Rejtő Sándor Faculty of Light Industry

Institute of Informatics and Mathematics

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1 Introduction

The education of mathematics and informatics at the Technical Collage of Light Industry belonged to the Department of Fundamental Subjects. In 1983 the Collage founded a Department of Computer Science, and Department of Mathematics. The staff teaching informatics has been transferred to Department of Computer Science. In 1993 the two Department was united and a new Institute was founded under the name Institute of Mathematics and Computer Science.

In year 2000 a new Technical College was created from three Polytechnics: Bánki Donát Polytechnic, Kandó Kálmán Polytechnic and College of Light Industry. At that time among others a new faculty was founded: John for Neumann Faculty of Informatics. The Institute of Mathematics and Computer Science joined to this faculty. The new name of the Institute: Institute of Mathematics and Multimedia Technology. In 2004 the Institute joined to the Rejtő Sándor Faculty of Light Industry and its new name became Institute of Computer Science and Mathematics.

2 Education Profile

The Institute responsibility is to teach mathematics and computer science in the Rejtő Sándor Faculty. Beside this there are several other subject to teach for other faculties.

In the Keleti Károly Faculty of Economic many courses are regulary offered:

- Information Technology I-II
- Computer Aided Software Engineering

- SAP for Organizing Information Systems
- Mathematical Programming I-II
- Probability therory.

In addition for the other faculties (Neumann, Keleti, Rejtő) several courses are offered:

- Introduction to Multimedia
- Digital Sound Processing
- Digital Picture Processing
- Digital Movie Processing

Beside the above mentioned subjects some other courses are offered:

- Network programming
- Informations Systems
- Phisics for Engineers
- Excel programming
- etc.

It was developed a multimedia speciality for the Faculty of Neumann both the traditional graduate and BSc level. This speciality is under the foundation at the Faculty of Rejtő.

3 Research and Scientific Activity

3.1 Researc Works in Civil Engineering

One of main scientific research field is related to the traffic engineering. In this field we deal with the mathematical modeling of some traffic problem. After the model prepariton usually the algorithm and the computer code is also prepared. Several problem solution was used for solving practical problems too. Some scientific degrees was reached in connection with these research activities (PhD, candidate, HAS doctor, etc.). This field we give several lectures in the doctoral courses of other universities (Technical University of Budapest, Széchenyi University, Győr).

The most important result are related to the folloving fields:

- Long –range planning of the Road Network (in cities and on the countriside).

- Deterioration Process of Engineering Structures.
- Optimal Maintenace and Rehabilitaion activity for roads and bridges.
- Data-base Background of the Above Mentioned Models.
- Genaralization and Combined Models in This Field.

In the case of long-range road network planning we have to determine the most economical road network development program.

We have to solved several mathematical problems, and the procedure could be used for example for planning the mass traffic network of a city. (see [1, 2]).

The project leader of application these models for Budapest mass traffic was the author of this article. The scientific results of this work was summarised in [3]. The results will be used in an other combined model in the near future (see [4]).

The deterioration process is important part of the maintenance and rehabilitation management models (see [5]). Beside the statistical model some other expert system is used for this purpuse. The adventage of this models, that we do not need time series, enough to know the receant condition of the object (see [6]).

The basic model for the determination of the optimal maintenance and rehabilitation policy user the following questions:

- ensure a prescribed improvement in the state of the road system with minimal agency cost;
- distribute a fixed amount of money between the road sections with different states in such a way that the achieved improvements should be the best in some sense (e.g. to minimise the user cost over the total transportation network).

The first version of the model solves the problems mentioned above in one time period. This period could be one year or several years but only one period. These limit the possible application of the model. That is why a multiperiod model was suggested where the user cost and the cost/benefit analysis could be more effectively taken into consideration (see [7, 8]).

Two main types are the solution algorithms the heuristics and the optimization. The heuristic techniques usually use a ranking algorithm and have limited application. The optimization models depending on the model to be solved use integer, linear or dynamic programming algorithm or other methods.

The linear programming model presented herein has some stochastic elements; the road deterioration process is described by Markov transition probability matrices. The road network has been divided into different groups according to their pavement type and traffic class.

In our model the following denotation will be used

i	pavement type index
s	number of the pavement types
j	traffic class index
f	number of the traffic classes
k	maintenance policy index
t	number of the maintenance policies
l	year index
T	the number of the years

The condition of a road segment is described by different types of deterioration parameters. The developed model uses 3 parameters: bearing capacity note (5 classes), longitudinal unevenness note (5 classes) and pavement surface quality note (5 classes). Note 1 denotes the best, and note 5 denotes the worst condition. The segments using these notes could have 125 different condition of states. This number determines the size of the unknown variable vector X_{ijkl}.

One co-ordinate of X_{ijkl} is the fraction of the road segments which belongs to a pavement condition state in the case of pavement type i, to the traffic class j to the maintenance policy k in the year l.

