Expert System Design for Mode & Route Selection

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Abstract
Travelling from one place to other in the most convenient and time saving manner requires appropriate selection of route, as well as medium of transport. It is not easy to study all the factors that identify the best route between any two places like distance, availability of different modes of travel, time, comfort, etc. Also, there can be multiple connectivity of routes between any two places which are generally not shown if you consider any railway or airline booking search. Furthermore, even if the connecting routes are known, arriving at the best route taking into account all the factors can be tedious. This paper aims at developing an expert system incorporating all the factors and constraints as knowledgebase with specific purpose of getting the best routes as output.
Keywords: *Expert System, Best route, Best mode of travel*

1. Introduction

India is a large subcontinent offering different routes and modes of travel between two given places. Therefore choice of the most appropriate route needs complex analysis involving evaluation of several factors such as distance, travel time, cost and relative convenience. This paper suggests an expert system which identifies the best route and mode of travel between two places.

An expert system is a computer program that simulates the judgment and behavior of a human or an organization that has expert knowledge and experience in a particular field[1]**.** 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 decisions have been made and take actions as a consequence of all the above[2]. It is divided into two parts, one fixed, independent of the expert system: the inference engine, and one variable: the knowledge base. To run an expert system, the engine reasons about the knowledge base like a human[3]. The rule base is obtained by a knowledge engineer from the subject matter experts. The rule base is typically stored in an external store and used to drive an inference engine. The inference engine uses the rule base to guide the end user to a solution [4,5].
Here are some factors which suggest an expert system is appropriate[6,8,9].

- Need justifies cost and effort
- Human expertise not always available
- Problem requires symbolic reasoning
- Problem domain is well structured
- Traditional computing methods fail
- Cooperative and articulate experts exist

Taking into account complexity of the problem of determining the best route and mode between two given places, designing a routing system is a practical necessity. The expert system presented in this paper would go a long way towards this end.

2. Selection of Routes

We take into consideration three different modes of transport for undertaking any journey i.e. road, rail and flight. The choice of the best route has to incorporate several factors such as travel time, comfort level, cost incurred etc. We subdivide these factors into two broad categories:

1. Convenience Factor
2. Comfort Factor

2.1 Convenience Factor

It is a common place observation that air travel would not be advisable for shorter distances on account of time taken for reaching airports and hassle security checks. Similarly for long journeys road travel would not be a very convenient option. Keeping the comfort and time factor in mind, Table 1 gives weightage to the three modes of travel. Furthermore if there is no direct route to the destination we have to take into account a discomfort factor for each change

Table 1. Convenience factor depending on Comfort & Travel Time (C)

	d < 200	**200 < d < 400**	**d > 400**
By Road (R)	1	0.7	0.5
By Train (T)	0.8	1	0.7
By Air (A)	0.7	0.9	1

where d is the distance in kms.

2.2 Comfort Factor

No matter what be your mode of travel, the comfort factor always varies depending on the quality of travel. The comfort in road journey depends on the quality of roads and traffic; the rail travel is more comfortable if the train is Luxury train. And of course Business class flights are more comfortable than Economy class. Following tables illustrates comfort factor on these bases:

Table 2. Train Categorization depending on comfort (Q)

Type	**Comfort Factor**	**Value of i**
Luxury	1	1
Superfast	0.7	2
Express	0.5	3

Table 3. Airways Categorization depending on comfort (Q)

Type	**Comfort Factor**	**Value of i**
Business	1	1
Economy	0.7	2

where Q stands for quality

Table 4. Discomfort factor in connecting trains/flights

Type of Journey (Regular/Connecting)	**Discomfort Factor (b)**
Single Train Boarded	1
Multiple Trains Boarded	0.9

2.3 Basic Assumptions for the Model

1. We have not considered cost factor in our analysis of the best route. The whole stress is on comfort and convenience.
2. If there is no direct train or flight between origin and destination, then we have considered two or more consecutive flights or two or more consecutive trains travel. We have not considered case where a switch over from one mode to other is required.
3. We have assumed that all modes of travel would be available at time of journey.
4. We have not taken any inconvenience due to odd timings of travel or odd timings of break in journey.
5. Inconvenience of airport check in and check out and reaching the airport is taken to be same for all airports.

