

Type of Accident: Vehicle - Pedestrian

Location: Straight Roads

Date of Accident: 02.10.1995 – 09:30

LOCATION:

Province: Ankara
District: Yenimahalle
Locality:
Suburb:
Road: İvedik
Street:

2- PEDESTRIAN INFORMATION

Full Name: Yaşar Ulutaş
Citizenship Number: Unknown
Pedestrian Address: Unknown

Pedestrian Telephone Number: Unknown

3-DRIVER INFORMATION

Driver Full Name: Hüseyin Gökoğlu

Driver Citizenship Number: Unknown

Driver Address: Unknown

Driver Telephone Number: Unknown

Driver Licence No and Class: Unknown

Alcohol Condition: Unknown

4- VEHICLE INFORMATION

Vehicle Model: Missing Data

Vehicle Purpose of Use: Unknown

Driver Status: Normal

Vehicle Plate Number: 06 V 7575

5- ROAD AND ENVIRONMENT CONDITIONS

Layout: Divided

Total number of through lanes: Three or Four Lanes

Operation: One Way

Signal Control: There isn’t any

Road Surface Type: Paved

Road Surface Condition: Wet

Time of Day and Lighting: Day time

Weather Condition: Clear

6- RESULT OF THE ACCIDENT

Severity of injury for pedestrian: Fatality
Severity of damage for vehicle: Negligible

7- DETERMINED ISSUES AND ASSESSMENT

QUESTION CHECK LIST

Did the vehicle collide with pedestrian on median or side walk or shoulder or lay-by? : NO

Was the vehicle on the wrong direction or entering a roadway with a no vehicle entry sign? : NO

Did the pedestrian suddenly enter the road without checking the traffic? : YES

Was there any vehicle on the adjacent lanes? : NO

Did the driver take precaution with steering maneuvers to avoid collision? : YES

Was the pedestrian far than 20m from the collision point? : NO

Was the vehicle on the road after the collision? : YES

Did the vehicle stop within 10m distance from collision point? : YES

Were there any hazardous objects that cause the driver's maneuver in wrong manner? : NO

Was there any zebra crossing/pedestrian bridge/pedestrian subway within 100m distance? : NO

Driver Faults:

According to The Highway Traffic Law No 2918 and item 52 b) The driver must adjust the driving speed according to the road properties, weather conditions, traffic density and traffic signs.

Pedestrian Faults:

According to The Highway Traffic Law No 2918 and item 68 b) The pedestrians must consider the distance and speed of the oncoming vehicles.

Fault Rates:

Pedestrian Fault Rate: 65% - 5,04 (8)

Driver Fault Rate: 35% - 2,96 (8)

Road Fault Rate: 0% - 0 (8)