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PROTOTYPE WEB-BASED EXPERT SYSTEM FOR OPTIMIZING THE ROAD NETWORK OF DEVELOPING COUNTRIES

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Abstract

Traffic road users encounter numerous problems while travelling on roads. Expected problems can range from mildly disruptive to catastrophic events. When attempting to optimize a road network and alleviate problems, it is vital to select appropriate solutions. This paper defines prototype web-based expert knowledge system improvement that can be utilized to optimize the road network of developing countries. Deciding on appropriate controlling measures is a crucial task because expected problems range from mildly disruptive to catastrophic. Experts can provide solutions to these problems only by using their previous experience. The ultimate task in optimizing road network problems is to select appropriate solutions. Although experts can regulate and resolve these problems by means of their silent knowledge and experience, novice engineers cannot, but expertise transfer from experts to novices is challenging in the traffic road area. Therefore, this body of knowledge needs to be stored in a computer system. Identifying the causes of traffic problems and applying appropriate actions and solutions to these problems could help control or prevent them. Therefore, the web-based expert system for optimizing the road network of developing countries that was developed in this study, Expert System to Control Problems in Traffic (TRSys), is a method concept. Knowledge was provided in the form of rules and coded in software through PHP programming. Web pages supporting the user interface were produced using a framework made up of HTML, CSS and J-Query. TRSys was verified and validated with extensive testing methods. Unit and integrated testing were performed during coding to correct the code and ensure that each unit performs its function and that all units work together correctly and efficiently.

Keywords: Expert System; Prototype system; Traffic road and road network.

1. Introduction

Roads are a vital infrastructural element in the economy of all nations and all commercial, as well as many social activities, depend on them. At the same time, roads are also locations where many human deaths and crash injuries take place. Road accidents threaten to individuals and health systems, especially in developing countries. While these countries account for slightly less than half of the world's motor-powered vehicles, more than nine-tenths of the 1.3 million road deaths each year occur in these countries [1].

Traffic on roads does not just include private motorized vehicles: it also includes pedestrians, animals and mass transit vehicles like buses and tramcars that use public roads to travel from one place to another. Based on studies by Singh et al. [2], while traffic laws administrate traffic and control vehicles, road rules consist of both formal legislation and informal rules established over time ensuring that traffic flows in a disciplined, efficient and safe manner.

The traffic system in all developing countries has been described as the most chaotic in the world. This is because the population of these countries force the roads to undergo higher physical stress, resulting in financial losses for the users, due to poor road infrastructure. Thus far, there seems to be no permanent solution to this problem, at least for the hazards it causes within the short and medium timeframe. However, numerous approaches and strategies have been adopted with the appropriate programs that force multilateral lenders to provide solutions for improving traffic situations. Some improvement has also been made towards reducing traffic congestions from a different point of view. There are also solutions offered by ordinary citizens and vehicle operators. As such, this study will combine these solutions in order to ensure that the focus is unidirectional. The focus is on how to reduce traffic jams.

Because vehicles are moving in many directions towards different destinations, vehicles often come into conflict with other vehicles and pedestrians. This can occur when their paths intersect and thus they may obstruct each other's progress. One issue that arises in these situations is: who has the "right of way", or the right to go first? Rules of "right of way" establish who has the right to use contested first [3]. The road traffic expert system described below was designed to help resolve conflicts such as these.

2. Reasons for using Expert System

An ES is no substitute for a knowledge worker's overall performance of the problem-solving task. But these systems can dramatically reduce the amount of work the individual must do to solve a problem, and they do leave people with the creative and innovative aspects of problem solving.

Some of the reasons for using expert system of expert systems are:

- Reliable solutions.
- Non-expert personnel can solve problems requiring some capability.
- Solutions attained more quickly.
- Achievement of more dependable resolutions.
- Cost reduction.

- Human experts not needed.
- Wider access to information.
- Elimination of uncomfortable and monotonous operations.

3. Development of TRSys Prototype

This section focuses on the description of different parts of the traffic road expert system together with task analysis, knowledge acquisition, knowledge base, building tool and TRSys user interface.

