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OPTIMAL RECOMMENDATIONS GENERATION SYSTEM FOR PRESCHOOL EDUCATIONAL INSTITUTION NETWORK DEVELOPMENT IN THE BIG CITY

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Abstract

In this paper an optimal recommendations generation system for preschool educational institution (PEI) network development is considered. It consists of three programmable blocks: logical-and-probabilistic modelling, optimization and expert forecasting. These modules provide input, storing and correction of the data, its attachment to the city map, modelling and forecasting changes of PEI's characteristics and producing recommendations with plotting for PEI network development.

Logical-and-probabilistic methods were used for modelling and forecasting, mathematical programming methods in ordinal scales were used in optimization.

As a result an optimal recommendations generation system for PEI network development was created. It was tested on the model of Saint Petersburg with real data.

INTRODUCTION

Shortage of places in preschool educational institutions (PEI), particularly in kindergartens, is the basic problem of children's education availability. For example, the number of kindergarten children in Saint Petersburg was 189000 or 79.6% of total amount of children from 1 to 7 years in 2012 [1].

Presidential decree about the national strategy for 2012-2017 [2] aims at improving the children's situation including increasing a children's education availability. Moreover, government decree №295 [3] aims at achieving 100% availability of preschool education for in 2016.

Requirements for the budget distribution for the PEI construction and repair in a condition of limited resources determines the relevance of the optimal recommendations generation system for PEI network development.

PEI network development in St. Petersburg is the object of the research. Determination of optimal resource distribution and forecasting of the PEI network development is the subject of the research.

Following tasks have been solved during the research:

- input, storing and correction the data;
- attachment the data to the city map;
- calculation of the economic and social indicators;
- identification of critical and problem zones on the maps;
- modelling and forecasting changes of PEI's characteristics;
- calculation of the optimal criteria;
- forecasting and producing recommendations for PEI network development;
- plotting of social and economic situation of PEI network development.

Logical-and-probabilistic methods [4] were used for modelling and forecasting, mathematical programming methods in ordinal scales [5] were used in optimization.

OPTIMAL RECOMMENDATIONS GENERATION SYSTEM

System Structure

Logical-and-probabilistic modelling, optimization and expert forecasting are three programmable blocks of the developed system, the structure of which is shown in Fig. 1.

Logical-and-probabilistic modelling block consists of:

- human machine interface (HMI), with the usage of which operator configures optimization parameters and update information in database;
- database (DB), which contains information about districts (Admiraltejskij, Kalininskij, Krasnoselskij and Centralnyj), its PEI and map data;
- knowledge base (KB) with rules for producing recommendations;
- inference engine (IE) which substitutes logical variables that characterize city district in the KB's rules.

Optimization and expert forecasting blocks constitute control block that receives the output data from logical-and-probabilistic modelling block and produce optimal recommendations for PEI network development considering various scenarios of PEI network development.

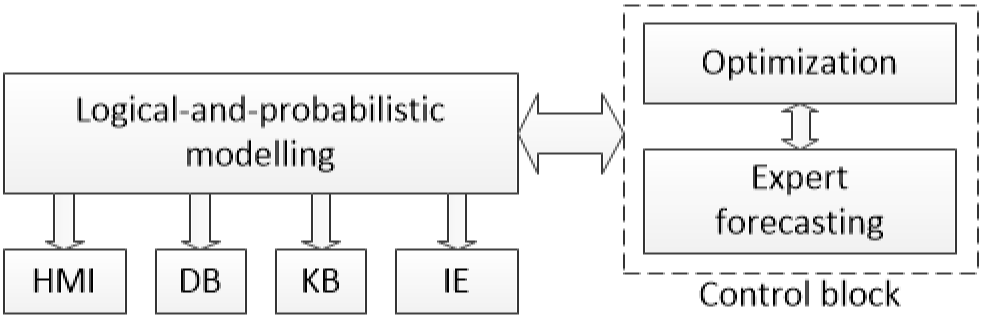

Fig. 1 *Structure of the optimal recommendations generation system*

Map Data

District's map data was obtained from the St. Petersburg Administration website [6] and Yandex.Maps service [7] which allows to determine boundaries of city districts and to locate its PEI. Service [7] also helped to calculate approximate population density and building density within districts using linguistic variables ("low", "medium", "high", etc.).

Reference Data

Sources [8] and [9] were used as a PEI's reference data. Use of building data were taken from [10]. The calculation of PEI's construction cost has been produced using [11].

LOGICAL-AND-PROBABILISTIC MODELLING

Logical-and-probabilistic modelling block gets data about districts, district's PEI, the number of children forecast and maps as input from DB. Further, it processes obtained data and generates input data for the control block. This block calculates the budget distribution and determines PEI for construction and repair.

HMI, which is shown on Fig. 2, provides DB and KB correction, different program subsystems starting and its interaction with control block.

The main application window visually can be divided into 3 parts:

1) selecting the district and displaying information about it (by pressing "Information" button);

2) imaging the district's map which is divided into cells (200x200 m) with selected masks;
3) selection of displayed parameters, such as district borders, PEI, color masks that indicate population density, building density within the district and possibility or necessity to build or repair a PEI in the cell.

