Session 6

City Development

INTEGRATION OF INTELLIGENT, VOICE STRESS ANALYSIS, AND IRIS RECOGNITION TECHNOLOGIES IN CONSTRUCTION AND REAL ESTATE

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The authors of this paper have participated in the project Framework 6 Intelligent Cities and the Lincoln Institute of Land Policy Fellowship. One of the project's goals is to develop and improve a Real Estate's Market Value, Pollution and Health Effects Analysis Decision Support System (RE-MVPHE-DSS). RE-MVPHE-DSS consists of a Market Value Analysis, Air Pollution, Premises Microclimate Analysis, Health Effects, Voice Stress Analysis, IRIS Recognition, Cooperative Decision Making and Multiple User Subsystems. RE-MVPHE-DSS is briefly analysed in this paper.

Keywords: cooperative decision making, multiple user, real time system, market value analysis, air pollution, premises microclimate analysis, health effects, voice stress analysis

1. INTRODUCTION

Certain groups of patients such as asthmatics, atopic patients, patients with emphysema and bronchitis, heart and stroke patients, diabetes, pregnant women, the elderly and children as especially sensitive to the health effects of outdoor air toxicants [1]. It is estimated that about 20% of the US population suffers from asthma, emphysema, bronchitis, diabetes or cardiovascular disease and is thus especially susceptible to outdoor air pollution (American Lung Association, 2005). Outdoor air quality plays an important role in human health. Air pollution causes large increases in medical expenses, morbidity and is estimated to cause about 800,000 annual premature deaths worldwide [5]. Much research [2, 3, 7, etc.], digital maps and standards [6, 8, 12] on the health effects (respiratory effects, cardiovascular effects, cancer, reproductive and developmental effects, neurological effects, mortality, infection and other health effects) of outdoor air pollution has been published in the last decade. Levels of priority air pollutants often exceed these limits in many parts of the world, especially in large cities.

Above and other problems are related with built environment air pollution, premises microclimate, health effects, real estate market value, etc. However, a Real Estate's Market Value, Pollution and Health Effects Analysis Decision Support System (RE-MVPHE-DSS) can in integrated way to analyse above factors. No-one thought of the above integration function before, so this attempt is the first. The authors of this paper participated in the project Framework 6 *Intelligent Cities* (INTELCITIES) and the Lincoln Institute of Land Policy Fellowship *Development of Market-Based Land Mass Appraisal Online System for Land Taxation*. One of the above project's goals (on the Lithuanian side) is to develop and improve Real Estate's Market Value, Pollution and Health Effects Analysis Decision Support System (RE-MVPHE-DSS) that can use best practices as well as explicit and tacit knowledge.

This paper is structured as follows: following this introduction, Section 2 describes Real Estate's Market Value, Pollution and Health Effects Analysis Decision Support System. Finally, some concluding remarks are provided in Section 3.

2. REAL ESTATE'S MARKET VALUE, POLLUTION AND HEALTH EFFECTS' ANALYSIS DECISION SUPPORT SYSTEM

Real Estate's Market Value, Pollution and Health Effects Analysis Decision Support System (RE-MVPHE-DSS) consists of a Market Value Analysis [9], Air Pollution, Premises Microclimate

Analysis [9], Health Effects, Voice Stress Analysis, IRIS Recognition, Cooperative Decision Making and Multiple User Subsystems. A more detailed description of the Air Pollution, Health Effects, Voice Stress Analysis, Cooperative Decision Making and Multiple User Subsystems will follow.

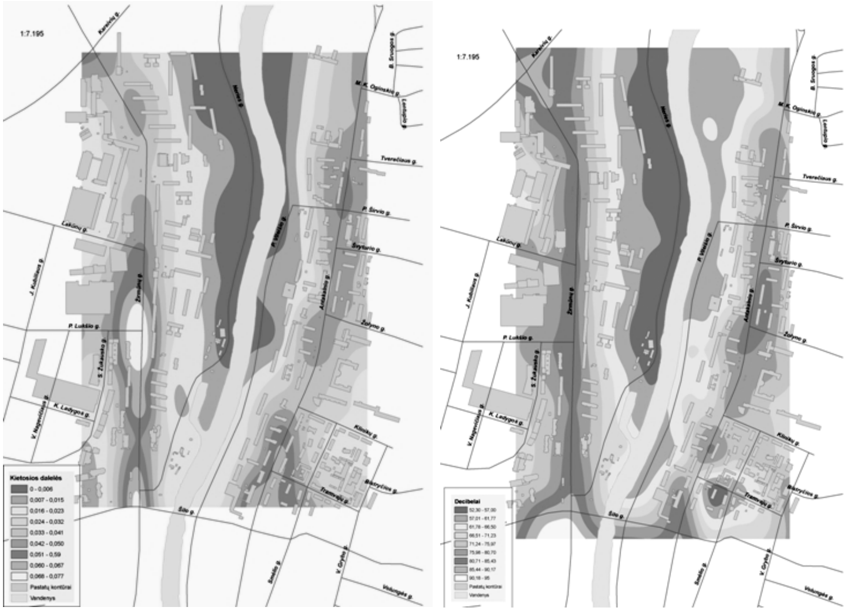

Fig. 1. *Concentration level of particle pollution (left) and the noise level in Antakalnis-Zirmunai Districts (right)*

2.1. Air Pollution Subsystem

Antakalnis and Zirmunai area of Vilnius alongside the river have been chosen in order to develop pollution digital maps. Vehicles are the greatest environment pollution sources in the analysed area. Morbidity in chronic bronchitis is by 72% higher among residents of the polluted districts than of non-polluted districts. Morbidity in other respiratory system’s diseases is noted to increase similarly in such areas. Another important trend is the relation between air pollution and morbidity in acute myocardial infarction. Studies of environment pollution show that higher concentrations of CO, NO_2 and SO_2 determine higher rates of morbidity in respiratory system and other diseases.

The level of carbon monoxide should not exceed 5 mg/m^3. It is found that CO concentration exceeds the normative requirements in Silo Street at the crossroads with Antakalnio and Zirmunu Streets by reaching 7.15 mg/m^3. Volatile organic compounds are vapours of any composition emitted by oil-based products. The highest allowed concentration in the air of residential environment is 5 mg/m^3. Analysis shows that norms are exceeded at the crossroads of Zirmunu and Kareiviu Streets and in sections of Antakalnio Street that have more intensive traffic.

2.2. Health Effects Subsystem

Health Effects Subsystem received information from Air Pollution Subsystem about pollution (carbon monoxide, noise, particle pollution, volatile organic compounds, nitrogen dioxide, etc.) and developed digital maps on the health effects (see Fig. 2).

EU pays considerable attention to preservation of the environment. It is recognised that environment pollution affects development, health and efficiency of humans negatively, and negative effects are evaluated in billions of Euros. Morbidity in chronic bronchitis is by 72% higher among residents of the polluted districts than of non-polluted districts in Vilnius. Morbidity in other diseases of respiratory system is noted to increase similarly. Studies of environment pollution show that higher concentration of CO, NO_2 and SO_2 determines higher rates of morbidity in respiratory system and other diseases.

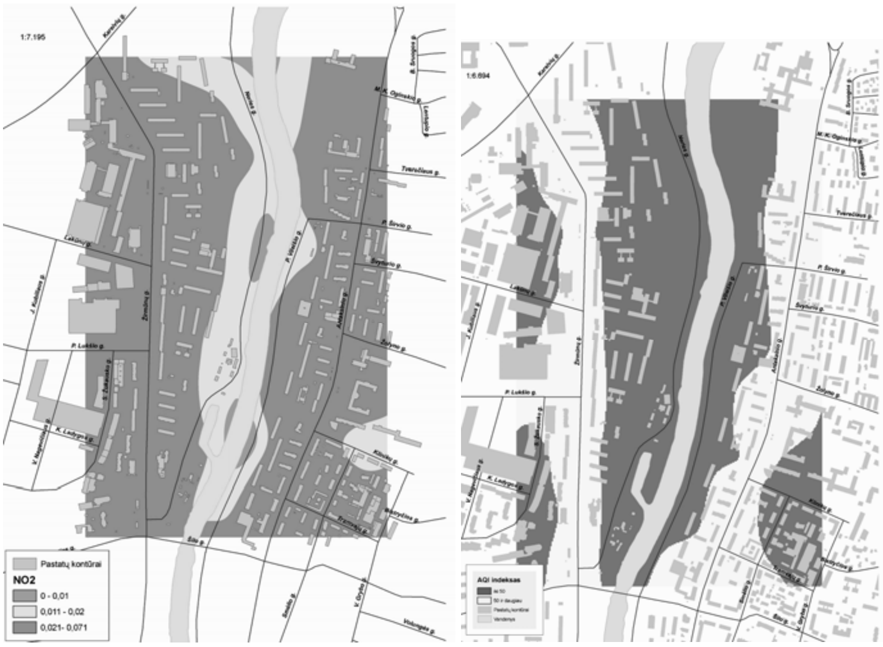

Fig. 2. *Zones of concentration of NO_2 (left) pollutions dangerous to people with respiratory disorders and asthma and pollution effect for human health (right)*

Several initial digital maps of respiratory disorders and asthma have been prepared on the basis of the above digital pollution maps. These Digital maps show clear zones of pollutant concentrations that are dangerous to people with respiratory disorders and asthma. Digital maps show the zones with dangerous concentration of CO and NO_2 (marked in red). Such concentration of pollutants can cause respiratory disorders and asthma (see Fig. 2).

2.3. The Voice Stress Analyser

The Voice Stress Analyser (VSA) Subsystem measures stress in a human voice. VSA Subsystem can be used for analysis of different situations in built environment (work of brokers, analysis of stakeholders' subjective opinions about pollution and health effects, etc.). It is necessary to develop statistical information database in order to efficiently use VSA Subsystem in practice.

The practical application of the Voice Stress Analyser (VSA) Subsystem in sales of real estate is briefly analysed as follows. A typical situation of a first visit to an apartment is selected. The discussion between the seller and the broker inspecting an apartment for sale is recorded (consent from both). Standard questions are asked during the conversation. Advantages and disadvantages of an apartment are detected, the sales price is established, as well as the size of the broker's commission and negotiations on conclusion of a mediation agreement. The VSA Subsystem analyses the record, shows the vibration curve of a sound document, which indicates the sound frequency in real time. If a sound frequency is high, the oscillation of the sound curve is denser. Such density of oscillations of a sound curve shows that a person is not sure of the correctness of his/her statement or conceals some truth. For example, it has been noticed that a sound vibration curve typically is very dense when a client speaks about the brokering contract. Evidence provided by the VSA Subsystem can show whether a client's statement is false or doubtful.

The research determined that people are usually unsure or conceal a part of truth when speaking about brokering contract, exact floor area of an apartment, furniture for sale with the apartment, sale's price of the apartment, and remuneration to a broker, etc. All these criteria are essential in the activities of a broker. False information may leave a broker without remuneration for the work. Knowledge that a client is lying when he/she speaks about such things can also protect a broker against fraud. Currently, when sufficient statistical information is not available yet, it would be wrong to rely on evidence provided only by the VSA Subsystem. However, it can help to avoid a number of misunderstandings and other problems.

Fig. 3 provides a graphic expression of the sound vibration curve at the moment when the client speaks about the conclusions of an agreement on mediation.