3.1. Task analysis

According to Basri [4], task analysis is "a methodological tool that can be used to describe the functions of expert performance in problem-solving and to determine the relationship of each task to the overall job". An expert system developer must first establish that the problem is an appropriate one to be tackled with the use of expert system technologies and that is previously unresolved to the client's satisfaction by any other more conservative method, for example by modelling, databases or decision support. Analysis results are then used to decide on the strategy, methodology and techniques that should be used to develop a prototype. TRSys is a knowledge-based expert system designed to optimize the use of the road network in developing countries. It comprises numerous varied tasks, each of which, has one or more sub-tasks, hence forming the foundation of the knowledge-based modules structuring the entire system's components.

The decision required the following characteristics, which indicate that the cognitive system application would be appropriate to reduce the optimizing the road network generated from the population:

- Has to address the problem of optimizing the road network at the international level and specifically by experts in many cases with the passage of time.
- The number and availability of experts are limited, so that capture of and access to, their expertise would be valuable and there is a need for the experts to spend their time and efforts on other problems.
- At least one expert exists who has a sufficient level of expertise and experience in solving the problem to be represented by the Knowledge-Based System. The expert has considered multiple cases under varying circumstances and is capable of articulating the important concepts in solving the target problem.
- There is some agreement among experts regarding approaches to and criteria for problem-solving for his application.
- The scope of the problem can be compartmentalized, limited and incremental development of the Knowledge-Based System is possible.

Integrating the optimizing the road network with the knowledge and build a system to limit the rise in traffic congestion and reduce air pollution and noise involves many multi-tasking. Each of these tasks has one or more sub-tasks that formed the basis of the existing units, which consists of knowledge of the integrated system components.

3.2. Knowledge acquisition

The first stage is knowledge acquisition, which can be the most challenging and time-consuming task in the development of an expert system [4, 5]. As a knowledge engineer, it is essential to obtain a good understanding of the domain in order to improve the building of the prototype with respect to its feasibility and evaluation [4]. Gaining skilled engineering knowledge can be regarded as the first step for the expertise engineer. Regard to areas of congestion, air pollution and noise from historical knowledge and to estimate the lifestyle price cycles of the few best administrative practices. Significant sources of materials include the following:

- Reviewing material in textbooks, guidelines and documented evidence on methodologies for the development of an expert system and the impact of the optimizing the effects of road network at peak times and other times [5].
- Participation in seminars and national and international conferences covering various topics such as transportation, traffic congestion, environmental pollution and management of transport and communications in general.
- Familiarizations with multiple analysis techniques with different applications and standards.
- Reviewing the architecture of various expert systems that have been developed in a range of different fields.
- Review of existing knowledge on developing an expert system on various topics related to the management of the transport and communication system model.
- Reconsideration of multiple criteria using different analysis techniques and methodologies, data entry, data analysis and ease of use.

An expert system is a computer program representing some specialist subject's knowledge source, which can be drawn upon in resolving problems or providing guidance or advice. The building expert systems process is occasionally known as knowledge engineering and the professional concerned with all components of an expert system is a knowledge engineer. Building an expert system is generally a time-consuming iterative process. As stated by Saba et al. [6], the refining of components and their interactions over the course of the knowledge engineer numerous meetings with the experts and the user. A proposed expert system of the general structure is set out in Fig. 1.

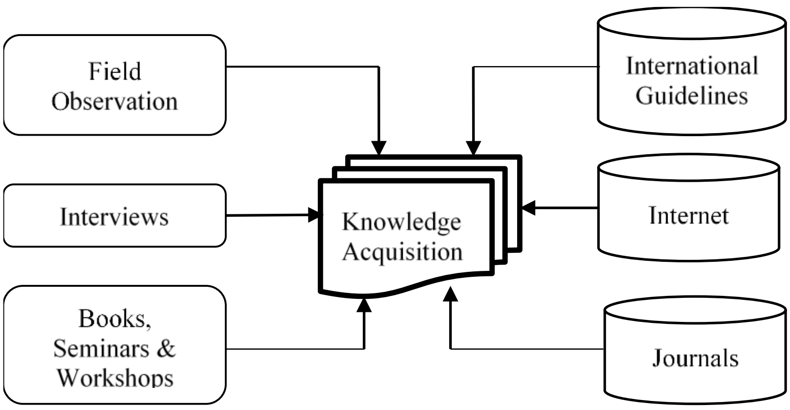


Fig. 1. Knowledge acquisition flow diagram.

