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Knowledge-based Expert System for Route Selection of Road Alignment

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Abstract: Highway geometric design is part of planning process design for physical highway to fill up basic function of roads, to give good traffic service from one place to another. The important component of highway geometric design is selection of a minimum cost route which involves careful planning, design, right-of-way acquisition and construction. The characteristics of traffic flow, size of vehicle, driver's behavior, sight distance, super elevation and topography are the variables of highway geometric design after determination of the economy route and safety. It is not easy to select an economical route by manual design because a good proposed route should involve a complex design processes such as detailed assessment of geographic features, potential land use for road construction and environmental evaluation. Therefore, Geographic Information System (GIS) is a potential solution for acquiring detail information for design process. In this research, a computerized highway design model based on GIS is proposed to assist in evaluation of several alignment alternatives. A knowledge-base expert system was developed with acronym of ES-HGDesign using shell expert system of KAPPA-PC Version 2.4 that is object oriented and displaying higher graphic resolutions. The study stresses on the provision of design output and suggests road alignment based on the accumulation of knowledge from several experts, collecting data, reading literature and reports, discussions with domain experts, case studies by applying a modular approach. Normally, the process geometric designs are carried out by experts. The design process was computerized and apply artificial intelligent to provide a system that give decision and suggestion for the best route alignment.

Key words: Experts system, GIS, Highway Geometric Design

INTRODUCTION

Malaysia is a developing country where industries and commercial product and transported are being are developed, roads are important for transportation of raw materials and products as well as the movement people. New roads have to be built to link up the city centers with the expanding district centers and neighborhood centers. In Ninth Malaysia Plan, where by RM714 million was spent to construct 340 kilometers of rural roads and RM1. 6 billion was spent to construct and maintain 500 kilometers of village roads benefiting about 2.5 million people (RMK-9). Mohamad Razali (2006) from Malaysia Public Works Department saying Malaysia have length road network 74,603 kilometers. It forecasted 10 reach 20 coming year have been lots new road construction that focused rural area. However expert and experience person in route selection and road construction not enough until they will not always got when needed. There by rural area not getting enough attention from local government.

Traditionally, highway geometric design used pencil and ruler to lay out lines and curves over contour maps. This design process is often cumbersome and time consuming. In this design, many calculations of stopping sight distance, minimum turning radius, and curve alignments are required during the roadway design process. Traditional generally used to make the mathematical calculation required in manual highway design. Beside, it not capable of minimizing total cost of construction, maintenance and transportation costs or aiming for least environmental impacts.

Highway development, planning and design is a very complex process, involving selection of cost effective alignment alternative with due consideration to environmental impact assessment and public acceptability (Manoj., 2006). The planners and designs have to go through five key highway development stages (FHWA, 1997) before highway construction is completed.

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1. Planning
2. Project development
3. Final design
4. Right of way
5. Construction

The good design of highway can make fill up basic function of road, to give good traffic service from one place to other and safety, the road is necessary to transfer goods and people the essential public traffic, the road network is connected with increasing the national land of function both all over country of road network and the local road network. Each road was charge of the national land development and the improvement of living conditions in cooperation with each other. Especially, increase a number of vehicles, according as road network by significant of traffic that is increased in movement, convenience and economic, economic and social development provided people of the improvement of living conditions (Hyun choi. 2004).

This study is a applying a Geographic Information System (GIS) to assist expert system for suggestion of route road alignment based on KAPPA-PC software package. This package comprised of programmers for geometric highway design that is written in KAL language (Kappa PC Application Language). The output of the package is in the form of display interfacing from the user and the computer. The purpose of developing this software package is to prepare a medium of simple instruction and attractive for person who wants to learn and to know the problem of highway geometric design. Geographic Information System (GIS) is a potential solution for acquiring the detail information for design process. In this paper, the model of computerized highway design based on GIS is proposed in order to greatly assist in evaluation of several alignment alternatives, highway geometric design, pavement design, and cost. The model can reduce the cost and the project timing, and give the reliable decisions in highway design features and application of the model may clearly result in a significant benefit to the designer, planner, and real estate professionals. It may also help to minimize the changes in the scope of the highway project at later resulting in will save of millions RM.

