Mechanics
Transport
Communications

Academic journal

ISSN 1312-3823

issue 3, 2009

article № 0354

http://www.mtc-aj.com

TRANSPORT NETWORK DEVELOPMENT PROJECT EVALUATION, USING DECISION MAKING

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Annotation: *In this article, some general issues associated with the joint consideration of indicators in decision making and transport project development and evaluation are described.*
Keywords*:* *MCDM; sustainability, transport, project management.*

INTRODUCTION

Transport projects social meaning is high, so it is important for monitoring situation in critical places, and choose the best alternatives from possible to have efficient transport system in long term.

Environmentally sustainable transport indicators application for transport project evaluation requires strong and effective methodology application, because of large amount of indicators and high importance of transport projects. After evaluation of existing methodology and tools, the following methods could be described as effective for project evaluation and transport system control (see Table.1).

Table 1: Technique application recommendation, according transport project development stage

Transport project development stage	MCDM and AI application
Objectives	System analysis
Generating of alternatives	Participation methods
Evaluation of criteria/ impacts	Multiple objective programming (MOP); expert methods
Evaluation of alternatives	Multiple criteria decision analysis (MCDA), Cost benefit analysis (CBA), MOP; problem solving; genetic algorithm, MOP, other AI,
Execution	Artificial intelligence (AI)
Control	AI based tools (intelligent agent technology based transport intelligent systems); statistics

Artificial intelligence methodology application allows monitoring transport system and making decision in real time.

DECISION MAKING PROBLEM FORMULATION

Decision making application is actual as in technical system control, as well in system management, taking in account economical parameters. Decision making process can be one-criteria or multi-criteria. The methodology for decision-making on set of criteria is called – multi criteria decision analysis (MCDA).

MCDA have 3 components (see Figure 1):

- A: alternative; the transport development variants are evaluated as alternatives.
- C: criteria; the character parameters of transport development variants in MCDA are evaluating as criteria, some of this criterion explicated as impacts.
- W: weight of criteria; the importance of each criterion is defining as weight of criteria.

Alternatives	Criteria			
	C_1	C_2	…	C_{an}
	(w_1)	(w_2)	…	(w_{in})
A_1	a_{11}	a_{12}	…	a_{1n}
A_2	a_{21}	a_{22}	…	a_{2n}
…	…	…	…	…
A_m	a_{m1}	a_{m2}	…	m_{an}

Figure 1: Structure of a typical decision matrix

The typical MCDM problem is concerned with the task of ranking a finite number of decision alternatives, each of which is explicitly described in terms of different characteristics (also often called attributes, decision criteria, or objectives) which have to be taken into account simultaneously. Usually, the performance values a_{ij} and the criteria weights w_j are viewed as the entries of a decision matrix defined as in Figure 1). The a_{ij} element of the decision matrix represents the performance value of the i-th alternative in terms of the j-th criterion. The w_j represents the weight of the j-th criterion [1].

Multiple criteria decision making (MCDM) [2] includes two complementary areas:

- mathematics-based multiple objective programming (MOP) and
- decision maker-driven multiple criteria decision analysis (MCDA).

MATHEMATICAL SELECTION METHODES USAGE

For transport alternatives evaluation the discrete decision making methods could be used. The main decision making methods are ELECTRE, ANP/AHP and UTA methods family. In ELECTRE [2] methods, the construction of an outranking relation amounts at validating or invalidating, for any pair of alternatives (a1,a2), the assertion 'a1' is at least as good as 'a2'.

The Analytic Hierarchy Process (AHP) was proposed by Saaty (1980) [3]. The basic idea of the approach is to convert subjective assessments of relative importance to a set of overall scores or weights. AHP is one of the more widely applied multi-attribute decision making methods.

The methodology of AHP is based on pair wise comparisons of the following type 'How important is criterion **C***i* relative to criterion **C***j*?' Questions of this type are used to establish the weights for criteria and similar questions are to be answered to assess the performance scores for alternatives on the subjective (judgemental) criteria [4].

The UTA method [5] has several interesting features: it makes possible the estimation of a non-linear additive function, which is obtained by the use of a linear program which provides a convenient piecewise linear approximation of the function, and the only information required from the decision maker is global stated preferences between the projects.

UTA methods we can use, for example, for the development of impact aggregation procedure for sustainable transport system.

DISCRETE APPROACHES

The main evaluation methodology could be grouped according to project importance, costs and its influence on the environment. The most popular tool now is single criteria Cost benefit analysis (see Damart, S., Roy, B.,) [6], but this methodology is just single criteria evaluation tool, that way could be not applicable in many cases. Cost benefit analysis allows just single criteria evaluation, in many cases it is disadvantage.

The application of Multi criteria analysis method depends of research task formulation. Classification of main multi criteria analysis method described in table 2.