3.3. Selection of the building tool

Web-based expert system development is fundamentally reliant on end-user interface Graphical User Interface (GUI) and server site programming (specifically the site at which, the knowledge-based rules are a programming task) designs [7]. An expert system construction tool for computer programming setting and the use of language by the knowledge engineer or computer programmer when building the expert system. The design of interfaces utilizing a framework comprising HTML, CSS and J-Query. Furthermore, a responsive web interface to facilitate browsing from mobile devices is guaranteed by utilizing the Bootstrap framework. On the server side, the extraction of data from the web page is administered by a proxy or agent process. This execution of processing on the server side utilizing PHP, high-level programming and scripting language that is user-friendly and does not necessitate broad knowledge of object-oriented programming that is essential when utilizing C++, C# or Java. According to Milad et al. [8], the relational database utilized in storing the attained knowledge is MySQL, a patented, modified entry-level SQL employment that has the capacity and tools to simplify building operations and build expert systems, thereby making the process cost-effective. Moreover, it can help in many areas, such as knowledge acquisition [9]. The primary software tools for developing an expert system can be classified as follows:

- Programming language;
- Expert system shells;
- Tools used in an artificial environment.

3.4. Knowledge representation

An expert system uses the knowledge gained in a symbolic representation in order to deal with it in an automated manner. In this study, Microsoft PHP is used for the construction of the proposed expert system.

This study's proposed method is an expert system development in detecting problems and providing a users' guide through a process of diagnosis. Information on these problems/challenges can be characterized in the form of rules. Traffic studies on the roads, when road security issues are raised, the experts and engineers' roles in collecting the necessary information on the issue as the next step is the decision-making process. Logic arises from the information provided and then continues forward with it. This approach depends on the relation IF-THEN. That is if a situation matches the IF condition in a general rule, the procedures on the THEN side should be applied. This process can be modelled as IF (the case), THEN (the conclusion). Rules can be assembled by employing terms of connectivity, including OR and others to form a combined rule or the rule for the vehicle [7].

3.5. Graphical user interface

A graphical user interface offers a means for humans to interact with a machine. User interface collects the information needed by the machine to complete the decision-making process by querying the user in responding to questions or providing additional specific information. A well-designed user interface is of great benefit to users because reduces the time required for users familiarise themselves with the system and it has the capacity in reducing the occurrence of mistakes while using the expert system. Microsoft PHP was the platform used to build the expert system: it is necessary for developers to generate several items or pages in the PHP environment. Figure 2 exemplifies the design window illustrations [10].

Traffic Roads System (TRSys) graphical user interface is pleasant and easy to use. Clarity and attractiveness can facilitate the utilization of the system. The design consists of a few controls such as text boxes, groups, buttons, with labels, option buttons, drop-down menus, image, video command boxes and box buttons [9].