Methodology:

Methodology of this study is integrated of GIS to expert system highway geometric design, which functions of GIS for to get the geographic database engine of contour map. This data will be implementation of expert system to select the good route for highway geometric design. The expert systems will be give out put to user which area must be selected for design. Basic structure of this research is shown in Figure 1.

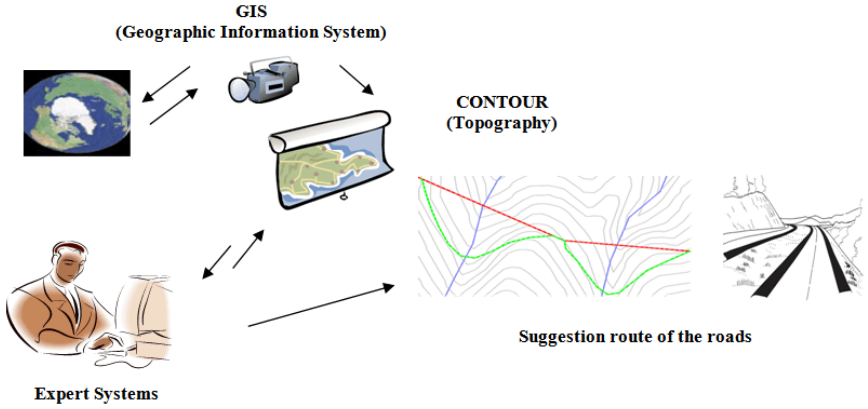


Fig. 1: Basic structure of this research.

Objective:

The main objective of this paper is development the expert system for geometric highway design using geographic information system to get database of contour map. The expert system will help the engineer to give recommendations concerning technical and institutional measures and data exchange policies in geometric highway design.

Selection of Route Alignment:

According Vast Consultant for route selection of alignment there are several aspects like economics, technical, social impact, construction, maintenance and environmental impact. Method that used in evaluating route selection are applying decision matrix (decision matrix). It is including inside two parts namely ranking and interest. Largest decision value product from method that is best choice which route choice was limited only three (3) routes. Description the method is as following.

1. The two dimensions of the evaluation matrix are ranking and importance. The product of the two dimensions is defined as the score for the factor being evaluated relative to other evaluation factor. The total score adding the scores of all evaluation factors is the aggregated and weighted outcome for the particular aspect being examined.
2. This evaluation is conducted on all identified aspects for all alternatives. At the end of the aspect being considered yields a total score or value for each alternative.
3. The next step is to evaluate the aspect against each other by assigning importance weightage. The alternatives being considered are then ranked relative to one another for each aspect. The product of ranking and weightage yields a value and larger the value the more favored is the alternative the precipitates it.
4. Ranking factors will be given by whole number with respect to the order of desirability among the alternatives. The rank 1 is assigned to the least desirable alternative and rank of n (equal the number of alternatives) is assigned to the alternative that is the most desirable. In this case a rank 3 signifies the most desirable alternative.
5. Importance factors will be given by weighing priorities among the aspects being evaluated. The assignment of importance factors is judgmental and subjective. The empirical influence of experience, precedent and observation contribute significantly in deciding weight allotment to the various aspects being evaluated.

The proposed road alignment is a linear entity made up of many components which are governed by economy, technical, social impact, construction and maintenance, and not least the environmental aspects. To select such a linear path for land transport, evaluation is required in two level, folds or hierarchy consequential and objective global judgment.

Consequential Evaluation:

For each proposed road alignment, evaluation was performed indirectly in the design process to arrive at individual solutions for alignment of interest. Thus the evaluation is consequent of the applied process and it implicitly measures various factors again established or widely accepted parameters.

In road planning and design, the following are the most common factors that are consequently evaluated.

1. Location, length and route alignment

Main considerations are as follows junction location by virtue of presence of existing road, useable tracts, and land and settlement features encountered along the route traverse.