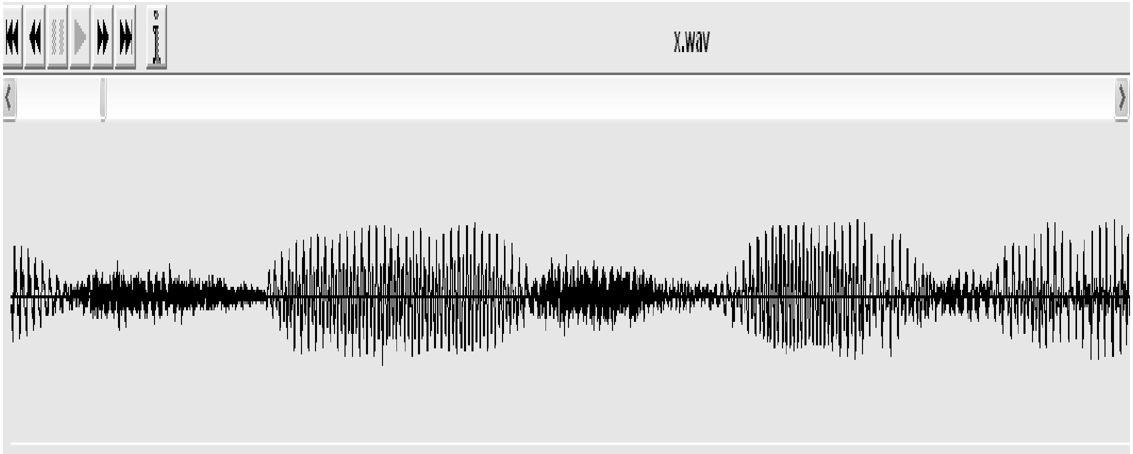

Fig. 3. *Sound vibration curve at moment when client speaks about conclusion of an agreement on mediation*

A company can use the VSA Subsystem for its specific purposes, e.g. at conferences, during reports to a top manager and at other meetings. Thus the head of a company will have an opportunity to analyse the information, requests and opinions, etc., provided at a meeting and to make decisions on the basis of the evidence of the VSA Subsystem as well as the manager's logical thinking. Such application of the system would not be difficult, because internal regulations of a company allow a head to collect and use information about the company's personnel. Besides, the obtained information would help to meet client's needs and the company's employee's needs in better ways.

For instance, a relationship between the deviation from the real area of apartment deliberately increased by the seller (in per cent) and the average micro tremor frequency of the voice when claiming bigger floor area is presented on Fig. 4. The x-axis shows the deviation (in per cent) of the increased area of the apartment (compared to the real) specified by the seller during the conversation. The y-axis shows the scale of the average micro tremor frequency noticed in the seller's voice during the conversation. Besides, the Fig. 4 clearly shows the relationship between the level of untruth told by the seller and the average micro tremor frequency. The higher the average micro tremor frequency the more area is added to the real area of an apartment.

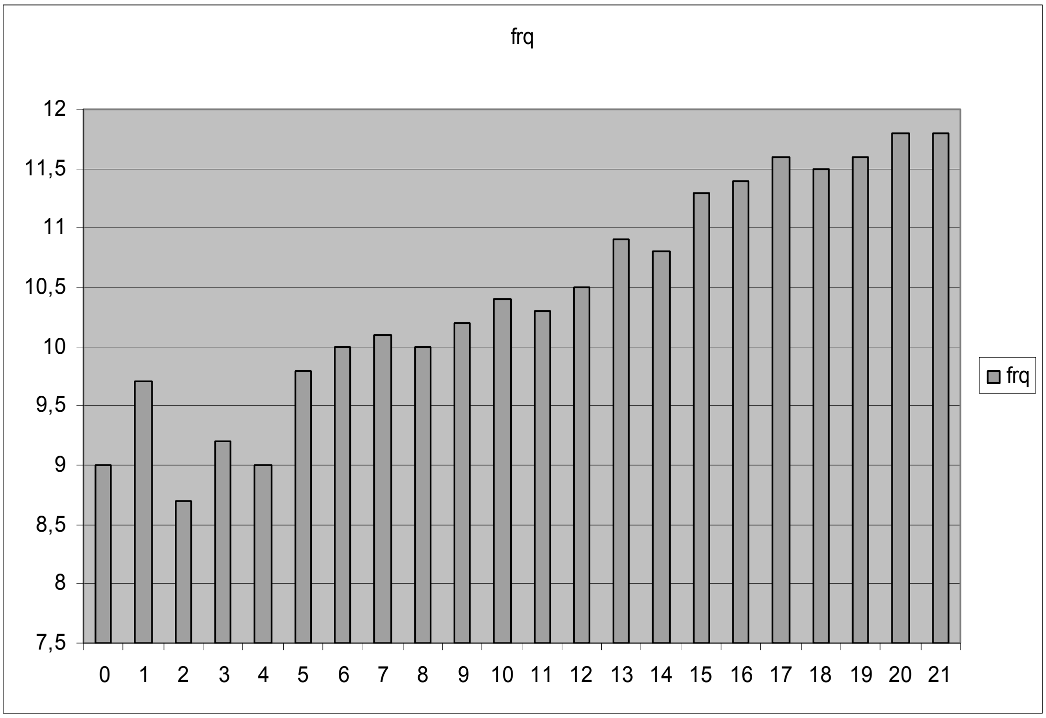

Fig. 4. *The relationship between the deviation from the real area of apartment deliberately increased by the seller (in per cent) and the average micro tremor frequency of the voice when claiming bigger floor area*

In the future there will be a possibility to assess correctness of provided information (in %) automatically by using VSA Subsystem on the basis of accumulated historic statistical data and determined regression equation. For example, according to a seller's answer about the floor area of an apartment, the VSA Subsystem would automatically convert the answer into frequency and specify the actual floor area of an apartment and the percentage of deviation from the floor area of the apartment as specified by a buyer.

2.4. Cooperative Decision Making Subsystem

Cooperative Decision Making Subsystems take more and more importance in the world. Cinderby and Forrester [4] report on a novel empirical approach to capturing and analysing public non-professional understanding of spatially related environmental issues and representations of local knowledge about air pollution and related problems. Public participation is an essential part of sound and legitimate political decision-making, since the awareness of environmental problems on the side of potential investors and that of the public may have a significant effect on environmental protection in the area [10]. Environmental impacts of air pollutants have impact on public health, vegetation, material deterioration, etc. [11].

Currently intelligent systems for real estate have been mostly looked at from a single-broker perspective, where only the purposes of a single client are taken into account. Cooperative Decision Making Subsystem considers the circumstance where a group of clients are planning a common real estate purchase, and therefore many potentially conflicting objectives have to be analysed. The Cooperative Decision Making Subsystem allows different stakeholders (e.g. family members) to solve common tasks in collaborative ways (e.g. development of joint criteria system, estimation of criteria weight and qualitative criteria values). RE-MVPHE-DSS helps a group of clients to achieve a cooperative decision on Web-based real estate search, analysis, negotiation and decision-making. This is done by transforming individual client models to the collaborative (medium) client model (decision-making matrix) and by using this model to mediate, a kind of group discussion with the goal to arrive at a compromise that is acceptable to all group members results. The Cooperative Decision Making Subsystem allows stakeholders to share ideas and to vote and select the one with the highest votes as a jointly accepted real estate alternative. The above helps to decrease mistrust problems, and allow one to apply multiple criteria methods as developed by the authors [13].

2.5. Multiple User Subsystem

The Multiple User Subsystem (MUS) stores data that is specific to each individual user. The MUS is used to accumulate information about the requirements, preferences and needs of a client for real estate, his/her financial capabilities, etc. Therefore, the MUS accumulate information about the aggregate client's requirements for real estate. The MUS starts by collecting the user's needs and knowledge of the required real estate or what the user already wants and knows. Sometimes users do not know or do not fully understand the importance of some information characterising the real estate, e.g. surrounding pollution and noise, and/or the interior's microclimate. The MUS uses the above data to create a representation of the user's requirements and knowledge and represents the client's knowledge in terms of deviations from an expert and a typical real estate seeker's knowledge. On the basis of these deviations it is possible to decide what criteria, or criteria weights and values should be added to the user's decision making matrix. During the e-negotiation process, brokers and user may take different perspectives but must reach an agreement in that they share the same understanding of searching and analysing for real estate alternatives. The found real estate alternatives, according to a set of searching parameters, are considered to be a part of the MUS. The significance of the analysed real estate alternatives for a user is measured by priority, utility degree and market values of alternatives that are under consideration. Also, the MUS research focuses on the Statistical Model that is statistically generated, find the average criteria system and criteria weights. In particular, clients are able to study and utilize the typical real estate seeker model (typical criteria system and criteria weights), by allowing users to see what can be inferred about the client from the typical real estate seeker model. Development of the MUS is a systematic process for continually improving the typical real estate seeker model by learning from different user's navigational and decision-making activities.

The addition of incorporating new knowledge is performed so that credible statistical information is gained and client’s activities are modified by historical experience.

Last years the Statistical Model has accumulated information about users’ navigational activities and decision-making. Concrete statistics on the level of real estate, about users’ navigational activities (the number of concrete real estate alternative visitors, the time period of analysing this alternative) and decision-making (selection of criteria system, criteria values and weights) is collected in the Statistical Model. The statistical information the authors have used to determine the most marketable real estate, and the most important criteria and their weights. The received statistical information reflects the navigational purposes of users. The ability to statistically measure the users’ navigational activities allows one to statistically generate the average criteria system and criteria weights for a typical real estate seeker. This solution improves the accuracy of the development of criteria system and criteria weights for the user. Statistical Model delivers proposals for development of a decision-making matrix by using historical clients' statistical information according to how well the real estate’s properties satisfy a client's preferences. Statistical Model integrates the concrete real estate’s level of statistics about a user’s navigational activities in a typical real estate seeker model. The above statistical information is also utilized to supplement the MUS so as to better adapt the searching process to the user’s needs.

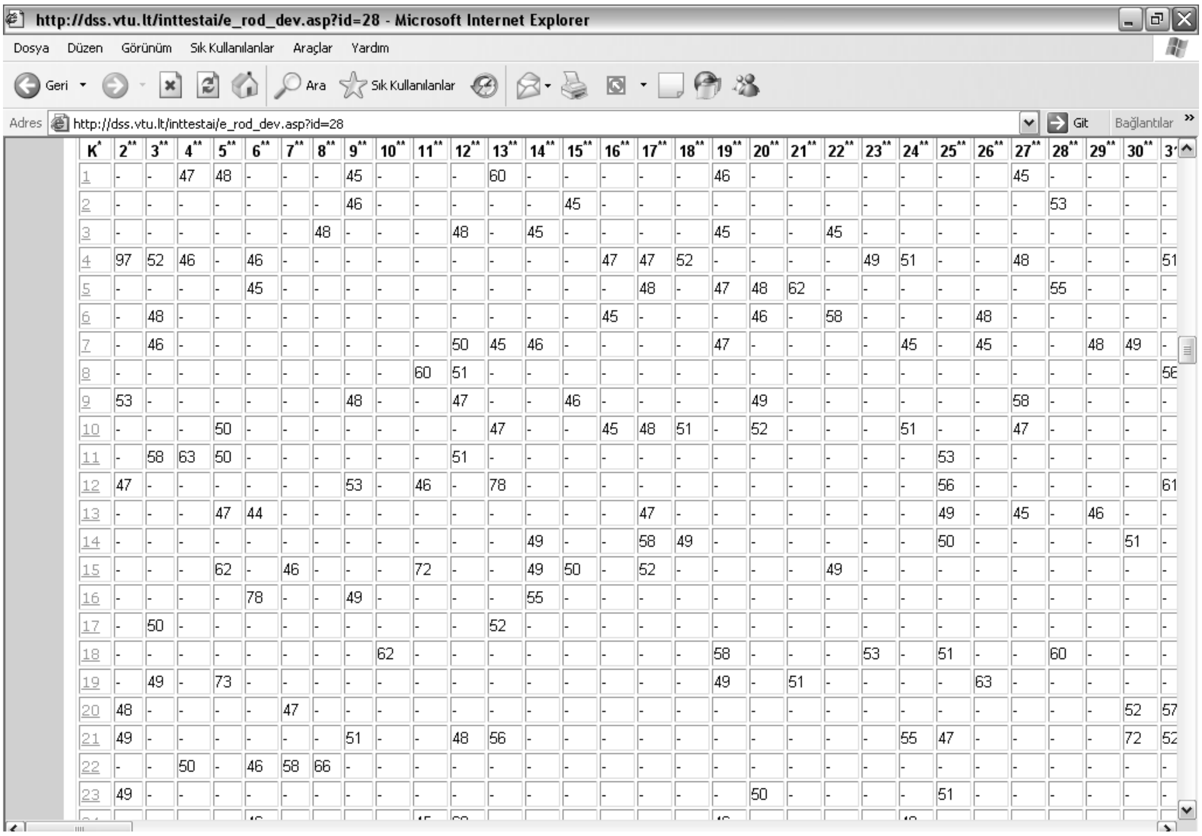

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Fig. 5. *The time period (seconds) of analysing the real estate alternatives by different clients*

All members of a real estate market can use the created system. Members are recommended to use as much of their knowledge as possible before making final decisions. For example, in order to perform the multiple criteria analysis of a real estate, buyers, sellers, brokers, financial institutions, neighbours and other stakeholders’ requirements should be estimated and submitted in a quantitative form.