3. Methodology (Evaluation of the best Path)

To identify the best route and mode between two places, we will calculate the Best Path Value for each route and mode. The ideal route will have the value 1. We will start with calculating values of each route for road journey:

(1) For Road:

Fig. 1. Road Travel Dependency on Traffic & Quality of roads

Let R_1, R_2, R_3…. R_s be the Array List of number of road routes possible between origin and destination where $\sum_{r=1}^{n} d_r < 1.25 \times d_0$

[$\sum_{r=1}^{n} d_r$ is the actual distance that would be travelled (distance may vary if there are more than 1 connecting flights), d is the shortest distance possible. So the system will sort only those routes which take from origin to destination not making the distance more than 1.25 times the shortest distance]

To calculate the Path Value, the convenience factor is taken from Table 1 based on the total distance. The road route from one place to another can be combination of more than one road and there can be more than one route possible. Now each road patch will have certain level of traffic and road quality. So With each patch, its road quality (q_r) and traffic factor (t_r) will differ.

The symbols used are defined as follows –
d_0 – shortest distance

d_r – road patch
$d = \sum_{r=1}^{n} d_r$ – total distance
t_r – Traffic factor
q_r – Road Quality factor
C = convenience,
$D = \frac{d_0}{d}$ (Discomfort factor due to actual distance being more than the shortest distance)
Possible set of values of t_r are $0 < t_r \leq 1$
where smaller value denotes high traffic and idealistic value is 1 which denotes zero traffic
Possible set of values of q_r are $0 < q_r \leq 1$
where smaller value denotes low quality of road and idealistic value is 1 which denotes best quality possible

$$R = \frac{C.D}{d} \times \left[\frac{\sum_{r=1}^{n} d_r t_r + \sum_{r=1}^{n} d_r q_r}{2}\right]$$

(2) For Train:
Let $T_1, T_2, T_3 \ldots T_s$ be the Array List of number of train routes possible between origin and destination where $\sum_{r=1}^{n} d_r < 1.25 \times d_0$ as in the case of road journey.
To calculate Path Value, the convenience factor is taken from Table 1 based on the total distance. The train route from one place to another can be combination of more than one train and there can be more than one route possible. Now each connecting train patch will differ in it's comfort and might have different quality factor Q_r (Taken From Table 2).

The symbols used are defined as follows –
d_0 – shortest distance
$d = \sum_{r=1}^{n} d_r$ – total distance
Q_r – Train Quality factor
C = convenience,
$D = \frac{d_0}{d}$ (Discomfort factor due to actual distance being more than the shortest distance)
b = discomfort due to change (Taken from Table 4)

$$T = \frac{C.D}{d}\, b^{n-1} \times \left[\sum_{r=1}^{n} d_r . Q_r\right]$$

(3) For Airways:
Let $A_1, A_2, A_3 \ldots A_s$ be the Array List of number of air routes possible between origin and destination where $\sum_{r=1}^{n} d_r < 1.25 \times d_0$ as before
To calculate the Path Value, the convenience factor is taken from Table 1 based on the total distance. The Air route from one place to another can be combination of more than one airplane and there can be more than one route possible. Now each connecting airplane patch will differ in its comfort and might have different quality factor Q_r (Taken From Table 3).

The symbols used are defined as follows –
d_0 – shortest distance
d_r – path travelled by a flight
$d = \sum_{r=1}^{n} d_r$ – total distance
Q_r – Airplane Quality factor
C = convenience,
$D = \frac{d_0}{d}$ (Discomfort factor due to actual distance being more than the shortest distance)
b = discomfort due to change (Taken from Table 4)
f_r = discomfort due to check in and check out and approaching the airport

$$A = \frac{C.D}{d} . b^{n-1} \times \left[\sum_{r=1}^{n} d_r . Q_r . f_r\right]$$

where $f_1 = .95$, $f_2 = 1 \ldots\ldots\ldots\ldots\ldots\ldots f_{r-1} = 1$, $f_r = .95$