2. Horizontal and vertical profiles

Cut and fills, and whether in soils or rocks. Kind of structures to be anticipated: eg. Culverts, bridges, anchored walls etc.

Recording Vast Consultant Sdn. Bhd. The weight contribution for each aspect being considered is assigned as in Table 1. below.

Table. 1: Weight contribution for each aspect.

Aspect to be evaluated	Importance factor	remarks
Technical	4	This is the single most important aspect as it relates to and determines the use ability of the end product. Other aspects emanate and hinges on its output.
Economy	3	This is the second most important aspect. If it is prohibitive or constrained by imposition at the will of the authority the final product may not materialize.
Construction & Maintenance	1.5	This is the third important aspect as it relates to time taken to create the product. It also relates to long term issues.
Social impact	1	This aspect addresses the end users and the degree of acceptance of the product to the end users.
environmental contribution	0.5	This aspect could not be ignored. It is significant and reason for its low weight is unavailability of data. The scope is covered by another party and done under the scope of EAI studies.
Total	10	

Geographic information system (gis):

GIS is not new but using the information from the mapping techniques and interpretation of the stability from the topographical map, soil data and contouring are useful in this study (Chowdry,1982, Coppin and Richards, 1990, and Ruslan Rainis dan Noresah Mohd Shariff, 1998).

According by ESRI a GIS is a computer system capable of capturing, storing, analyzing, and displaying geographically referenced information; that is, data identified according to location. Practitioners also define a GIS as including the procedures, operating personnel, and spatial data that go into the system. GIS can store and analyze geographic data and maps. For highway design applications, detailed geographic data for properties, contour, environments, geology, and terrain are needed, which can be directly retrieved from GIS (Figure 2). In this study GIS used for obtaining relevant databases, topographical for highway optimization and computing right of way and environmental costs. From the topographical map we can actually identify:

- Area coordinate
- Environment status
- Contours for the surface area
- Facilities or land usage

For the purpose, GIS layers of property maps and databases are obtained from aerial photographs (also know as orthopoto) and MDProperty View (letter et al., 1997). For the resulting map has a number of attributes stored in a table, including are of properties, unit cost of properties, cost of structure, and land-use code.

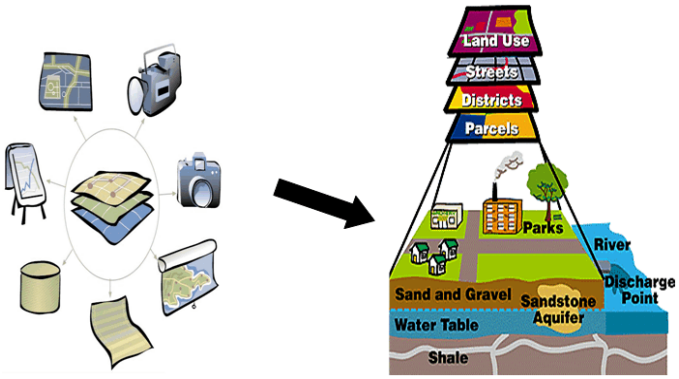


Fig. 2: Intergrate of GIS for many data.

Expert System:

Firebaugh, Morris W (1986) expert systems are class of computer programs that can advise, analyze, categorize, communicate, consult, design, diagnose, explain, explore, forecast, from concepts, identify, interpret, justify, learn, manage, monitor, plan, present, retrieve, schedule, test, and tutor. They address problems normally though to require human specialists for their solution. Expert system according to Durkin (1994) is defined 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". Today, with the new advances, an expert system could be defined as: "a computer system that simulates the learning, memorization, reasoning, communication and action processes of a human expert in a given area of science, giving, in this way, a consultant that can substitute the human expert systems with reasonable guaranties of success". These characteristics allow expert system to store data and knowledge, draw logical conclusions, make decisions, learn from experience and existing data, communicate with other human experts or expert systems, explain why decision have been made and take actions as a consequence of all the above. According to Deprizon (2009) was modification the expert system procedures shown in Figure 3.