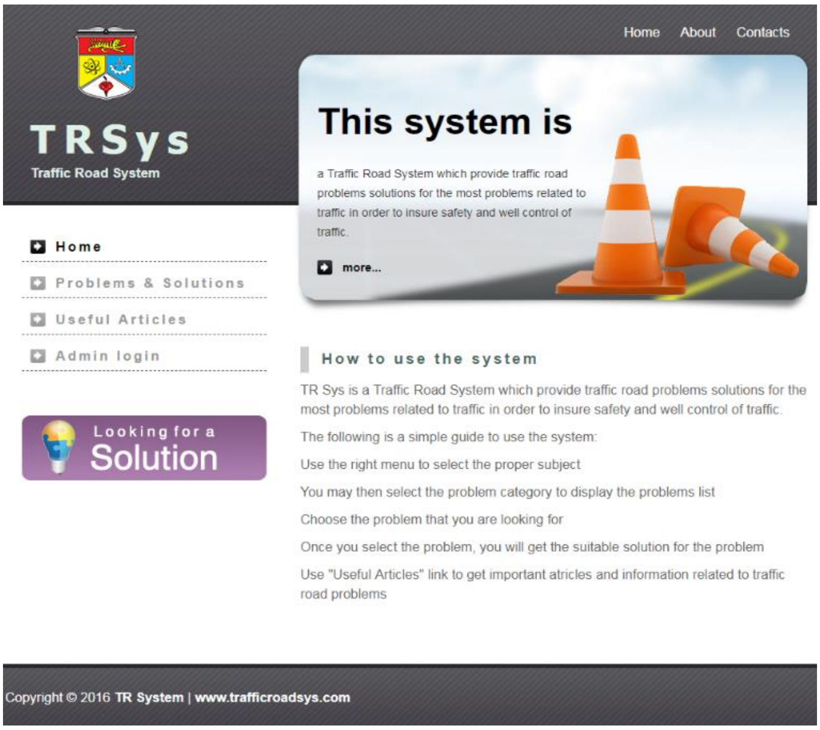


Fig. 2. A screenshot of the main menu.

3.6. Problems selection toolbox with solution

In the problems and solutions toolbox, a listing of 16 traffic road complications formerly defined are shown to users, as shown in Fig 3. On this page, users can select any of the difficulties met by searching through the list, or via a problem search by typing the name of the problem or by using a classification.

For example, if a problem is selected, users will be directed to the road traffic flow page in major road problems, as shown in Fig. 4, which describes the results and negative effects of traffic flow. Traffic flow conditions on the road network that occur due to increased usage of the road and it typically features slower speeds and longer time for the journey as well as an increase in queues for cars. It also can block full usage of roads in front or cause severe traffic congestion. When vehicles are held for an extended period in the traffic, it can result in the drivers being frustrated and engaging in road races. Figure 5 shows screenshots of solutions for road service on the road.