2.6. IRIS Recognition Technologies in Real Estate

An IRIS Recognition Subsystem using the analogy of the Voice Stress Analyser Subsystem is developed. Similarly to the Voice Stress Analyser Subsystem, the IRIS recognition technology can show the relation between changes of the eye’s pupil and the emotional condition of a person. The

IRIS Recognition Subsystem uses technology to identify features particular to each student's eye. The IRIS Recognition Subsystem is technology for the measurement of human physiological or behavioural features. Current research is searching for a relationship between the change of an iris' diameter and the emotional condition. During research, a micro-camera is mounted in front of a student; the camera records changes of the diameter of the student's iris and passes the data to a PC. Special software takes pictures of the iris every three seconds and saves the results into a PC's hard-drive in separate files. By using the *Matlab* software and accessory scripts, the diameter of the iris is calculated by using the pictures, and the determined changes are saved into a database. For a final result, a database which keeps students' answers to questions and the information about a change of the diameter of the iris during examination (every three seconds) is developed. A possibility is planned to assess student's knowledge using automated measures on the basis of the accumulated data and determined causal relationships in the future. For example, when a teacher asks a student about the level of his/her preparedness for an examination, the IRIS Recognition Subsystem will automatically assess the student's knowledge according to the average number of changes in the student's iris and on the basis of the accumulated data and determined causal relationships.

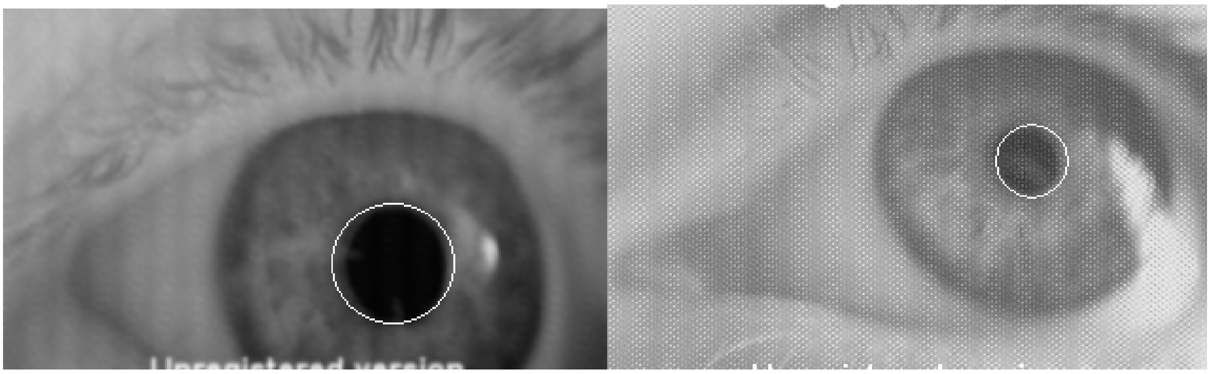

Fig. 6. *Captured images of the Student's IRIS in a stress and being relaxed*

CONCLUSIONS

The authors of the present research have suggested the idea of integrating knowledge-based, devices-based, environment friendly and decision support systems. In order to demonstrate the integration decision support, environment friendly, knowledge and devices systems in the real estate sector, a Real Estate's Market Value, Pollution and Health Effects Analysis Decision Support System have been considered in the paper as an example.

References

1. American Lung Association, 2005. American Lung Association, State of the Air 2005. Available online – http://lungaction.org/reports/sota05_heffects3a.html
2. Atkinson, R.W., Anderson, H.R. and Sunyer, J. Acute effects of particulate air pollution on respiratory admissions: results from the APHEA2 study, *Am J Respir Crit Care Med 164*, 2001, pp. 1860-1866.
3. Brook, R.D., Franklin, B., Cascio, W., Hong, Y., Howard, G. and Lipsett, M. et al. Air pollution and cardiovascular disease: a statement for healthcare professionals from the expert panel on population and prevention science of the American Heart Association, *Circulation 109*, 2004, pp. 2655-2671.
4. Cinderby, S., Forrester, J. Facilitating the local governance of air pollution using GIS for participation, *Applied Geography*, Vol. 25, Issue 2, April 2005, pp. 143-158.
5. Cohen, A.J., Ross, A. H., Ostro, B., Pandey, K.D., Kryzanowski, M. and Kunzail N. et al. The global burden of disease due to outdoor air pollution, *J Toxicol Environ Health A 68*, 2005, pp. 1-7.

6. Environmental Management Centre, 2006. Environmental Management Centre. A comparison of ambient air quality standards applied worldwide (2006) Available online – http://www.emcentre.com/econnection/RW_AQStd.htm
7. Grossman, C.M., Nussbaum, R.H. and Nussbaum, F.D. Cancers among residents downwind of the Hanford, Washington, plutonium production site, *Arch Environ Health 58*, 2003, pp. 267-274.
8. Hubbell, B.J., Hallberg, A., McCubbin, D.R. and Post, E. Health-related benefits of attaining the 8-hr ozone standard, *Environ Health Perspect*, Vol. 113, 2005, pp. 73-82.
9. Kaklauskas, A., Zavadskas, E., Ditkevičius, R. An Intelligent Tutoring System for Construction and Real Estate. Lecture Notes in Computer Science. 2006, 4101, pp. 174-181.
10. Peterlin, M., Kontic, B., Kross, B. C. Public perception of environmental pressures within the Slovene coastal zone, *Ocean & Coastal Management*, Vol. 48, Issue 2, 2005, pp. 189-204.
11. Pummakarnchana, O., Tripathi, N., Dutta, J. Air pollution monitoring and GIS modeling: a new use of nanotechnology based solid state gas sensors, Science and Technology of Advanced *Materials,* Vol. 6, Issue 3-4, April-May 2005, pp. 251-255.
12. US Environmental Protection Agency (EPA), 1987. US Environmental Protection Agency (EPA), Revisions to the National Air Ambient Air Quality Standards for particulate matter, *Fed. Regist.,* 52, 1987, pp. 24634-24669.
13. Zavadskas, E. K., Kaklauskas, A., Vainiūnas, P., Šaparauskas, J. A model of sustainable urban development formation, *International Journal of Strategic Property Management,* Vol. 8, No. 4, 2004, pp. 219-229.

VEHICLE ROUTING PROBLEM FOR CITY SERVICES SOLUTION BY HYBRID GENETIC ALGORITHM

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The problem of optimization of routes of visiting of the set points with the fixed duration of stops in order to avoid the specialized transport in streets with the maximal congestion in demanded time is considered. Firstly, stops consistently bring in fixed by the number of points clusters with a minimum average distance between all points of the cluster. It uses the techniques of dynamic programming. The number of clusters, and hence the required number of routes, are determined experimentally. At the second phase of optimisation the shortest route within each cluster is selected using genetic algorithms. The results of calculations are tables and charts routes.

Keywords*:* intelligent control, optimisation, vehicle routing problem, dynamic programming, genetic algorithms

1. INTRODUCTION

Transport infrastructure is one of the most important elements, providing the modern city vital functions. Permanent increasing of the urban traffic volumes and intensity leads to extreme loading of main city roads. Consequently, the effects of 'bottleneck", heightened noise and gas pollution are analysed in the article. Last decade the possibilities of extensive development of the city transport infrastructure are finished or near to come to an end for many large cities, including Riga, the capital of Latvia. It is especially important here to obtain the compatibility of public, cargo and car transport so, that it not provides the problems to each other [6].

The observations reveals the most congested streets during rush hours in the central part of Riga. It is found that the routes of municipal special vehicles, the so-called honeywagons for handling and removal of domestic waste exist during the same time on the same streets and roads. The waste handling stops the city vehicles on the road and it takes the lane that greatly exacerbate the difficult situation. To prevent the negative impact of the honeywagons on the characteristics of traffic (average speed and capacity of the road), it is necessary to re-route traffic (in time and distribution of stops for domestic waste handling).

2. THE ANALYSIS OF TRANSPORT FLOWS IN RIGA CENTRE DURING THE PEAK HOURS

The handling of domestic waste from the central part of Riga has remained virtually unchanged over the years. Honeywagons like all the participants in urban traffic, moves at its own pace and has a great impact on the traffic flow in a whole. To assess the impact of the honeywagons in the city traffic it is important to study the characteristics of traffic flow during the peak hours.

2.1. Analysis of Intensity and Speed During the Peak Hours

The most informative features of traffic is the intensity and high speed. The data for 2003 at 8.00 AM in working days are presented by the Transport Department of Riga City Council (TD RCC) (Fig. 1). For data correction of the average speed of traffic in the streets of Riga and the changing flow during peak hours the measurements of these parameters on seven specific intersections in the city in November 2006 were fulfilled. Topology of the existing transport network leads to traffic concentration on the streets Kr. Valdemāra, Brīvības, Kr.Barona, Marijas-Čaka, Valmieras directed to the bridges crossing the Daugava and the overpasses. Intersections for measurements are shown in Fig. 1. Measurements are performed on weekdays from 7:30 to 10:00 at 6 street intersections: Brīvības (junctions No 2 and 3), Kr. Barona (junctions No 4 and 5), Čaka (junctions No 6 and 7) with Lāčplēša and Bruņinieku streets (see Figure below) in two directions to the centre and from the city centre. Separately investigated intersection of streets Kr. Valdemāra un Elizabetes (intersection No 1). Measurements at this crossroads held by street Kr. Valdemāra in both directions in the morning rush hour (from 7:30 to 10:00) and night (from 17:00 to 19:00). The results of measurements of the intensity and the changes in flow are presented on the Figure 2. For ease of use in the calculation the dates of the speed are presented in relative form.