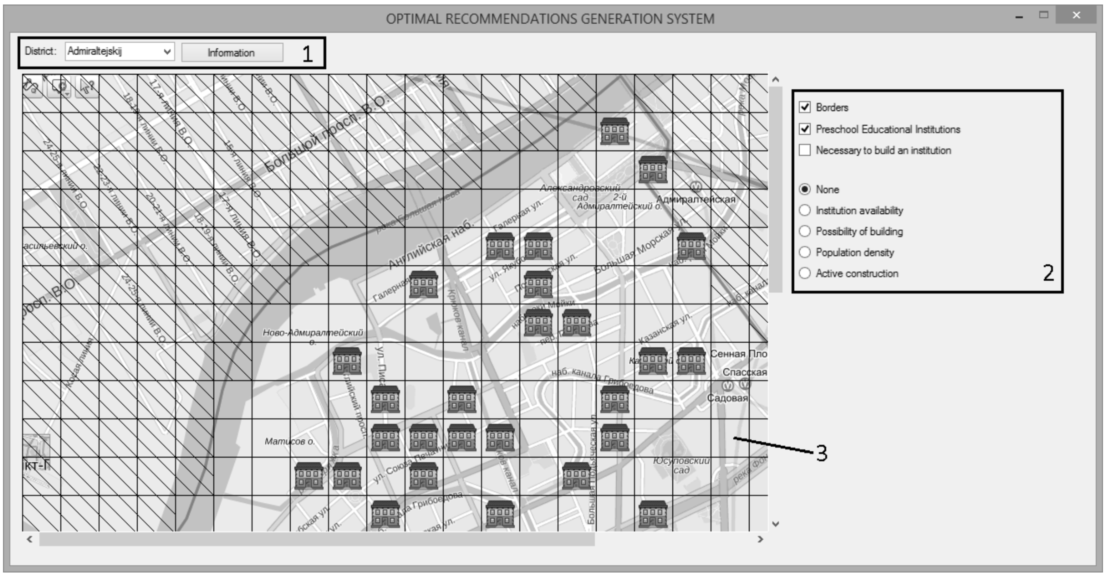

Fig. 2 *Optimal recommendations generation system's HMI*

Selected cell scale is induced by the scale of average PEI's territory (about 40 m^2 per child [8]), thus there is no more than one PEI in the cell.

DB stores information about the districts of St. Petersburg including a forecast of population in the 2015-2031 according to [12]. Also it contains masks for each district, made up with logical and linguistic methods. This approach allowed us to avoid the problem of lack of data (population density, building density, etc in each cell) through the provision of linguistic variables for each parameter:

- population density – low, medium, high;
- building density – low, medium, high;
- availability of PEI's construction – yes, no.

Information about PEI is stored in a separate database tables thus forecasting of PEI network development considers:

- PEI's address on the map and address relatively to the cell (Fig. 2), so each PEI is linked with map data in DB;
- each PEI's accommodation;
- year of construction and lifetime (effects on the repair necessity);
- money for repairing;
- planned date of closure for repairing.

KB contains information about criteria for expert system's (ES) decision-making. Criteria can be changed by the operator with a special form. Such criteria may include, for example, choosing rules for cells where PEI should be build or repaired or budgets distribution's rules.

The resulting output data contains the details of each district's cell, which are used in determining the place for the PEI construction (considering social and economic indicators), choosing PEI for repairing and effective distribution of the budget.

OPTIMIZATION

Described block makes calculations and forecasting data for plotting according to economic and social indicators, as well as the calculation of the optimization criterion for each district's cell using formula (1):

$$K = k_1 * PD + k_2 * BD + k_3 * AB + k_4 * A, \text{ where} \quad (1)$$

K – optimization criterion for district's cell;
k_1, k_2, k_3, k_4 – user-defined optimization coefficients;
PD – population density's coefficient;
BD – building density's coefficient;
AB – active construction's coefficient;
A – availability coefficient.

District's cell ranking in ascending / descending order of optimization criterion determines the cell in which it is necessary to build a PEI.

Fig. 3 presents PEI network development of the Admiralty district on 2015-2031. It could help to determine the ratio of the number of available places and the total number of children aged 2 to 7 years.

This approach allows the operator to estimate the approximate costs of PEI construction and repairing to ensure the availability of pre-school education in each district. Developed system provides the operator different variants for PEI construction and repairing in limited resources conditions to achieve the highest availability of pre-school education. Optimization block also displays a forecast of PEI network development using graphs.