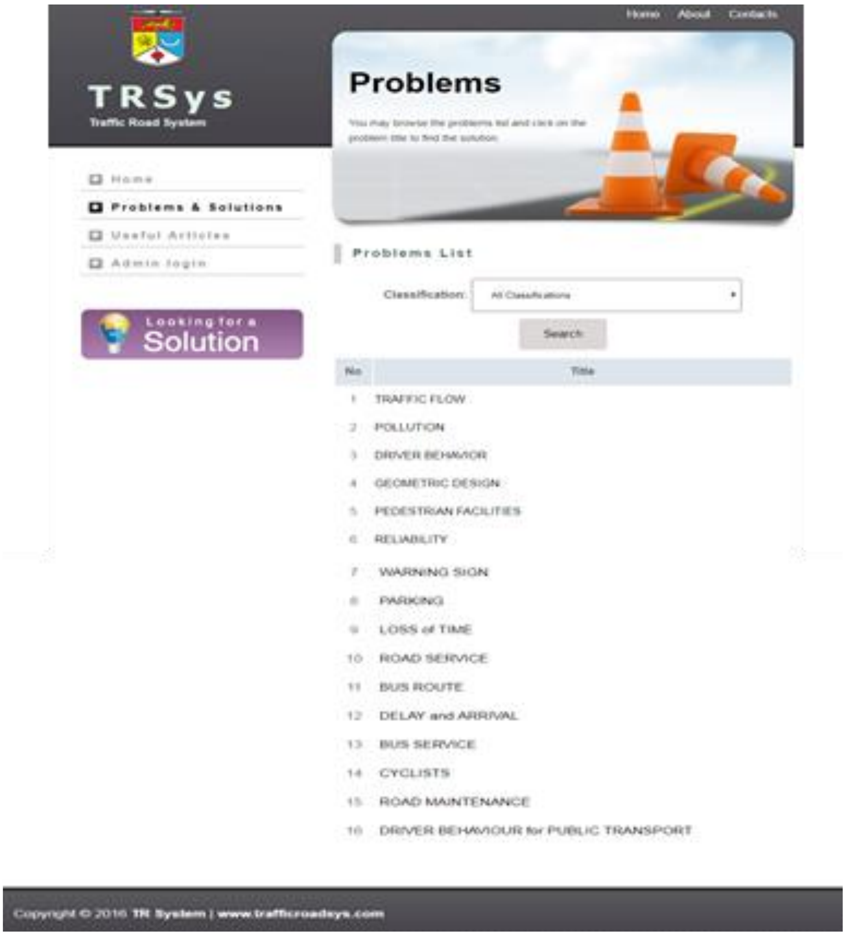
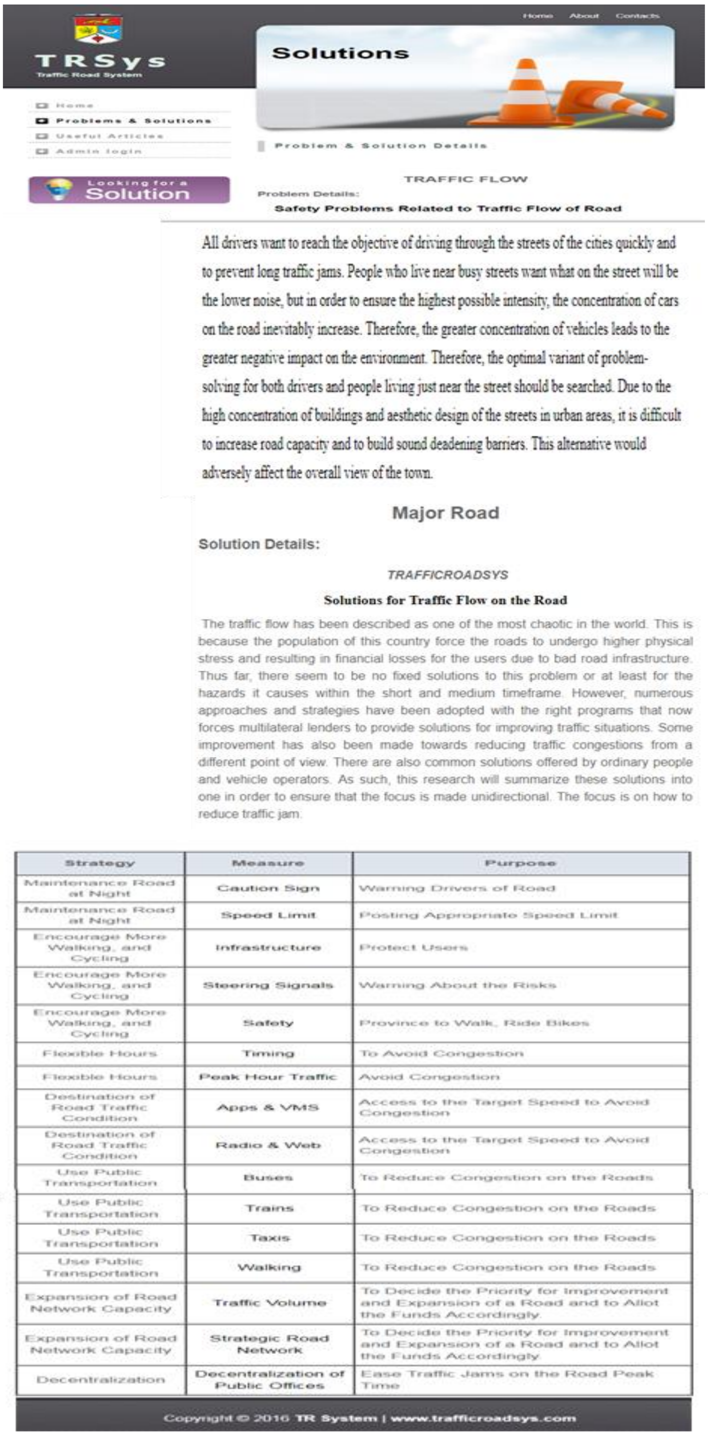


Fig. 3. Screenshot of the problems list.



TRSys
Traffic Road System

Home About Contacts

Solutions

- Home
- Problems & Solutions
- Useful Articles
- Admin login

Looking for a Solution

Problem & Solution Details

TRAFFIC FLOW

Problem Details:

Safety Problems Related to Traffic Flow of Road

All drivers want to reach the objective of driving through the streets of the cities quickly and to prevent long traffic jams. People who live near busy streets want what on the street will be the lower noise, but in order to ensure the highest possible intensity, the concentration of cars on the road inevitably increase. Therefore, the greater concentration of vehicles leads to the greater negative impact on the environment. Therefore, the optimal variant of problem-solving for both drivers and people living just near the street should be searched. Due to the high concentration of buildings and aesthetic design of the streets in urban areas, it is difficult to increase road capacity and to build sound deadening barriers. This alternative would adversely affect the overall view of the town.