Example:

An example is provided here to demonstrate the capability of the prototype expert system for highway geometric design. First time users click the button "PENILAIAN DAN PEMILIHAN LALUAN" shown in Figure 4a. After that next screen will be show as Figure 4b. user must to fill up the data, next form by click the button of ">>". The screens show in Figure 4d. The systems will show to user final decision of route selection. The final of that system will give output to user about the aspect technical, economy, construction & maintenance, Social impact and environmental.

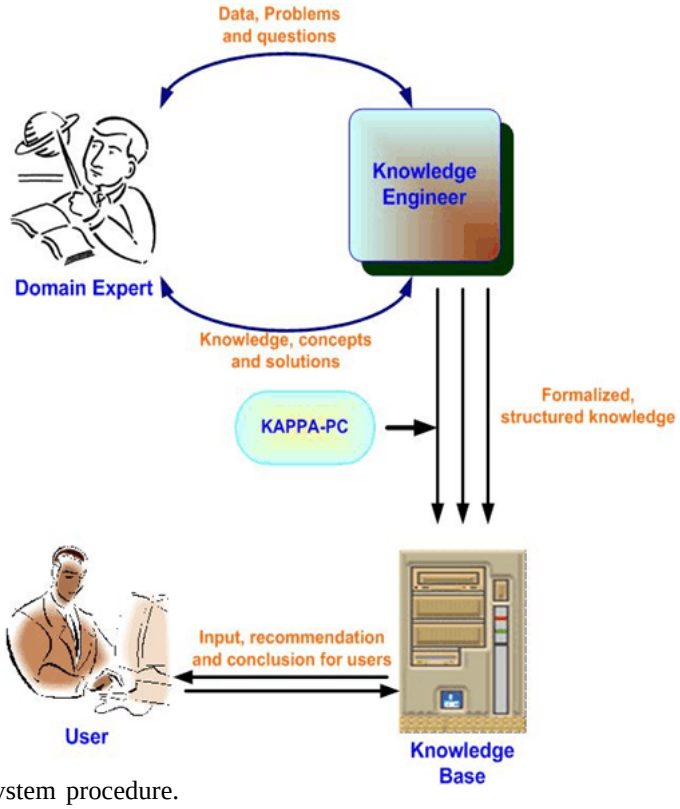
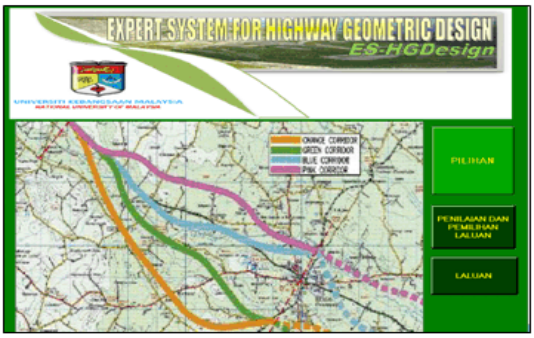
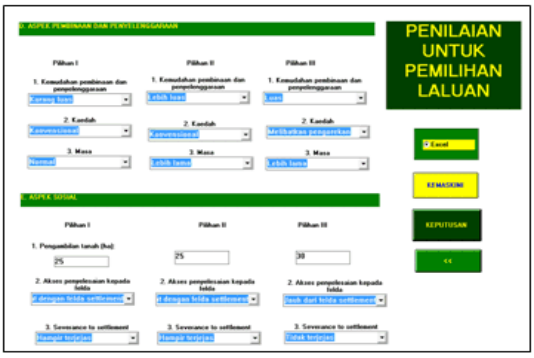


Fig. 3: The expert system procedure.



a. Main window for ES-HGDesign

b. Data of route selection



a. Continue data of route selection

d. final decision of route selection

Fig. 4: Expert system for route selection module.

Conclusion:

An expert system for highway geometric design is to be developed based upon the object oriented procedures using the KAPPA-PC system. The success of this system shall depend on the knowledge in the database and information placed by the user. This paper is proposal of research for development expert system for highway geometric design to get alternative route for alignment of highway and geometric highway design with faster and effective.

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