Let us denote the Markov transition probability matrix by Q_{ijk} which belongs to the pavement type i, traffic class j and maintenance policy k.

The matrix Q_{ijk} is quadratic, and the number or rows is equal to the number of the road condition states. The element q_{ijkmn} of Q_{ijk} means the probability that the road segment being in state m at the beginning of the planning period will be in state n at the end of the planning period.

Let us denote the unknown vector by Y_{ijl} which is the fraction of the road segments which belongs to the pavement type i, to the traffic class j at the end of planning period l.

The initial fraction of road segment is denoted by b_{ij} which belongs to the pavement type i to the traffic class j.

There are several conditions to fulfil. The first condition is related to the fraction of the road segment at the initial year:

$$\sum_{k=1}^{t} UX_{ijk1} = b_{ij} \quad ,i = 1,2,...,s \;\; j = 1,2,...,f \tag{1}$$

where U is a 125x125 unit matrix.

The second condition defines the vector Y_{ij1} at the initial year:

$$\sum_{k=1}^{t} Q_{ijk} X_{ijk1} = Y_{ij1} \;,\; i = 1,2,...,s \quad j = 1,2,..., f \tag{2}$$

For each year the following conditions must be fulfilled

$$\sum_{i=1}^{s} UX_{ijk(l+1)} - Y_{ijl} = 0 \quad j = 1,2,..., f \quad k = 1,2,...,t \tag{3}$$

$$l = 1,2,...,T-1$$

The conditions (3) define the unknown vectors Y_{ijl} which contain the fractions at the beginning of the planning period *l* by the sum of $X_{ijk(l+1)}$ which contains the fractions at the end of the planning period (*l-1*).

One of the maintenance policies has to be applied on every road segment in each year:

$$\sum_{v=1}^{125} \sum_{i=1}^{s} \sum_{j=1}^{f} \sum_{k=1}^{t} (X_{ijkl})_v = 1 \quad l = 1,2,,...,T \tag{4}$$

The segments are divided into 3 groups: acceptable (good), unacceptable (bad) and the rest. Let us denote the three set by J (good), R (bad) and by E (rest of the segments) and by H the whole set of segments.

The relation for these sets is given by:

$$J \cap R = \emptyset \quad J \cap E = \emptyset$$
$$R \cap E = \emptyset \quad J \cup R \cup E = H \tag{5}$$

The following conditions are related to these sets at the initial year:

$$\sum_{i=1}^{s} \sum_{j=1}^{f} \sum_{k=1}^{t} (Q_{ijk} X_{ijk1})_v \geq \alpha_1 \sum_{i=1}^{s} \sum_{j=1}^{f} (b_{ij})_v, \quad v \in \mathrm{J}$$

$$\sum_{i=1}^{s} \sum_{j=1}^{f} \sum_{k=1}^{t} (Q_{ijk} X_{ijk1})_v \leq \alpha_2 \sum_{i=1}^{s} \sum_{j=1}^{f} (b_{ijv})_v, \quad v \in \mathrm{R} \tag{6}$$

$$(\underline{b}_E)_v \leq \sum_{i=1}^{s} \sum_{j=1}^{f} \sum_{k=1}^{t} (Q_{ijk} X_{ijk1})_v \leq (\bar{b}_E)_v, \quad v \in \mathrm{E}$$

where J, R, E are given above, and

$\sum_{i=1}^{s} \sum_{j=1}^{f} (b_{ij})_v$, $v \in$J the share of the good road segments before the planning period,

$\sum_{i=1}^{s} \sum_{j=1}^{f} \sum_{k=1}^{t} (Q_{ijk} X_{ijk1})_v$, $v \in$J the actual share of the good road segments after the first year,

$\sum_{i=1}^{s} \sum_{j=1}^{f} (b_{ij})_v$, $v \in$R the share of the bad road segments before the planning period,

$\sum_{i=1}^{s} \sum_{j=1}^{f} \sum_{k=1}^{t} (Q_{ijk} X_{ijk1})_v$, $v \in$R the share of the bad road segments after the first year,

$\sum_{i=1}^{s} \sum_{j=1}^{f} \sum_{k=1}^{t} (Q_{ijk} X_{ijk1})_v$, $v \in$E the share of the other road segment group after first year,

$\underline{b}_E \in$ the lower bound vector of the other road segment group,

$\overline{b}_E \in$ the upper bound vector of the other road segment group,

α_1 and α_2 given constants.

The meaning of the first condition is that the amount of ‘good’ road segment after the first year must be greater than or equal to a given value, in this case the actual proportion of the good road segments before the first year. The second relation does not allow higher proportion of ‘bad’ roads after the first year than a specified value, the actual share of the bad road segments before the planning period. The third relation gives an upper and lower limit to the proportion of the rest of the road segments after the first year.