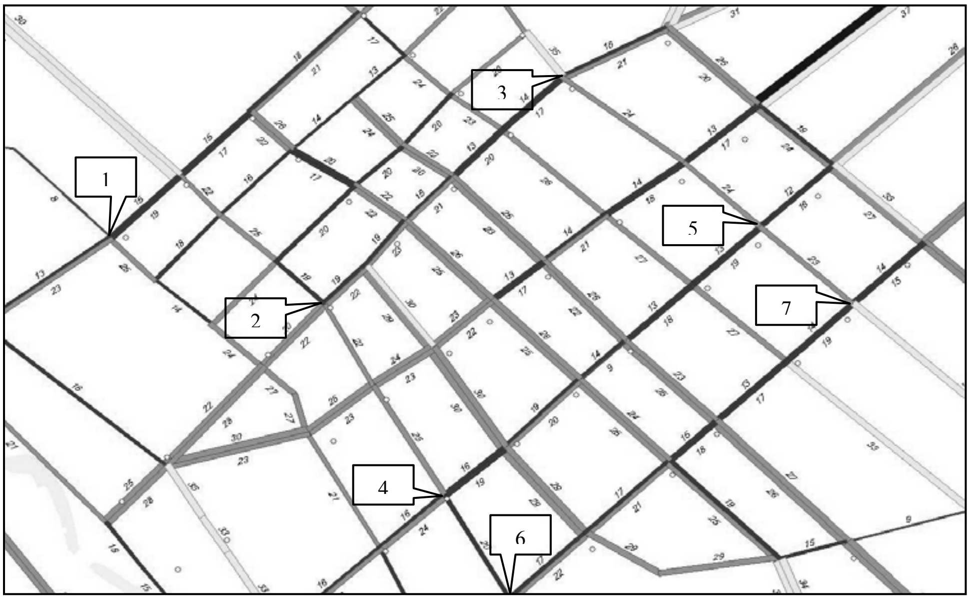

Figure 1. *Vehicle velocities at the Riga historical centre (RDSD data). The intersections are marked in the scheme, where the measurements are obtained by the reseachers*

Handling of domestic waste goes on as follows – company's "L&T Hoetika" honeywagons move on the given routes with a fixed time stops on the road to definite addresses. The duration of each stop range from 1 to 5 minutes for load of rubbish.

Currently, in the central part of Riga operate 10 routes. The studies selected routes in the region, limiting the following streets:

- Marijas-A. Čaka;
- Kr. Valdemāra;
- Raiņa blvd.;
- Pērnavas.

Some of the routes run on the busiest streets in the city centre. Honeywagons have to stop on the right side of the street thus blocking and greatly reducing the capacity of the streets. The time of the routes service coincides with the peak hours (see Fig. 3). Therefore, when planning the best route, it is necessary to avoid stopping these cars on the streets with heavy traffic during the peak hours.

The addresses of handling of domestic waste in these streets should be served before or after the peak hours (7:30 till 10:00 in the morning, 17:00 till 19:00 in the evening). Due to the above-said it can be identified sites streets to be closed for maintenance during the peak hours. Fig. 4 demonstrates schematically the street sites that must be closed for maintenance in the city centre. These sites are as follows:

1. Pulkveža Brieža (from Elizabetes till Hansas)
2. Krišjāņa Valdemāra (from Merķeļa till Stabu)
3. Brīvības (from Merķeļa till Krišjāņa Barona (overpass))
4. Krišjāņa Barona (from Merķeļa till Brīvības (overpass))
5. Marijas-Čaka (from Merķeļa till Pērnavas)
6. Avotu (from Pērnavas till Marijas-Čaka)
7. Valmieras (from Ģertrūdes till Tallinas-A.Deglava)
8. Tallinas (from Brīvības till Čaka)
9. Pērnavas (from Brīvības till Čaka)

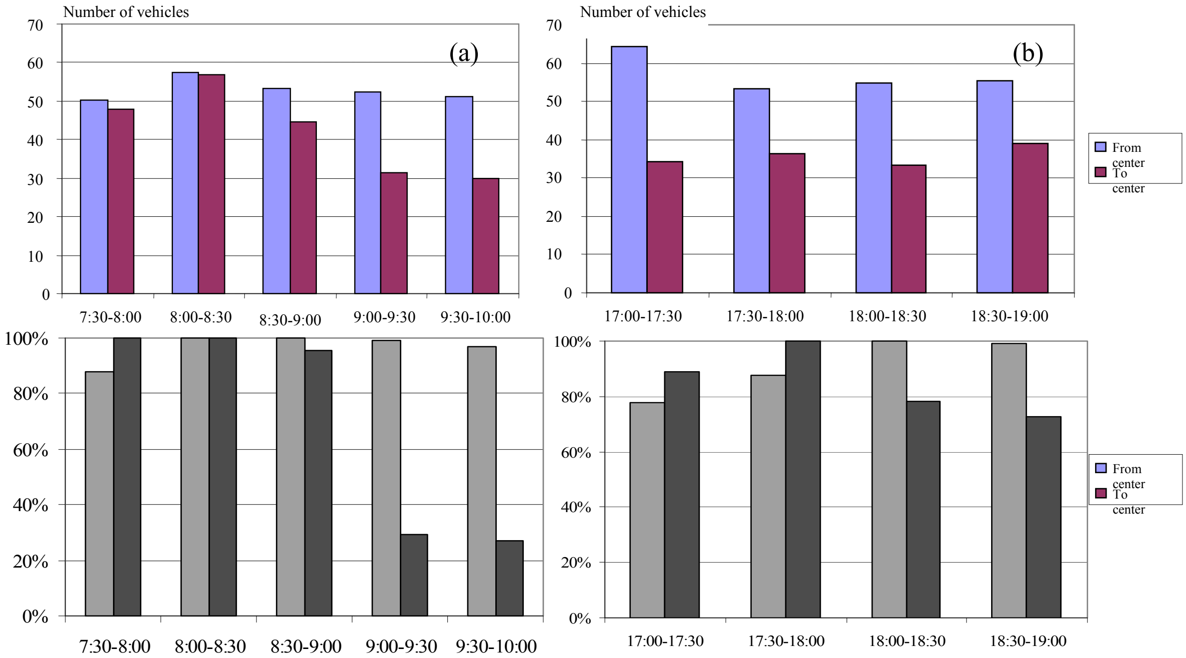

Figure 2. *Transport flows relative speed and intensity Kr. Valdemāra and Elizabetes streets intersection (No 1) a) morning (from. 7:30 till 10:00); b) evening (from 17:00 till 19:00)*

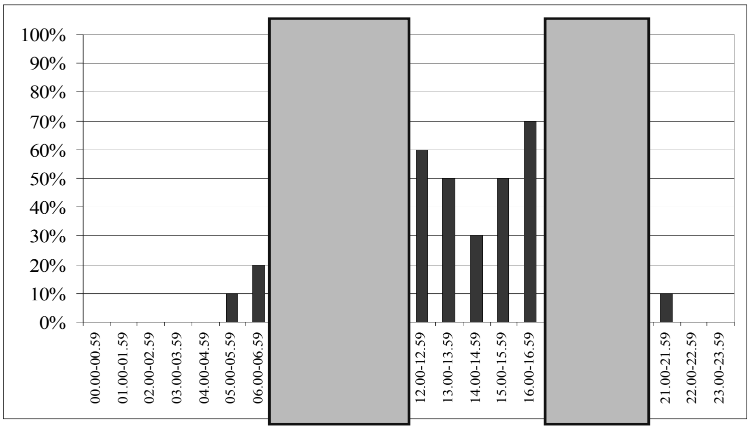

Figure 3. *Intensity of traffic in rush hours in the Riga center*

Figure 4. *Streets of intensity of traffic in peak hours in the Riga centre*

2.2. The Restrictions Imposed on the Planning of Routes

- maintenance of critical areas (see Fig. 4) shall not occur during peak hours (7:30 till 10:00 in the morning, 17:00 till 19:00 in the evening), i.e. the vehicle can pass only on the specified streets without service (stops);
- the full service time should not exceed that exists for today more, than on 30 minutes in the morning and in the evening;
- stop addresses and time of stop are given;
- movement shall be subjected to the rules of the road and the existing road network;
- distribution of vehicles for each route should be consistent.

2.3. Conventional Average Speed of Traffic in the City Centre

- before 7:30 and after 19:00 speed is assumed to be 25 km/h on the main streets and 15 km/h on the other ones;
- peak hours (7:30 till 10:00 in the morning, 17:00 till 19:00 in the evening) the speed is taken from the data of Riga City Council Transport Department (Fig. 1);
- in the most congested streets in rush hours speed was corrected according to data of measurements (Fig. 4) up to 5 km/h

3. DESIGN OF THE DIGITAL MODEL FOR ROUTES OPTIMISATION

The best routes are considered the routes that are satisfying to the most of the conditions described in the previous section. To design optimal routes, as the main criteria are selected minimum total length of the route and full-time service let minimize the vehicles situation on the streets of the city at the peak hours.

3.1. Problem Formalization

Problem formalization can be carried out in two phases: the first one is focused on the description of the initial data, and the second is to bring the data in a format suitable for the selected algorithms.

An initial task is formulated for the oriented graph $G = \langle V,E \rangle$ of city streets, the vertexs $V=\{v_1,v_2,\dots v_n\}$ of the graph are intersections, and arcs $E = \{e_1,e_2,...e_m\}$ are the lanes of the roads. Note that the number of lanes on the road is not taken into account, instead, each arc contains the information about the length of the segment of road through a function $d{:}E\rightarrow R^+$, as well as information on two speeds: $u{:}E\rightarrow R^+$ for normal traffic during $t \in T$ and $u^*{:}E\rightarrow R^+$ for traffic during peak hours $t \in T^*$. Thus, $d(e_i)$, $u(e_i)$ and $u^*(e_i)$ denote the length of the road segment e_i, average speed to navigate under normal circumstances, and the average speed during peak hours respectively. Such flagrant division of the time T and T^* has two reasons: the first is that it is possible to divide the task in time for two similar homogeneous sub-tasks, independent of the time, and second is that only measurements of this data are made. Among the other arcs there is a special subset of E^*, the so-called critical spots. Such arcs e_i where the ratio of $u(e_i)/u^*(e_i)$ more than any value w_{crit}, indicating how much time is reduced speeds during peak hours on the streets: $E^*= \{e_i \in E \mid u(e_i) / u^*(e_i) > w_{crit}\}$. In Riga, these zones are shown in Fig. 4.

Supporting functions $from{:}E\rightarrow V$ and $to{:}E\rightarrow V$ are used to determine how crossroads each arc starts and where it ends. Traffic rules are defined as $q{:}E\times E\rightarrow R^+$, defined only on the pairs e_i and e_j for whom $to(e_i) = from(e_j)$. This function determines the time it takes to move from one arc to another, for those arcs, where can pass consistently (average time for travel or turn). For those arcs, which can drive consistently, according to the graph structure, but it is forbidden by the traffic rules, function q relies equal ∞, and for other non-adjacent it is not defined. In the same manner the function $q^*{:}E\times E\rightarrow R^+$, defining rules and delays to move between the arcs during peak hours, is given. Function $follow{:}E\rightarrow 2^E$ put to response to each arc the set of arcs that can be visited from the arc in accordance with the rules of traffic *follow*$(e_i) = \{e_j \in E \mid q(e_i,e_j) < \infty\}$. Graf G is strongly coherent, and there is additional restriction $\forall e \in E, follow(e) \neq \varnothing$. It means that traffic rules do not violate destination possibility of any intersection from any other point (similarly determined $follow^*$ for rush hours, and the graph G imposed similar restrictions). The graph with listed above properties, we will call as *coherent with the roads*.