Table 2: Classification of multi criteria analysis method

Multi criteria analysis method classification	**Method**
Fuzzy set analysis	Fuzzy set analysis (software TOMASO).
Distance to ideal point	Compromise programming
Pairwise comparison	Analytic Hierarchy process (AHP/ANP); MACHBETH; Pairwise Criterion Comparison Approach (PCCA): Martel and Zaras´ method; MAPPAC; PRAGMA; IDRA;PACMAN

Outranking methods	Electre I, Iv, IS, II, III, IV, TRI; PROMETHEE I, II, III, IV, V; IV, visual interactive module GAIA; IRIS; NTHomic; VIKTOR; PROAFTM; SUREMESURE; AGATHA; MAPPAC; PRAGMA; IDRA; PACMAN
Conjoint measurement tools	UTA; UTA GSM;
Particular binary relations	QUALIFLEX; REGIME; ORESTE; ARGUS; EVAMIX; MELCHIOR; TACTIC
Multi – criteria value function	Multi attribute utility theory (MAUT)
Distance to ideal point and outranking methods	Multi-criterion Q analysis (MCQA I, II, III)

Since the early 1990s, multi-criteria analysis has been coupled with geographical information systems *(GIS)* for an enhanced spatial multi-criteria decision making [7]. Usage of GIS-based multi-criteria spatial modelling generic framework is described by *Chakhar, S., Mousseau, V., [8].*

Outranking methods, a family of multi-criteria methods, may be useful in spatial decision problems, especially when ordinal evaluation criteria are implied. This is a framework to facilitate the incorporation and use of outranking methods in geographical information systems. The framework is composed of two phases. The first phase allows producing a planar subdivision of the study area obtained by combining a set of criteria maps; each represents a particular vision of the decision problem. The result is a set of non-overlapping spatial units. The second phase allows constructing decision alternatives by combining the spatial units. Point, line and polygon feature-based decision alternatives are then constructed as an individual, a grouping of linearly adjacent or a grouping of contiguous spatial units. This permits to reduce considerably the number of alternatives, enabling the use of outranking methods. The framework is illustrated through the development of a prototype and through a step-by-step application to a corridor identification problem.

CONTINUOUS APPROACHES

Modern information technologies application for transport system monitoring, allows to make some control of transportation and to collect input data for decision making. The programming methods application helps make decisions on – line. Computer control and various information system development are rapid. The main of continuous approaches is Multi-Objective-Programming (MOP), Goal Programming (GP) and some application of Artificial intelligence (for example multi agent systems). Continuous approach systems often are called intelligent transport systems (ITS). Main examples of ITS technologies have been mentioned by Zietsman, J., at COST 356 seminar in Oslo, Norway, February 2008. His report was about using sustainable transportation performance measures in corridor decision making: electronic license plate matching; cellular phone tracking; global positioning system; loop detectors; video imaging; automatic vehicle location; automatic vehicle identification; micro simulation see also Zietsman, J., Rilett, L.R. and Kim, S-J.

Multi-Objective-Programming (MOP).

Very general formulation of decision problems where a set of objective functions representing different criteria have to be “optimized”.

Decision making with relevant information about non-dominated solutions to obtain useful information about the preferences

Pioneers R. Keeney, H. Raiffa. Decision with multiple Objectives: Preferences and Value Tradeoffs. John Wily and Sons, New York 1976

The goal of MOP is to find optimal solutions of mathematical programs with multiple objective functions.

Multi-objective programming is a part of mathematical programming dealing with decision problems characterized by multiple and conflicting objective functions that are to be optimized over a feasible set of decisions. Such problems, referred to as multi-objective programs (MOPs)

Fuzzy MOP description.

Multiple objective programming problems with fuzzy coefficients, is one of practical approach to make decision for transportation development alternatives selection. As write Masahiro Inuiguchi in book Multiple criteria decision analysis [2] In multiple objective programming problems, parameters such as coefficients and right-hand side values of constraints are assumed to be known as real numbers.

Goal programming is a branch of multi-objective optimization, which in its turn is a branch of multi-criteria decision analysis (MCDA), also known as multiple-criteria decision making (MCDM). It can be thought of as an extension or generalization of linear programming to handle multiple, normally conflicting objective measures. Goal programming was originally proposed by Charnes, Cooper, and Ferguson (1955) by Dyer. J., see [2] Multiple criteria decision analysis, 2005 as an ingenious approach to developing a scheme for executive compensation.

The free path finding is the important task of transport system, with IT support. The using of some algorithms is useful for that. In the article the "ant algorithm" usage continuous transport system monitoring are proposed.

"Ant algorithms" were first proposed by Dorigo and colleagues [9] as a multi-agent approach to difficult combinatorial optimization problems like the traveling salesman problem (TSP) and the quadratic assignment problem (QAP). There is currently a lot of ongoing activity in the scientific community to extend/apply ant-based algorithms to many different discrete optimization problems [10, 11]. Recent applications cover problems like vehicle routing, sequential ordering, graph coloring, routing in communications networks, and so on.