EXPERT FORECASTING

ES provides optimal production plans for PEI network development with possibility of optimization coefficients correction and works according to the algorithm shown in Fig. 4

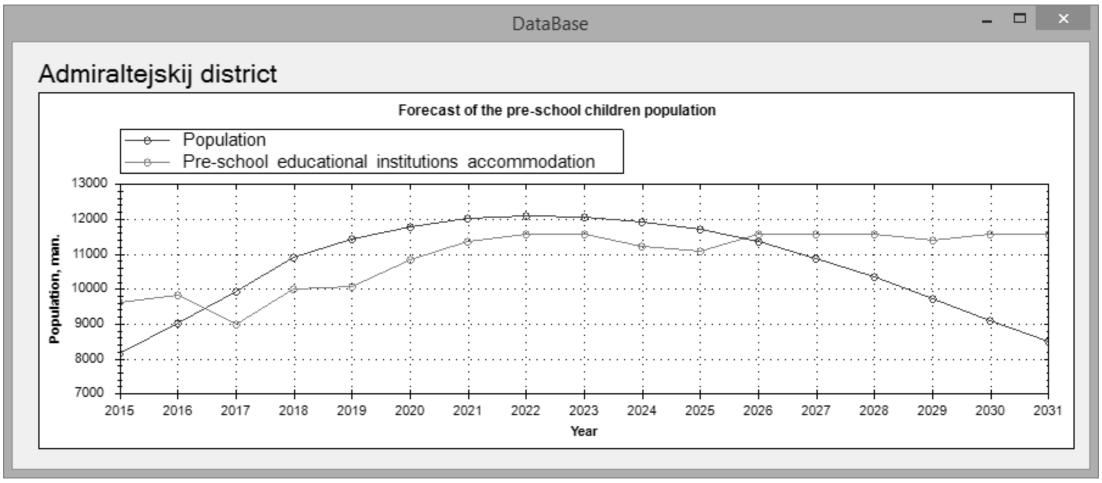

Fig. 3. *Forecast plotting*

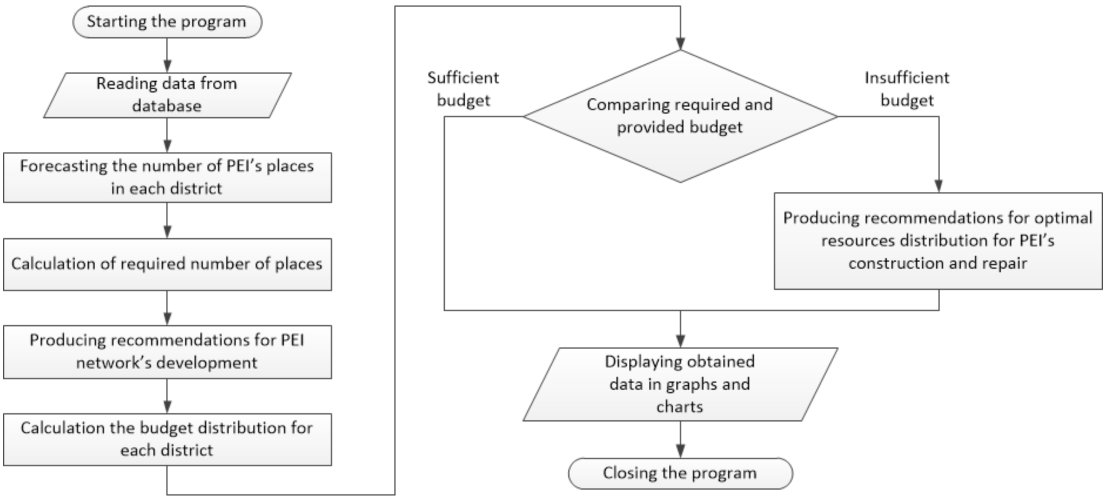

Fig. 4. *Program algorithm*

RESULTS

The developed optimal recommendations generation system for PEI network development in big cities has been tested on a model of the four St. Petersburg's districts: two central (Admiraltejskij, Centralnyj) and two marginal (Kalininskij, Krasnoselskij).

The results of modeling and prediction confirmed the data [1] about the lack of places in PEI for children aged 2 to 7 years. System proposed several solutions to the problem of inaccessibility of pre-school education through the PEI construction and repairing, the number of which varied depending on the budget provided by the district.

Thus, the system allowed to automate the process of identifying places for new PEI (according to population density, building density and availability of nearest PEI) and the process of selecting of PEI which are in need to be repaired. The aim is to maximize the conjunction of two curves: the one providing PEI capacity and the curve of the population's forecast to 2031 (see Fig. 3).

The authors of the system believe that the novelty of the research is an automatization of the budget's distribution on PEI construction and repair in a condition of limited resources based on social and economic indicators.

SUMMARY

Taking everything into account, paper described the optimal recommendations generation system for PEI network development that solves such tasks as:

- input, storing and correction the data;
- attachment the data to the city map;
- calculation of the economic and social indicators;
- identification of critical and problem zones on the maps;
- modelling and forecasting changes of PEI's characteristics;
- calculation of the optimal criteria;
- forecasting and producing recommendations for PEI network development;
- plotting of social and economic situation of PEI network development.

The system was created using high-level language C# in Visual Studio 2012 Professional, with the usage of which were also designed the DB and KB. It showed efficient simulation of the PEI network development in the big city (St. Petersburg).

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