Instead the length of the routes here we will have a duration of these routes. We define it only for a given time interval T and T^* affecting to the speed. Temporary route duration $t(r)$, where $r = (e_{i1},e_{i2},\ldots e_{ik})$, and $to(e_{ij}) = from(e_{ij+1})$, is described by the following ratio:

$$t(r) = \sum_{j=1}^{k} \frac{d(e_{ij})}{u(e_{ij})} + \sum_{j=1}^{k-1} q(e_{ij}, e_{ij+1}) \text{, for } T \text{ and } t^*(r) = \sum_{j=1}^{k} \frac{d(e_{ij})}{u^*(e_{ij})} + \sum_{j=1}^{k-1} q^*(e_{ij}, e_{ij+1}) \text{ for } T^*. \tag{1}$$

It should be noted that the city roads graph, or the graph any one part of the city, is likely to be coherent with roads without additional constructions. In this case, we will designate its $G^- = \langle V,E^- \rangle$. The set of intersections V may not be changed here. This is because the city or separate parts of it, are open systems, and have incoming and outgoing arcs connecting them with the rest of the world. In some cases, the arc can be excluded from consideration, but this may result the loss of important information. Particularly it is clear in the case of segments of the road network with a single track. To bring the graph to road-coherent form, we will take a special operation of *connection*. Let's consider the outside world as the graph $G^+ = \langle V^+,E^+ \rangle$, where G^- is subgraph. G^+ supposed to be linked to the road (at least, providing a continental transport system). Then let's define the perimeter P of graph G^- as a minimal subset of vertices $P \subseteq V$, where each route with the ends in opposite sets V and $V^+ \backslash V$ necessarily contain at least one vertex of P (in real practice it is the entrances and exits from the city). In assumption that the graph G^- is not coherent with the roads and G^+ is coherent, it appears that there are pairs of intersections lying on the perimeter P that the duration of time for any route r, laid on the G^- owned arcs, is not less ∞. At the same time, among the routes laid on G^+ owned arcs, there is at least one route, where $t(r) < \infty$. The shortest of the routes we turn to artificial rib, with a time and speed characteristics, equivalent to the shortest route. Likewise, we come with all the vertex pairs V, for which there is no finite route in G^-. We add to another set E^-. It is not difficult to show that the resulting graph will be coherent with roads, and imposed artificial arc permit application natural interpretation – leave and enter the city on the shortest route.

Then we define the set of clients $C = \{c_1,c_2,\ldots c_k\}$. The time of customer service c_i is given as functions $s{:}C \rightarrow R^+$. Each customer attributed its arc through the function $g{:}C \rightarrow E$. The set of clients assigned to one e arc, we will designate as $dem(e)$. Thus, $dem{:}E \rightarrow 2^C$, and $dem(e_i) = \{c_j \in C \mid g(c_j) = e_i\}$, $\cup dem(e_i) = C$, $dem(e_i) \cap dem(e_j) = \varnothing$, when $i \neq j$. The time t_{serv} to be spent on customer service, assigned to e_i arc is a simple sum:

$$t_{serv}(e_i) = \sum_{c \in dem(e_i)} s(c) . \tag{2}$$

To simplify, let's say that customers of one arc operated simultaneously during t_{serv} because as a whole it corresponds to the vehicle behaviour, when it is riding down the street and serves all individuals points at the site. Thus, the task can be formulated by simpler terms of arcs visiting. A subset of arcs with the customers we can identify as E_{dem}.

Let's give the definition of *working route*. Working route $y = \langle r,b \rangle$ is a sequence of adjacent arcs $r = (e_{i1},e_{i2},\ldots e_{ik})$, $to(e_{ij}) = from(e_{ij+1})$, with the final value of $t(r) < \infty$ and supporting vector of remarks b (it will meet each element e_{ij} from r booleans remark of $\{0,1\}$. 0 means that the arc is only used for transportation, 1 – that at the present arc is also required to implement customer service (this is useful only for arcs from E_{dem}). The same arc may be present in the working route several times (also in the different routes), but only once and only into one route it can be serviced. If to designate by $b(y_i)$ set by arcs where the service in the working route y_i takes place, then such a set of working routes $Y = \{y_1,y_2,\ldots y_k\}$ when $b(y_i) \cap b(y_j) = \varnothing$, $i \neq j$ and $\cup b(y_i) = E_{dem}$, is called as *plan of services* [3, 6].

The time of start t_{enter} and finish of service t_{leave} is assigned for each arc in the working route depending on speed limits and the need for services have been accumulating since the time t_0. The selection of speed limits for the benefit of treatment if the time $t_{enter} \le t \le t_{leave}$ where $t \in T^*$, exists, leads to advantage of peak hours. Evaluations of this time can be easely calculated by linear interpolation of slots of t_{enter} и t_{leave} for the position of customer arc.

The task can be formulated as follows: find a service plan *Y*, where:

1. The arcs of E^* not served during the T^* (*restrictions*).
2. The beginning and end of each working route is the part of the route between t_0 and t_{end} (*restrictions*)
3. Number of routes leads to the minimum (*priority optimization*)
4. Total time (distance) of all vehicles is minimal (*residual optimization*).
5. All routes should obey traffic regulations, as well as to be "appropriate" to travel. It is a subset of the requirements 4, since these penalties and regulations are already substituted into the function *q*, used to calculate the time of travel.

Figure 5. *Graph G design using Google Maps*

There are two types of tasks, tentatively named "Morning" and "Evening". Both forms on the scale of time between t_0 and t_{end} a certain point t_x which symbolizes time of speeds change. But if in the morning version of this point it is the beginning of peak hours, or $T = [t_0;t_x)$ and $T^* = [t_x;t_{end}]$, in the evening, it conversely means the end of peak hours, $T^* = [t_0;t_x)$ and $T = [t_x;t_{end}]$. As a result, the principle of rush hour bus in the range of time (see the requirement 2), the tasks are different. It can be illustrated by the following sentences:

- Morning: there must cover all arc of $E_{dem} \cap E^*$ (critical arcs with the customers) until t_x moment;
- Evening: do not serve the arc of $E_{dem} \cap E^*$ t_x.

The breadboard model column G for a site of city Riga has been constructed on the basis of digital cards Google Maps (Fig. 5), from the same source have been received values *d(e)*. Most of the *u*(*e*) and $u^*(e)$ and $q(e_i,e_j)$ are generously provided by the Riga City Council Transport Department, and the missing information has been collected by students of Transport and Communications Institute by the method of experimental measurements. Information about clients *C*, their location *g*(*c*) and the time of operation *s*(*c*) is obtained from the JSC “Hoetika”, that also provided information on t_0 and t_{end} for morning and evening raids. The information about t_x is selected on the basis of the average speed in the sites of Riga. Thus, the model, as well as the initial data are on, which makes it possible to begin the task [8].

3.2. Further Formalization (data transformation)

It is not difficult to show that the goal can be done on a dual column *G’* = *<V’,E’>*, transforming the vertexes to the arcs, and saving the adjacency ratio for those vertexes, where the function *q* (corresponding to the other in the original graph) is finite. Thus, customers are concentrated in the vertexes of the graph, what is much closer by task formulation to the classic problems of TSP and VRP [1-5], and the rules of traffic are included here automatically. The distance (duration of time), t(v'_a,v'_b) between new vertexes v'_a and v'_b corresponding to arcs e_a and e_b calculated from the ratio:

$$t(v'_a, v'_b) = \frac{d(e_a)}{2 \cdot u(e_a)} + \frac{d(e_b)}{2 \cdot u(e_b)} + q(e_a, e_b)\ . \tag{3}$$

Time duration at the peak hours is defined analogically:

$$t^*(v'_a, v'_b) = \frac{d(e_a)}{2 \cdot u^*(e_a)} + \frac{d(e_b)}{2 \cdot u^*(e_b)} + q^*(e_a, e_b)\ . \tag{4}$$

The distances calculated in the graph, completely consistent with the distance between geometric middle points of the arcs in the original graph. Thus, we fully expected to turn to a new graph for calculations, which will call as *road dual graph*. It is not difficult to show that if a graph is coherent with the roads, then the road dual graph will be strongly coherent.

3.3. Applied Algorithms

The "morning" and "evening" tasks are based on preliminary data clustering, and then find the best routes within each cluster. There are several stages of clustering, which will be described below. But in any case, clustering occurred on the same manner:

1. Find the vertexes (seeds) of clusters (all of them will be N)
   - The first of them are chosen on a condition of the maximal total remoteness of vertex from all other vertexes;
   - Other seeds are chosen on a condition of the maximal total remoteness from already found vertexes-germs.
2. Step-by-step building clusters, ensuring that the time of service (exclusive of the time for transfer) in each cluster does not exceed the ratio of total time for all customer service to the number of clusters (except perhaps the last cluster, which can be served additionally).
   - Next vertex included in the cluster, is selected on the basis of minimal total distance (both direct and reverse) to all vertexes of already owned cluster.

To accelerate the calculations the pre-processing of the graph is applied here. It builds a matrix M={<t,t'>$_{ij}$} of direct and inverse distances only for those vertexes of the road dual graph, which asked for customer service.

To find the shortest path, passing through all vertexes of the cluster, using a modified genetic algorithm for conservative Travelled Salesman Problem (TSP) solution that does not require a return to the starting point. The individuals here are shifting of vertexes and fitness function is a time of travel (including processing time).

Conservatism consists that the operator of a crossover necessarily keeps in the affiliated individual all sub-routes, which meet in both parents, and the others sub-routes tries to choose so that they were present even at one of parents. Those sections of the route that are not included in the route in this manner, are included as conditions for minimization of received total length of the route (the "greedy" algorithm is used). Also apply improve operators *Opt-n* type (n = 2,3,4) [7].

Number of routes N in the plan is not minimized directly, but considered as experimental parameter. The variation of it is achieved for existance (on basis of the first two requirements).

3.4. The Results of Vehicle Routing (optimization)

The algorithm was applied to real data, so were following new lines of cars "Hoetika" in the Riga city centre, excluding servicing of critical areas during peak hours.

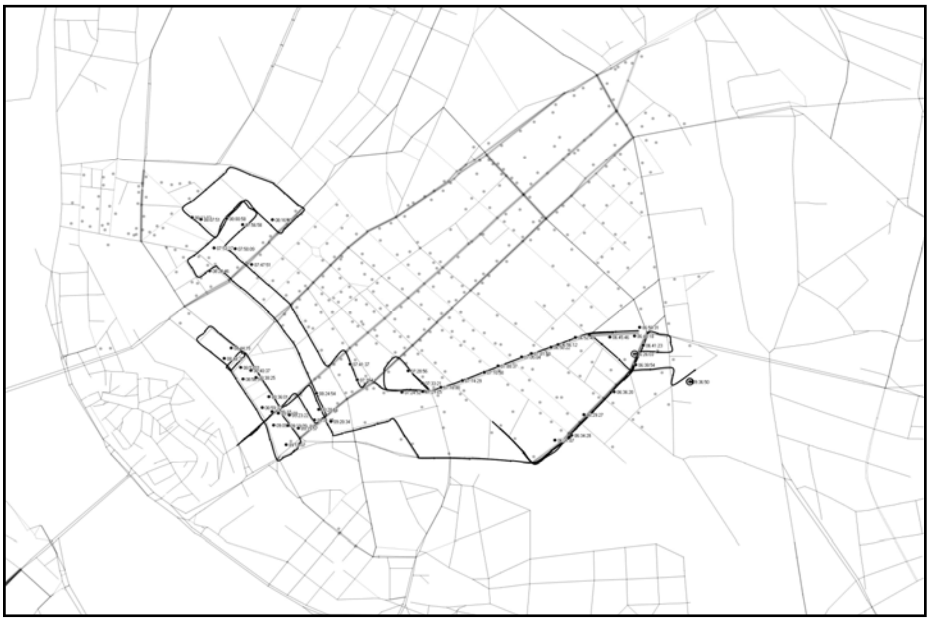

Figure 6. *The example of new route chart*

Table 1. The example of new route shedule

Stop No	Stop start	Stop finish	Adress	Duration (min.)
1	6:26:03	6:28:03	Valmieras 43	2
2	6:29:27	6:30:27	Valmieras 23	1
3	6:31:07	6:32:07	Valmieras 11	1
...	...	...	...	...