Ant algorithms were inspired by the observation of real ant colonies. Ants are social insects, that is, insects that live in colonies and whose behavior is directed more to the survival of the colony as a whole than to that of a single individual component of the colony. Social insects have captured the attention of many scientists because of the high structuring level their colonies can achieve, especially when compared to the relative simplicity of the colony's individuals. An important and interesting behavior of ant colonies is their foraging behavior, and, in particular, how ants can find shortest paths between food sources and their nest.

NUMERICAL EXAMPLE USING ANT ALGORYTHM

Let's assume that the system with three cities and four ants is given.

Step 1: We initialize co-ordinates of cities, distances between cities and pheromone levels.

Initially levels of pheromone for each distance = 1/3, so we have only 3 cities in our system. Further, using the Pythagorean theorem, we can calculate the distances between cities.

For the first ant, with number 0 visiting 0-th city we will write down:

ants[0].curCity=0;

The ant is not forbidden to visit any of cities:

ants[0].tabu[0]=0;

…

ants[0].tourLength=0;

And 0 ant is forbidden to come back in 0-th city as the ant there already was:

ants[0].tabu[ants[0].curCity]=ants[0].tabu[0]= 1;

We repeat it for the second ant with number 1, for the third ant with number 2 and for the fourth ant with number 3, which also begins the way from 0-th city.

Step 2: Choice of a following city which will be visited by an ant:

moving=0;

For the first ant, with number 0:

ants[0].pathIndex<3;

ants[0].nextCity=selectNextCity();

from=0;

denom= …

p=1/24 / 1/8 = 1/3;

0.987<1/3 – The received number *p* is compared to a random number. The ant choice dynamics follows from the above equation: $Um_{+1}=Um+1$, if $\psi \leq PU$, $Um+1 = Um$ otherwise, where ψ is a random variable uniformly distributed over the interval [0,1].

In our case the result does not approach, since the inequality is not carried out. Therefore algorithm proceeds until, the inequality becomes will be executed. In the given example the ant will go further to a city at number 2:

to=2;

p=1/12 / 1/8 = 2/3

0.109<2/3

selectNextCity()=to=2;

…

ants[0].curCity=2;

The same operation it is carried out and applicable to other ants:

....

moving=1;

Step 3: Calculation of level of concentration pheromone:
pheromone[0][0]=1/3;
pheromone[0][1]=1/3(1-RHO)=1/3*(1-0.5)=1/6;*
pheromone[0][2]=1/3(1-RHO)=1/3*(1-0.5)=1/6;*
....
pheromone[2][2]=1/6;

Restart

After the way of an ant is finished, edges are updated according to length of a way and there was an evaporation of pheromone on all edges, the algorithm is started repeatedly. The taboo list is cleared, and the length of a way is nulled. This process can be carried out for constant quantity of ways or till the moment when throughout several starts it has not been noted repeated changes. Then the best way which is the decision is defined.

CONCLUSIONS

The efficiency of the public urban transportation system depends on the identification of relevant parameters and their weights, which directly or indirectly influence the quality of urban traffic.

Based on the preferences of decision-makers, it is necessary to consistently determine the significance of criteria, compare the strategies, and determine the one used in decision-making.

Multiple criteria decision making (MCDM) theories which integrate logic reasoning, mathematics, computer science, operation research, management science to solve the problems of multiple attributes decision making have been applied to various kinds of real-world problems.

MCDM algorithms allow to solve a lot of problems: a square-law problem about appointments, a scheduling problem, a problem of routeing of transport, working out GPS of networks, a problem of optimisation of a transport route, a problem of optimisation of the schedule, a lining of pipelines, roads, cable and telephone systems, definition of optimum sequence of processing of details, optimisation of assembly lines and conveyors etc. These problems arise in business, engineering, manufacture and many other areas.

Evaluating transport network development projects it is offered to use modern scientific achievements, strong and effective methodology application, decision making theories, theories of the information and artificial intellect systems. It is recommended to use Multi Criteria Decision Making and Artificial Intellect applications according transport project development stage, such as: system analysis, participation methods, Multiple objective programming (MOP); expert methods, Multiple criteria decision analysis (MCDA), Cost benefit analysis (CBA), genetic algorithm, AI based tools (intelligent agent technology based transport intelligent systems) and statistics.

The system approach allows to see on a substantial scale a problem, defines a generality of the processes proceeding in the general service conditions, gives their universal description and allows to build the forecast on the basis of external and internal displays of behaviour of objects.

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ОЦЕНКА НА ПРОЕКТ ЗА РАЗРАБОТВАНЕ НА ТРАНСПОРТНА МРЕЖА ПОСРЕДСТВОМ ВЗЕМАНЕ НА РЕШЕНИЕ

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Ключови думи: *MCDM; трайност, транспорт, управление на проекти*
Анотация*: Настоящата статия третира някои общи въпроси, свързани със съвместното разглеждане на индикатори при вземането на решения, разработването на транспортни проекти и оценката им.*