For the further years similar inequalities could be used

$$\sum_{i=1}^{s}\sum_{j=1}^{f} Y_{ijl} \ \mathrm{R} \ \sum_{i=1}^{s}\sum_{j=1}^{f} Y_{ij(l+1)} \qquad l = 1,2,...,\mathrm{T}-1 \qquad (7)$$

where R coluld be one of the relations <, >, =, <=, >= and these relations could be given in connection with each condition states (e.g each rows could have different relations).

Instead of (6) and (7) a condition states could be applied for the end of the planning period (e.g for *l*=T):

$$\sum_{i=1}^{s} \sum_{j=1}^{f} (Y_{ijT})_v \geq \alpha_1 \sum_{i=1}^{s} \sum_{j=1}^{f} (b_{ij})_v, \quad v \in \mathrm{J}$$

$$\sum_{i=1}^{s} \sum_{j=1}^{f} (Y_{ijT})_v \leq \alpha_2 \sum_{i=1}^{s} \sum_{j=1}^{f} (b_{ijv})_v, \quad v \in \mathrm{R} \qquad (8)$$

$$(\underline{b}_E)_v \leq \sum_{i=1}^{s} \sum_{j=1}^{f} (Y_{ijT})_v \leq (\bar{b}_E)_v, \quad v \in \mathrm{E}$$

Let us denote by C_{ijk} the unit cost vector of the maintenance policy k on the pavement type i and traffic volume j.

One more condition is in connection with the yearly budget bound of each maintenance action:

$$\sum_{i=1}^{s} \sum_{j=1}^{f} r^{(l-1)} C_{ijk} X_{ijkl} = r^{(l-1)} M_k, \qquad l = 1,2,...,\mathrm{T} \qquad (9)$$

$$k = 1,2,...,t$$

where r is the interest rate, C_{ijk} is the unit cost vector of the maintenance policy k on the pavement type i and traffic volume j and M_k is the budget bound available for maintenance policy k in the initial year.

Now the objective of the problem is formalized. The objective is to minimise the total cost of maintenance

$$C = \sum_{i=1}^{s} \sum_{j=1}^{f} \sum_{k=1}^{t} \sum_{l=1}^{T} X_{ijkl} C_{ijk} \rightarrow \min! \qquad (10)$$

If the available budget B is known two further budget limitation conditions are added to the constraints.

The budget limitation condition for the initial year is:

$$\sum_{i=1}^{s}\sum_{j=1}^{f}\sum_{k=1}^{t} X_{ijk1}C_{ijk} \le B \tag{11}$$

For the years $l = 2,3,...,T$ this condition is the following:

$$\sum_{i=1}^{s}\sum_{j=1}^{f}\sum_{k=1}^{t} r^{(l-1)} X_{ijkl}C_{ijk} \le r^{(l-1)}B \tag{12}$$

The cost of travelling depends on the pavement type i and the traffic class of j. Let us denote the travelling cost vector by K_{ij}. The νth co-ordinate of this vector belongs to the condition state ν (1≤ ν≤75).

The objective in this case is to minimise the total user (travelling) cost:

$$C = \sum_{i=1}^{s} \sum_{j=1}^{f} \sum_{k=1}^{t} \sum_{l=1}^{T} X_{ijkl}K_{ij} \to \min! \tag{13}$$

The development of the data base for these models was supported by our Institute (see [9]). Several generalization of the models was prepared. One of them is the combined road/bridge management system (see [10]). The other genaralization deals with the infrastructure management. The most general model is the asset management system, which is under the development (see [11]).

3.2 Other Research Activities

We have several scientific results in analytical investigation of the trcak/vehicle system dynamics:

(i) Mathematical investigation of the Bernoulli-Euler and the Timoshenko beam operators. [12]

(ii) Analytical solutions to the beam equations for different, coupled track and vehicle models in case of a discrete, elastic suppoprt system. [13]

(iii) Investigation of the above problem in case of continuous, elastic support systems. [14]

(iv) The effect of geometric and dynamic irregularity of the track. [15]

(v) Analysis of the nonlinear resonances of vehicle system dynamics. [16]

(vi) Geometrical investigation of the wheel/rail contact. [17]

(vii) Mathematical construction of railway track measurement processes [18].

(viii) The explicit represaentation of the Green function for the periodically supported string and beam problem.

(ix) Investigations into fracture dynamics.

Scientific Relations:

Budapest University of Technology and Economics

Technische Hochschule Dresden

Moscow Lomonosov University

Universität Hannover

European Consortium for Mathematics in Industry

International Society for the Interaction of Mathematics with Mechanics

Other filds is investigation of methods for solution of two and three dimensional boundary layer problems ([19, 20, 21]):

(ii) Using Blasius and Görtler type expansions for flow past cylinrical bodies at high Reynolds numbers.

(ii) Investigation of swirling flow boundary layers with Ritz-Galerkin type weighted residual methods.

Beside this we have some results in mathematical modeling of carcinogenesis.

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