The computer calculations by successive approximation, the optimum route for vehicles separately in the morning and evening hours (Figure 6 and Table 1). Final results are showed in the form of charts and tables, each route schedule.

DISCUSSION

To prevent the emergence of waste collection vehicles at the busiest streets during the peak hours, it is recommended to change the schedule and routes. The calculations are routes that can be considered the best in terms of the criteria and restrictions listed in paragraph 2.2 and 2.3. Correctness received direct route depends on the quality of a given topology and the correctness of the road bends in the digital map. The proposed algorithm has enough hard common frame based on heuristics obvious, but much of the computing within phases are using genetic algorithms. This leads to large scale as a result depends on the quality of clustering, but with the correct genetic clustering algorithms to significantly improve the quality of decisions.

References

1. Dantzig, G.B. and Ramser, R.H. The Truck Dispatching Problem, *Management Science,* **6**, 1959, pp. 80-91.
2. Toth, P., Vigo, D. *The Vehicle Routing Problem: Monograph on Discrete Mathematics and Applications.* Philadelphia: SIAM, 2001.

3. Lenstra, J.K., and A.H.G. Rinnooy Kan.Complexity of vehicle routing and scheduling problems, *Networks,* **11**, 1981, pp. 221-227.
4. Handbook of Metaheuristics / Ed. by Glover, Fred W.; Kochenberger, Gary A. In: *Series: International Series in Operations Research & Management Science,* Vol. 57, 2003. 570 p.
5. Goldberg, A.V., Kaplan, H. and Werneck, R. Reach for A*: Efficient Point-to-Point Shortest Path Algorithms, Technical Report MSR-TR-2005-132, *Microsoft Research*, 2005.
6. Tavares, J., Pereira, F.B., Machado, P., Costa, E. GVR Delivers It On Time. In: *Proc. of the 4th Asia-Pacific Conference on Simulated Evolution and Learning (SEAL'02).* Singapore, November 2002, pp. 745-749.
7. Merz, P. *Memetic Algorithms for Combinatorial Optimization Problems: Fitness Landscapes and Effective Search Strategies: PhD thesis.* Germany: University of Siegen, Department of Electrical Engineering and Computer Science, 2000.
8. Grakovski, A., Ressin, A., Medvedev, A. Optimisation of operational routing for supply chain on basis of genetic algorithms. In: *Proceedings of the 6th International Conference "Reliability and Statistics in Transportation and Communication (RelStat'06)", 25-28 October 2006, Riga, Latvia*. Riga: Transport and Telecommunication Institute, 2006, pp. 125-137.

NEURAL NETWORK APPLICATION FOR HOUSEHOLD ELECTRICITY CONSUMPTION FORECAST. SPECIAL EMPHASIS ON RENOVATION

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The building sector accounts for 25-40% of the final energy consumption in OECD countries, space heating being the largest proportion of energy consumption in both residential and commercial buildings. The particular microclimate conditions of the urban area have in fact a significant influence on the thermal balance of buildings. The paper is mainly based on Italian experience on neural network application for HVAC systems energy consumption forecasting. It presents a forecasting model based on Elman's Artificial Neural Network (ANN) for the short time prediction of the household electricity consumption related to the area.

The model mainly used for Mediterranean area energy consumption forecasting can also be applied for heating energy consumption forecasting due to renovation works and renovation efficiency estimation in Lithuania.

Keywords: household energy consumption, Elman's neural network, humidity index, renovation

1. INTRODUCTION

The European building stock is a major contributor to energy waste and CO_2 emission. The building sector accounts for 25-40% of the final energy consumption in OECD countries, space heating being the largest proportion of energy consumption in both residential and commercial buildings [1].

Multi-storey buildings form a significant proportion of this building stock –13 % in the old EU member states and more than one third in the new Central and Eastern European member states. Here, the prefabricated housing stock is predominant, characterized by an enormous maintenance backlog and very low structural and thermal quality.

So far, no comprehensive strategies have been developed in the countries to start energy efficient multi-storey housing refurbishment. Especially effective legal and administrative structures need to be developed, energy efficient refurbishment measures chosen, complex housing renovation implemented.

According to Papadopoulos et al. [2], Gorgolewski et al. [3] the energy efficient renovation of the existing buildings is an important tool for the reduction of energy consumption in the building sector, the improvement of prevailing indoor thermal comfort conditions and also for the improvement of environmental conditions in urban areas.

The development of an energy and informatics industry in the buildings sector has been under the way for many years. Several control and regulation systems for HVAC plant have attained levels of sophistication that would have been impossible without adoption of informatics' tools. These concern not only the management of heating and cooling systems for a healthy and thermally comfortable working and living space, but also the optimum control of appliances and building automation [4] and, more generally, the planning of most important activities such as maintenance, retrofit actions and so on.

Since renovation is sophisticated by itself, recent papers adapt decisions on economically efficient renovation to the methods of new technologies: Adeli [5] applies general theories and techniques of expert systems to construction, Henket [6] suggests a theoretical model of several modular stages in the decision process, Reddy et al. [7] offer a frame-based decision support model for building renovation, Alanne [8] proposes a multi-criteria "knapsack" model to help designers select the most feasible renovation actions in the conceptual phase of a renovation project. Zavadskas, Kaklauskas, Raslanas et al. [9, 10] integrate various IT supported knowledge management, decision support, expert models for management of building life cycle and assessment and energy optimisation of renovation projects.

For single buildings is common to use load and energy simulation programs, which model the energy balances in the buildings including transmission, ventilation and infiltration losses. For time series prediction problems the use of Neural Networks (NNs) is also very common [11]. For this task different approaches have been used, based for example on the application of self organizing maps (SOMs), recurrent SOMs, multi layer perceptions (MLPs) or the combination of SOMs and MLPs [12]. Specific studies based on application of NNs have been successfully carried out to predict the residential use energy consumption [13].

NNs are particularly suited for load and energy estimations and whenever the data to be processed have some missing or incomplete values as often happens with metered energy or weather data. NN based models are also able to solve nonlinear problems and "exhibit robustness and fault tolerance [14].

This paper shows a forecasting model for the household electric consumption of particular area within the district of the town of Palermo (Italy).The information considered is obtained during the authors' internship at Palermo university.

The forecasting model is based on Elman's recurrent neural network (RNN). The original contribution of the Palermo university scientists [15, 16] lies in the exploitation of a comfort index (the *Humidex index*) within a neural network model for the evaluation of the influence of the air conditioning equipments on the overall residential consumption of the studied area. This index as well as Elman's neural networks can be applied also for heating energy consumption forecasting due renovation works in Lithuania.

2. ELMAN'S NEURAL NETWORKS

Neural network (NNs) connectionist models or neuron-morphed systems are names of artificial systems based on operational principles similar to those of the human brain. These models consist of many simple neurons – like processing elements called "units" interacting with each other by means of weighted connections. Each unit has a "state" or "activity level" determined by the input received by other units in the network. The weights modulate the relative importance of the incoming signal to each unit, thus encoding the relations of the state level of certain units with respect to others [4].

A neural network can be considered, in general, as a set of linked units able to connect an input phenomenon which can be described in a space of dimension n to an output result or command in a space of dimension m. Relationship can be not only linear but of any kind.

Elman's NNs [17] discussed in this paper are also known as partially recurrent networks. These are MLP networks augmented with additional context layer which store the output values of the hidden layer delayed by one step. The network has a feedback from each of the hidden units, as it is shown on Fig.1.

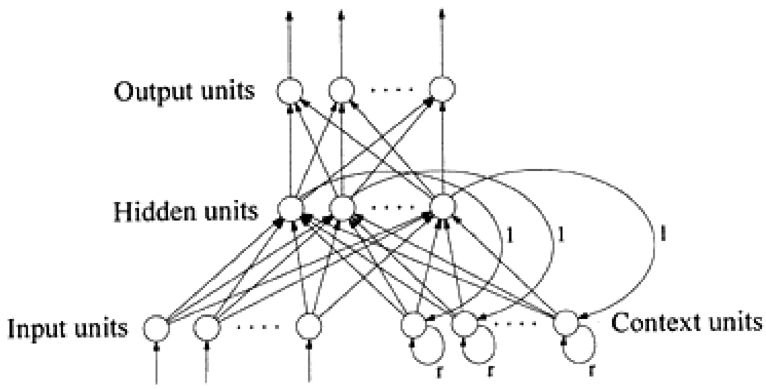

Figure 1. *Schematic representation of an Elman's recurrent neural network*

Each context unit has an auto-connection with constant weight r, called *recency constant*. Useful values of r are between 0 and 1. A value of 1 means that all the past is factored in. On the other extreme, a value equal to zero means that only the present time is factored in. The closer value to 1, the longer the memory depth and the slower the forgetting factor.

The feedback from the hidden to the context layer allows Elman's networks to learn, recognize and generate temporal patterns, as well as spatial patterns. Every hidden neuron is connected to only one neuron of the context layer through a constant weight equal to +1. Hence, the context layer constitutes a kind of copy of the state of the hidden layer, one instant before. The number of context neuron is consequently the same as the number of hidden neurons.

The output vector of an Elman's network is computed as:

$$O(t+1) = C^T z(t) + c_0 \tag{1}$$

and

$$z(t) = F_{n_h}(Ak(t) + B^T u(t) + b), \tag{2}$$

where $O(t+1)$ is $n_0 \times 1$ vector (being n_0 the number of output units) containing the outputs of the network; C is a $n_h \times n_0$ matrix (being n_h the number of hidden units and n_0 the number of output units) which represents the weights from the hidden layer to the output units; c_0 is a constant bias vector; $z(t) \in \Re^{n_h}$ is an $n_h \times 1$ vector denoting the outputs of the hidden units at the time step t; A is an $n_c \times n_h$ matrix (being $n_c = n_h$ the number of context layer units) which represents weights from the context units to the hidden units; $k(t)$ is an $n_c \times 1$ vector denoting the output of the context units; B is an $n_i \times n_h$ matrix (being n_i the number of inputs) which represents the weights from the input layer to the hidden layer; b is a $n_h \times 1$ vector containing the bias values to the hidden units; $u(t)$ is the input vector, whose dimension is $d_e \times 1$ (being d_e the so-called embedding dimension, that is the number of past input values used to compute the next values of time series):

$$u(t) = \begin{bmatrix} s(t) \\ s(t-1) \\ . \\ . \\ . \\ s(t-d_e+1 \end{bmatrix}. \tag{3}$$

F_{n_h} is an $n_h \times 1$ vector containing the activation functions of the hidden units. In Eq. (3) , $s(t)$ is the input variable (or the vector of input variables) sampled at time t.

Discussed Elman's NN was used for the case study in Palermo. Findings are the following.

3. THE CASE STUDY: A SMALL RESIDENTIAL AREA IN THE TOWN OF PALERMO

The case study presented in this paper is done by scientists of Palermo university [16] and the information considered is obtained during the authors' internship at Palermo university.

The study deals with electric energy consumption of a small district of the town of Palermo. The climate of Palermo is typically Mediterranean, mild and humid because of the vicinity of the sea. It is totally different from the climate in the Baltic region. Indeed the presented model can be studied and applied for the Baltic region, taking in account and making adequate corrections for the climate differences.

On Fig. 2 the position of Palermo within Sicily is showed.