4. Expert System Development

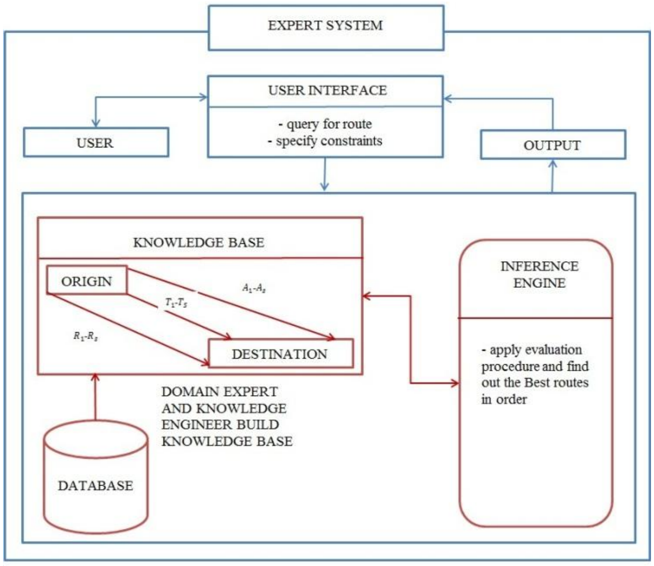

Fig. 2. Expert System

Considering all the above factors in road, train and air, it will be tedious task to evaluate manually the best route and best mode because there are so many routes available in each mode between two places. Also, no such routing system exists at present that considers all the defined factors for all the three modes. To evaluate such path by the specified procedure, we require a system that will understand the problem first, structure all the possible paths by different modes and then will find the best possible solution by applying the evaluation process. Such system should be expert in the knowledge of the problem domain (i.e. all the possible routes between two places by each mode), and help in making the correct and efficient decisions regarding the path[10,11,12].

The expert system will have following four major components -

1. Knowledge-Acquisition - The knowledge which the expert system should possess consists of primary, direct and indirect routes of road, train and air between the origin and destination. It also includes the total time that would be taken by the different mode of transports. To construct knowledge base, knowledge is acquired from different sources. Road database is developed by the official data of State and National Highways. Traffic data is developed by expert opinion of traffic for different highways and also a part of it is developed by customer feedback. Rail data obtained using existing data for rail travel or via connecting to rail booking sites. Similarly airline database could be prepared with the help of Airline sites/information systems.

2. User Interface - User will give the origin and destination as input. Also the priorities of transport, travel conditions can be prescribed.

3. Knowledge Base - In this expert system our database contains knowledge of all the trains, road routes, flights, their travel timings, and their costing. Knowledge base will consist of the rule base that will contain all the routes between the origin and destination defined by the user. Knowledge is acquired by following knowledge acquisition process. This knowledge base will pass the knowledge rules to the inference engine, which will evaluate the best suitable route and mode.

4. Inference Engine - The inference engine uses the evaluation procedure on the three mode of transport and the routes that were found from the knowledge base and compare all the three on the basis of their convenience factor, based on which it finds the best route and mode. A strong interest in using logic is that this kind of software is able to give the user clear explanation of what it is doing (the "Why?") and what it has deduced (the "How?"). Better yet, thanks to logic the most sophisticated expert system are able to detect contradictions[7] into user information or in the knowledge and can explain them clearly, revealing at the same time the expert knowledge and his way of thinking.

5. Conclusion

In this paper the possibilities of an expert system for dynamic route and mode planning are discussed. The expert system provides the most convenient routes swiftly. Its true potential is realized when real time constraints are elaborate. The system first constructs all possible solutions and then computes the best available taking into account time, comfort and convenience. The most important aspect of the expert system approach is the construction of the rules. This is a very intensive process and may require a lot of time if official data is not available. The future prospective of this model would be the inclusion of factors like cost, journey time and public modes of transport. The success of this system shall depend on how efficiently and accurately the knowledge is placed in the database.

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