Major Road

Solution Details:

TRAFFICROADSYS

Solutions for Traffic Flow on the Road

The traffic flow has been described as one of the most chaotic in the world. This is because the population of this country force the roads to undergo higher physical stress and resulting in financial losses for the users due to bad road infrastructure. Thus far, there seem to be no fixed solutions to this problem or at least for the hazards it causes within the short and medium timeframe. However, numerous approaches and strategies have been adopted with the right programs that now forces multilateral lenders to provide solutions for improving traffic situations. Some improvement has also been made towards reducing traffic congestions from a different point of view. There are also common solutions offered by ordinary people and vehicle operators. As such, this research will summarize these solutions into one in order to ensure that the focus is made unidirectional. The focus is on how to reduce traffic jam.

Strategy	Measure	Purpose
Maintenance Road at Night	Caution Sign	Warning Drivers of Road
Maintenance Road at Night	Speed Limit	Posting Appropriate Speed Limit
Encourage More Walking, and Cycling	Infrastructure	Protect Users
Encourage More Walking, and Cycling	Steering Signals	Warning About the Risks
Encourage More Walking, and Cycling	Safety	Province to Walk, Ride Bikes
Flexible Hours	Timing	To Avoid Congestion
Flexible Hours	Peak Hour Traffic	Avoid Congestion
Destination of Road Traffic Condition	Apps & VMS	Access to the Target Speed to Avoid Congestion
Destination of Road Traffic Condition	Radio & Web	Access to the Target Speed to Avoid Congestion
Use Public Transportation	Buses	To Reduce Congestion on the Roads
Use Public Transportation	Trains	To Reduce Congestion on the Roads
Use Public Transportation	Taxis	To Reduce Congestion on the Roads
Use Public Transportation	Walking	To Reduce Congestion on the Roads
Expansion of Road Network Capacity	Traffic Volume	To Decide the Priority for Improvement and Expansion of a Road and to Allot the Funds Accordingly
Expansion of Road Network Capacity	Strategic Road Network	To Decide the Priority for Improvement and Expansion of a Road and to Allot the Funds Accordingly
Decentralization	Decentralization of Public Offices	Ease Traffic Jams on the Road Peak Time

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Fig. 4. Screenshot of the traffic flow problems and solutions page.