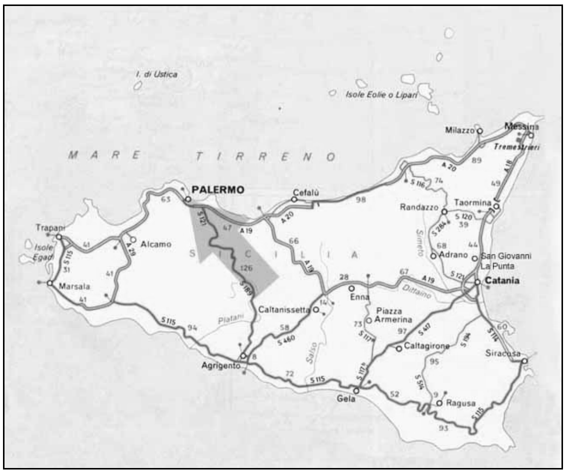

Figure 2. *Position of the town of Palermo within Sicily region*

The data used as input of the model is divided into measured data (electric current intensity and weather data) and data calculated starting from measured data (*Humidex index*).

The time series of the electric current intensity is constituted by the hourly mean values collected in the period from the 1st June 2002 to the 10th September 2003. The weather data is supplied by the Astronomic Observatory by G.Vajana at Palermo. It is apparent that the household electricity consumption is strongly influenced by utilization of household appliances. In particular, one of the aims of this study is the estimation of the influence of the use of Air Conditioning (AC) appliances on the overall domestic electricity demand.

The number of AC devices in the investigated area is assessed by using statistical data and inspection data. More in detail, statistical data concerning the trend of AC appliances sales in Italy in years 2002 and 2003 [18] are used.

The effect of changes in weather conditions on electricity load can be significant. Even if the available data set is not very wide, with a simple pot is possible to observe that variation of electricity demand with temperature is not linear. On Fig. 3 is showed the trend of the electricity demand as a function of the daily mean temperature for the same period.

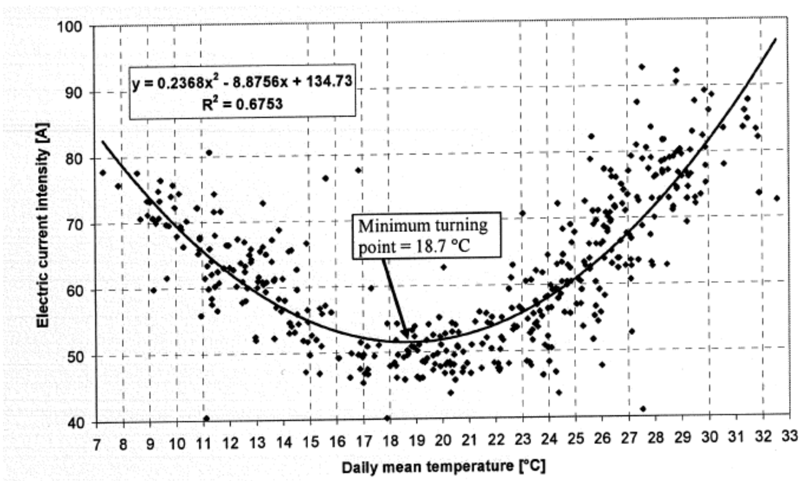

Figure 3. *Relationship between electricity demand and temperature for the investigated district*

A method which is universally used in the Heating, Ventilation and Air-Conditioning (HVAC) industry to relate the outdoor air temperature to the energy consumption is based on the concept of degree-days and, on the finer temporal scale, degree hours. The methods based on the concept of the degree dates assume that the energy needs for a specific building in specific location are proportional to the difference between the mean daily temperature and the base temperature. The base temperature in the outdoor temperature below or above which heating or cooling are needed [19].

The heating degree – days (HDD_t) and the cooling degree – days (CDD_t) of the day t can be estimated on the basis of the following equations:

$$\begin{aligned} HDD_t &= \max(T_{ref} - T_t;0) \\ HDD_t &= \min(T_{ref} - T_t;0) \end{aligned}, \tag{4}$$

where T_t is the average temperature for the day; T_{ref} is a reference temperature that should be adequately selected to separate the heat and cool branches of the demand temperature relationship; it is generally regarded as the outdoor temperature at which neither artificial heating nor cooling is required.

On Fig. 4 the electricity demand is split into the cooling period and the heating period. In this case the determination coefficient is the same (R^2 = 0.6 for the cooling period and R^2= 0.7 for the heating period) whether using a linear or quadratic regression. An increase of one degree-day in summer is associated with an increase of the daily average current intensity of 3.58 A, whereas the same increase in winter increased energy consumption by 2.26 A.

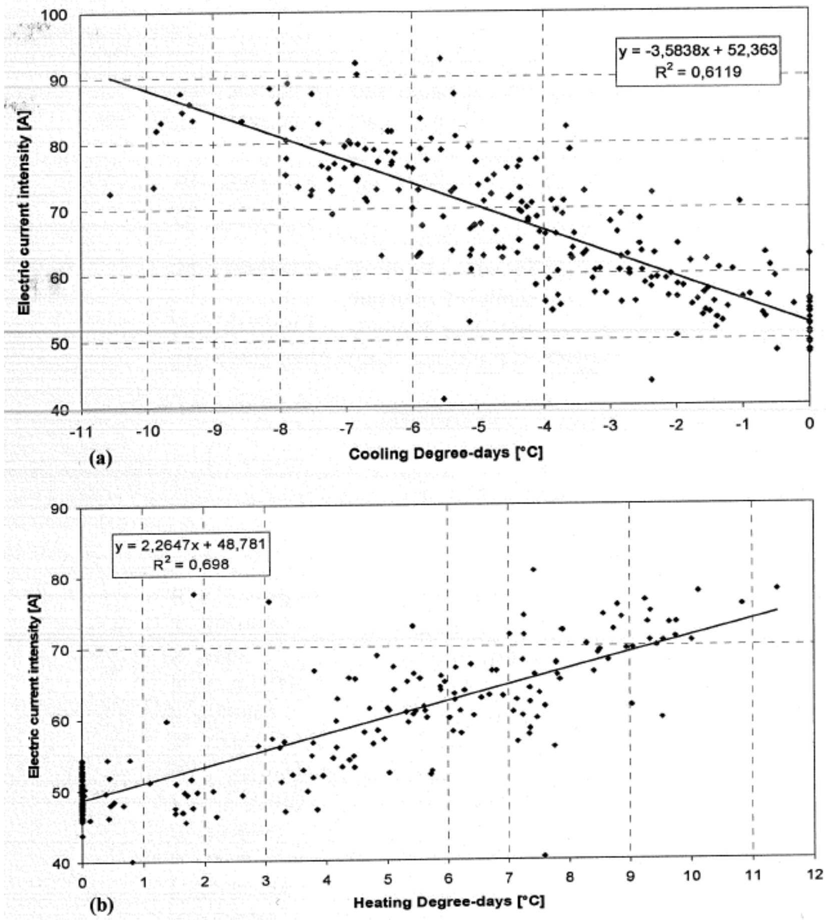

Figure 4. *Relationship between daily mean electric energy intensity and degree-days during the cooling periods (a) and the heating periods (b)*

The Elman's NN presented in this paper is able to predict the electric current intensity (C) at time t, knowing the values of several variables at time $(t-1)$.

Several different Elman's networks are tested varying the number of neurons in the hidden layer, the number of variables used as inputs of the model embedded dimension. Tab. 1 shows the results obtained with the main Elman's networks tested in comparison with MPL trained on the same data. The Elman's network with 50 hidden units (and 50 context units) gives the best results in terms of Absolute Percentage Error (APE) calculated as:

$$APE = 100 \cdot \left| \frac{y(t_i)^* - y(t_i)}{y(t_i)} \right|, \tag{5}$$

where $y(t_i)^*$ indicates the forecasted current intensity at hour t_i and $y(t_i)$ indicates the observed current intensity at the same hour.

Table 1. Summary of structures and performances of neural networks tested [16]

	Elman's 25 neurons	Elman's 50 neurons	Elman's 75 neurons	Elman's 100 neurons	MLP 25 neurons
Maximum APE, [%]	18.3	10.9	17.5	17.1	51.6
Average APE, [%]	6.2	3.1	6.1	6.6	5.4
Variance of APE	21.1	6.9	23.2	25.3	37.1

The activation function of the neurons of the hidden and the output layer is the hyperbolic tangent sigmoid function, which describes the following equation:

$$f(x) = \tanh(x) = \frac{1-e^{-2x}}{1+e^{-2x}}. \tag{6}$$

The generic *i*-th neuron of the context layer integrates with a time constant r_i the activity received by the correspondent neuron is the hidden layer. The operation implements a normalized feedback from the scaled output of the hidden neurons to their input. The output of the *i*-th context neuron at time t is expressed by the following equation:

$$k_i(t) = z_i(t) + r \cdot k_i(t-1), \tag{7}$$

where $z_i(t)$ is the output of the corresponding *i*-th hidden neuron at time t; $k_i(t)$ is the output of the *i*-th context neuron at time t and r is the recency constant mentioned in section 2. In this case recency constant is equal to 0.8.

The actual and forecasted values of the electric current intensity for the chosen week are plotted on Fig. 5, along the correspondent values of APE.

A forecasting model based on the previously discussed Elman's ANN trained with the back propagation with momentum algorithm is used for HVAC energy consumption forecasting. The model is designed to predict, one hour ahead, the intensity of electric current supplied to a sub-urban area of town of Palermo, characterized by the sole presence of household users. Among the input variables of the model inputs are both weather data and electric intensity data.

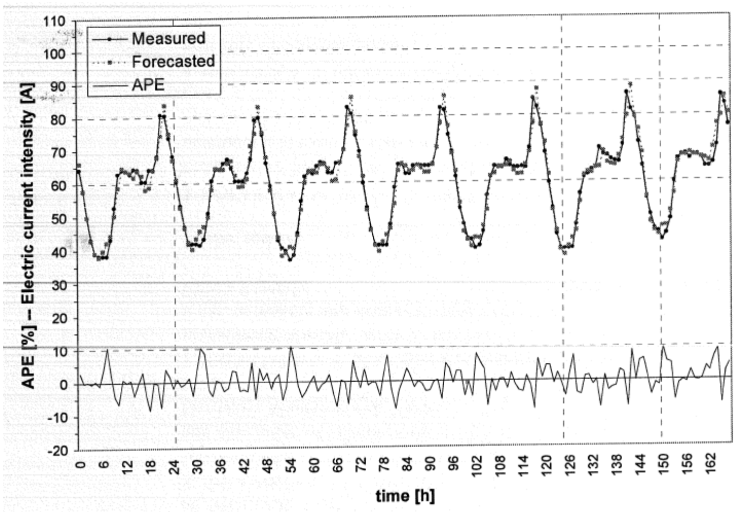

Figure 5. *Performances of the model for the week 17/07/02-23/07/02* [19]

The work also pointed the importance of the comfort index (*Humidex index*) for the evaluation of the household electricity consumption, underlining how the overall domestic electricity demand is influenced by the HVAC appliances.

In fact it is normal to expect that the decision to turn a cooling (heating) system on or off is mainly based on a discomfort sensation felt by the population. In particular, the discomfort index called *Humidex index* [20] is used. It is one of the most used discomfort indexes useful to evaluate how current temperature and relative humidity can affect the discomfort sensation and cause health danger for the population. It is defined as follows:

$$H = T + 5/9 \cdot (e - 10), \tag{8}$$

where T is the dry bulb air temperature and e is the water vapour pressure of the air measured by psychrometer. If the value of the water vapour pressure is not available, it can be estimated through a function that combines relative humidity and dry bulb temperature:

$$e = 6.112 \cdot 10^{[(7.5 \cdot T)/(237.7+T)]} \cdot RU/100. \tag{9}$$

Some values of H identity different categories of discomfort, corresponding to levels of alert are described in Table 2.