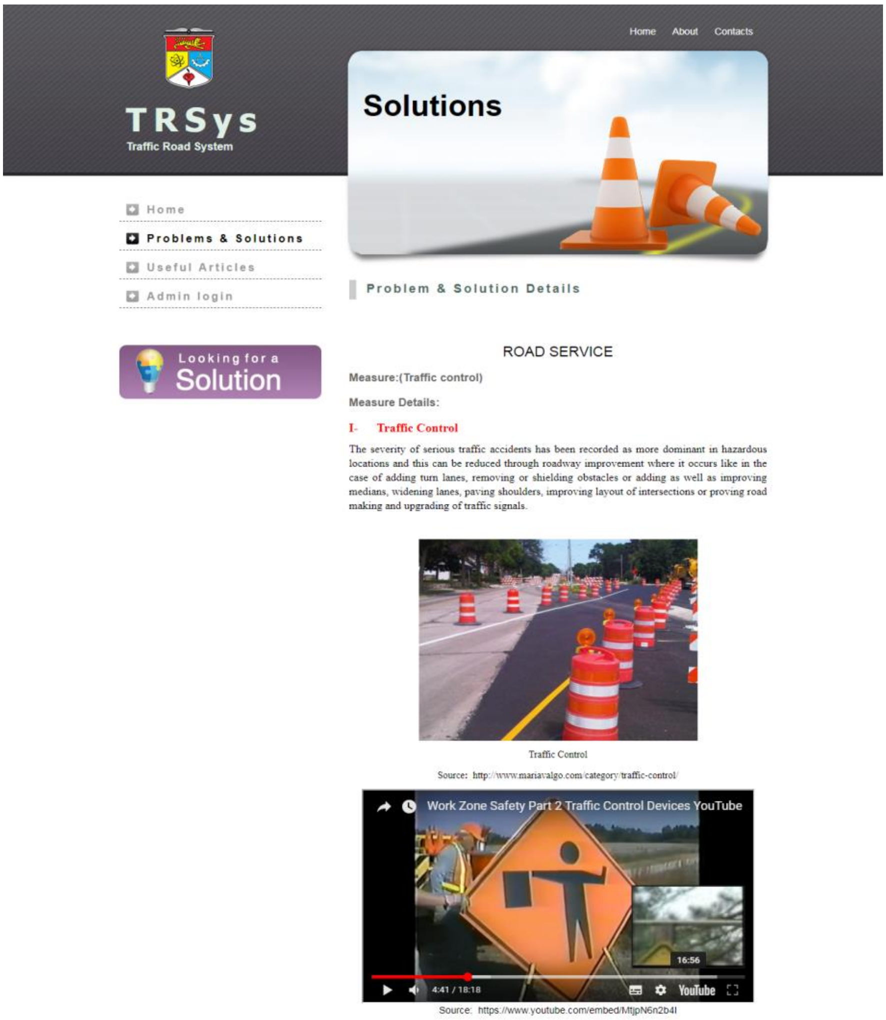

Fig. 5. A screenshot of the road service problems and solutions page.

4. Validation of System

For validation of the problem finding module, the output of TRSys must be compared with the answers of experts regarding the identical input. Input includes all traffic road problems. As described before, the answers obtained from the module for problem identification were qualitative rather than quantitative. For this reason, the answers of experts, including the proposed treatment, were sorted and compared with those recommended by the system. The number of similar answers regarding each sub-module was counted and the percentage of matching answers was calculated and is presented in Table 1. According to the results, the average percentage of matching was 79%, which shows the consistency and accuracy between the responses of experts and recommendations of TRSys.

Table 1. Matching percentage between the answers of evaluators and TRSys.

Sub-modules	Matching percentage between answers of TRSys and advice from experts				
	1st expert	2nd expert	3rd expert	4th expert	5th expert
Traffic flow	87%	75%	60%	78%	70%
Pollution	75%	90%	80%	100%	65%
Driver behaviour	85%	80%	77%	86%	95%
Geometric design	88%	85%	79%	70%	85%
Road service	80%	75%	60%	85%	70%
Pedestrian facilities	84%	85%	75%	88%	90%
Reliability	80%	70%	66%	60%	75%
Parking	82%	80%	70%	65%	75%
Loss of time	94%	80%	100%	90%	80%
Road maintenance	95%	85%	90%	80%	70%
Bus route	78%	70%	77%	55%	60%
Delay and arrival	88%	90%	80%	87%	60%
Bus service	78%	80%	75%	60%	65%
Cyclists	95%	95%	90%	87%	90%
Warning sign	84%	75%	80%	70%	90%
Average of percentage numbers			79%		

5. Evaluation of System

As presented by Aguilar et al. [11] and Mosqueira-Rey and Moret-Bonillo [12], evaluating expert systems is a complex assignment, but essential if the expert system is to be implemented. Evaluations are beneficial to determine in case an expert system meets its proposed objectives, by confirming that the system's accuracy integrating human proficiency with the high-tech decision-making process. Consequently, a significant factor in the evaluation process is that expert evaluators should be satisfied. The evaluation to test the level of user satisfaction with the TRSys was carried out by two groups of evaluators. The primary group comprised five domain experts, whereas the subsequent group comprised five computer engineers. Users appraised TRSys using a rating system, with a value of five indicating they were completely satisfied with the system. The group of specialists within the traffic engineering domain created a system verification mean value of (3.950) signifying (3.950/5) = (79%) satisfaction level that the system is functioning correctly. The group of computer scientists created a system evaluation mean value of (4.133); that is (4.133/5) = (83.0%) level of satisfaction. Our questionnaires' data was examined by means of an independent t-test over the sample space such that the t statistic value was (-0.809) with (12) degrees of freedom, with a p-value of (0.434). Consequently, there is no statistical difference between these groups of evaluators, at alpha=0.05. Furthermore, no significant difference between the groups was found for any of the individual questions, as shown in Table 2. Figure 6 sets out the mean values obtained for each item evaluated on the questionnaire: learnability, or the system application's capability authorising end-users learning how to work with the prototyping, Usefulness, Coverage of safety problems, Ease of use, Quick to run, User-friendliness, Learn-ability, correct codes and overall assessment [7].

Table 2. Responses for evaluation statistically by t-test.

Group	N	Mean	SD	t	DF	P value
TE	5	3.950	0.4243	-0.09	12	0.434
CE	5	4.133	0.4131			

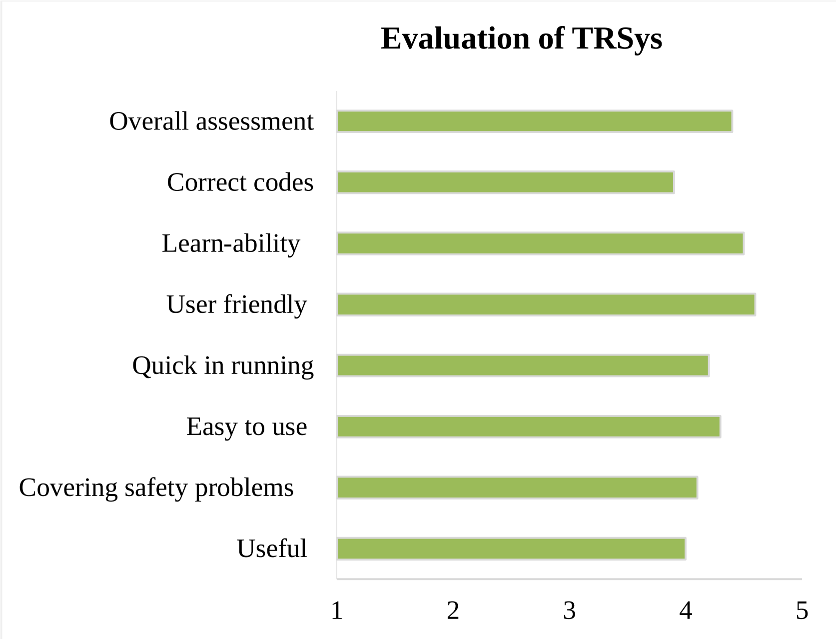

Fig. 6. Results of prototype system evaluation.

6. Conclusions

This paper had described some aspects of the prototype web-based expert system developed to optimize the road networks for developing countries. The implementation of TRSys expert system suggests remedies occurring on traffic roads. The problems ensuing from the recommendations have been documented with the intention of assisting practising engineers. The TRSys inference engine investigates data parameters input and comments for each problem a set of solutions. In situations where there is a recommendation of more than one solution, the inference engine demands additional data, made up of damage factors or conditions allowing the inference engine to recognise the optimum resolution. The knowledge extracted is not dependable, but offers well to excellent traffic damage documentation, predominantly its reactions, grounds, precautionary actions and countermeasure. The expert system can benefit road traffic workers better their specialized abilities in assessing existing resolutions. The subsequent deductions obtained from this study are:

- The identification and classification of single traffic distress problems consistent with numerous sources, for instance, manuals, journals and field experts.
- The web-based expert system prototype TRSys to optimize the road network effects developing countries was advanced based on knowledge attained using PHP programming.

- The creation of web pages supporting user interface utilizing a framework made up of HTML, CSS and J-Query. TRSys owns an advanced knowledge base.
- The verification, validation and evaluation of TRSys. TRSys verification needs unit testing.

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Abbreviations

CE	Computer Experts
CSS	Cascading Style Sheets
C++	General-Purpose Object-Oriented Programming Language
C#	Microsoft Programming Language
GUI	Graphical User Interface
HTML	Hyper Text Markup Language
JQuery	JavaScript Library
PHP	Programming Hypertext Pre-processor
SD	Standard Deviation
SQL	Structured Query Language
TE	Traffic Engineering
TRSys	Traffic Road System

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