Table 2. Comfort categories related to the values of the *Humidex index*

Values	Description
H<27	Full comfort
27≤H≤30	Subtle discomfort
30<H≤40	Great discomfort
40<H≤55	Danger
H>55	Imminent heat stroke

The relationship between the average daily energy consumption and the average daily values of *Humidex index* in the cooling and heating period are showed on Fig. 6.

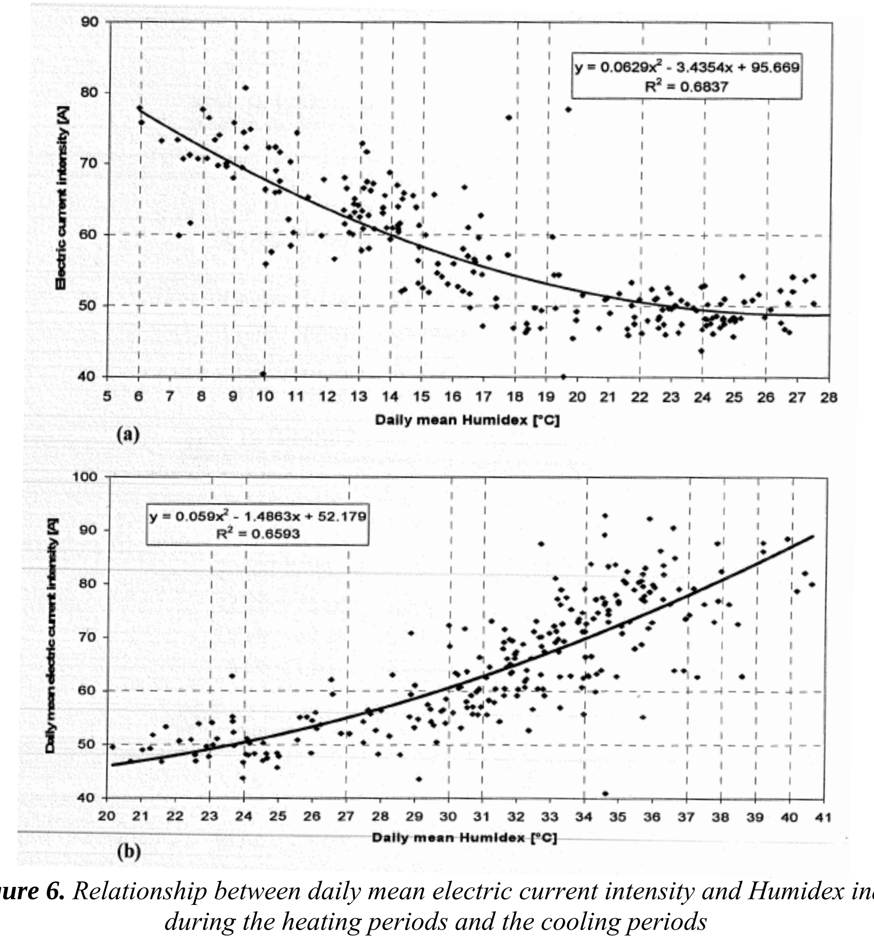

Figure 6. *Relationship between daily mean electric current intensity and Humidex index during the heating periods and the cooling periods*

The above discussed Elman's NN model is confirmed by high sensitivity index (comparable to the one computed for the *Humidex index* and air dry bulb temperature) determined for the HS index, a variable related both to estimate presence of occupants in the dwellings located within the studied area and to number of air cooling split systems supposed to be turned in the same area.

4. NEURAL NETWORK APPLICATION ABILITIES FOR ENERGY CONSUMPTION FORECAST DUE TO RENOVATION IN LITHUANIA

The majority of Lithuanian housing stock consists of large-panel buildings. Therefore a demand for heating in these houses is two or more times higher than in those in Western countries. All the above problems and defects indicate the need for innovation of Lithuanian apartment buildings and of their surroundings. The main attention must be paid to heating energy consumption minimization due to renovation works.

The energy saving potential of advanced construction techniques and building energy automation systems is high: 30-40 % with the best available technology and up to 75 % with the best prototype technology [4].

Implementation of the best currently available techniques in a new construction will not, however eliminate the need of renovation in 20 or 30 years time. This is due in particular to the rapid obsolescence of informatics' products of some building and plant components. On the other hand, speeding up the commercialisation of prototype technologies could bring early improvements in energy consumption levels. The setting up advanced new techniques of renovation is, therefore, something that will become increasingly urgent as time passes.

In fact, growing pressure to such advanced techniques is due to:

1) the need for reconfirmation of the building industry from the field of new construction to that of renovation and retrofit, and,
2) the increasing social awareness of energy and environmental problems which will lead to extensive specific renovation actions.

These requirements have lead to pay particular attention to the development of sophisticated design tools for renovation actions on existing buildings [21]. The new goal of these tools is to serve as a guide for efficient renovation design tasks. One kind of these tools are advanced statistical computerized technologies for future energy consumption forecasting.

Previously discussed neural network application model was used for HVAC energy consumption forecasting in Mediterranean area. As the climate in this area is hot, the main discussed problem was energy consumption of cooling and conditioning equipment during summer season. Lithuania being in colder climate conditions faces totally different situation. The main problem considering the energy consumption is heating systems energy requirements for cold winter periods.

The measurement of heating energy consumption is critical for renovation efficiency forecasting. For this reason previously discussed neural networks can be applied. Also to estimate the possible heating energy demand the previously discussed *Humidex index* can be used.

CONCLUSIONS

1. Basing on the experience of Palermo University Elman's neural networks with implied *Humidity index* can be used for HVAC systems energy consumption forecasting.

2. The main problem of energy consumption in the Mediterranean area is cooling energy consumption in hot summer season. In Lithuania the alternative problem of heating consumption in cold winter period is more common.

3. Italian experience can be used for energy consumption forecasting for Lithuanian housing due to renovation works.

4. Neural network application for energy consumption forecasting due to renovation results will be practically implemented in authors' future research.

References

1. Sunikka, M. Sustainable housing policies for the existing housing stock in Europe, *Open House International*, Vol. 28, No 1, 2003, pp. 4-11.
2. Papadopoulos, A.M., Theodosiou, Th.G., Karatzas, K.D. Feasibility of energy saving renovation measures in urban buildings. The impact of energy prices and acceptable pay back time criterion, *Energy and Buildings*, No 34, 2002, pp. 455-466.
3. Gorgolewski, M. Optimizing Renovation Strategies for Energy Conservation in Housing, *Building and Environment*, Vol. 30, 2005, pp. 583-589.
4. Candana, B., Conti, F., Helcke, G. and Pagani, R. A prototype expert system for large scale energy auditing in buildings, *Pattern Recognition*, Vol. 28, No 10, 1995, pp. 1467-1475.
5. Adeli, H. *Expert Systems in Construction and Structural Engineering*. New York City, NY: Chapman & Hall, 1988.
6. Henket, H.A.J. Choosing an Appropriate Intervention in Existing Building: A Theoretical Model. In: *Proceedings of the International Symposium on Property Management and Modernization*. 7-9 March, 1990, Singapore / Ed. by Q.L. Kiang. Singapore, 1990, pp. 473-482.
7. Reddy, P.V., Socur, M., Ariaratnam, S.T. Building Renovation Decision Support Model. In: *Proc. of the 5th International Conference on Computing in Civil and Building Engineering, Anaheim, CA, USA, 1993.* Anaheim, CA, USA, 1993. pp. 1547-1554.
8. Allane, K. Selection of renovation actions using multi-criteria "knapsack" model, *Automation and Construction,* Vol. 13, Issue 3, 2004, pp. 377-391.
9. Zavadskas, E.K., Bejder, E., Kaklauskas, A. Raising the efficiency of the building lifetime with special emphasis on maintenance, *Facilities*, Vol. 16, No 11, 1998, pp. 334-340.
10. Kaklauskas, A., Zavadskas, E.K., Raslanas, S. Multivariant design and multiple criteria analysis of building refurbishments, *Energy and Buildings*, Vol. 37, Issue 4, 2005, pp. 361-372.
11. Ringwood, J.V., Boffel, D., Murray, F.T. Forecasting electricity demand on short, medium and long time scales using neural networks, *Journal of Intelligent and Robotic Systems*, Vol. 31, 2001, pp. 129-147.
12. Beccali, M., Cellura, M., Lo Brano, V., Marvuglia, A. Forecasting daily urban electric load profiles using artificial neural networks, *Energy Conversion and Management*, No 45, 2004, pp. 2879-2900.
13. Aydinalp, M., Ismet Ugursal, V., Fung, A.S. Modeling of the space and domestic hot-water heating energy consumption in the residential sector using neural networks, *Applied Energy*, Vol. 79, 2004, pp. 159-178.
14. Kalogirou, S.A. Artificial neural networks in renewable energy systems application: a review, *Renewable Sustainable Energy*, Vol. 5, No 4, 2001, pp. 373-401.
15. Beccali, G., Beccali, M., Cellura, M., Lo Brano, V., Marvuglia, A. *The influence of air conditioning systems for the residential electricity consumption: a neural network application.* Palermo: Palermo University, 2002.
16. Beccali, M., Cellura, M., Lo Brano, V., Marvuglia, *A. Short-term prediction of household electricity consumption: assessing weather sensitivity in Mediterranean area.* Palermo: Palermo University, 2007.
17. Elman, J.L. Finding structure in time, *Cognitive Science*, Vol. 14, 1990, pp. 179-211.
18. Italian National Grid Operator (GRTN), Operation data. Available online – http://eee.grtn.it. Accessed September 2005.
19. German, S., Bienenstock, E., Doursat, R. Neural networks and the bias/variance dilemma, *Neural Networks*, Vol. 4, No 1, 1994, pp. 123-132.
20. Masterton, J.M., Richardson, F.A. *Humidex, a method of qualifying human discomfort due to excessive heat and humidity. Environmental Canada, Atmospheric Environment Service*. Ontario, 1979.
21. Raslanas, S., Gulbinas, A., Tupėnaitė, L. Peculiarities on Vilnius multi-storied housing refurbishment from the energy efficiency aspect. In: *Proceedings of the International Conference Buildings Energy Efficiency in the Baltic (BENEFIT-2006), October 25, 2006, Riga, Latvia.* Riga, Latvia, 2006, pp. 176-197.

INFLUENCE OF KNOWLEDGE AND INFORMATION TECHNOLOGIES ON THE EFFECTIVENESS OF CONSTRUCTION EXPORT

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Recent changes in the globalisation process have an impact on all human activity and international trade too. Increase in export efficiency is important to both as policy makers as well as to management within a firm. International trade is information and knowledge based business. Various decisions supports (Export Analysis Tools and Decision Support System, Logistics Solution (export, dispatch, freight and import) and other intelligence systems can be used online.

This paper presents current situation of the construction export sector in Lithuania and possibilities to apply information technologies.

Keywords: international trade, construction materials, information technologies

1. INTRODUCTION

Knowledge of policy and strategy of the targeted foreign markets and current laws and additional information are vital for the success in international trade. The Internet and other information technologies help to learn about the market of any country of interest, to get its legal and financial information, to be advised by business experts and to make an analysis.

Currently there are several web-based support systems for exporters in the world. Some of them provide statistical and legal information and others give recommendations on export of some types of goods and share accumulated experience. Web-based search systems of business contacts and potential transactions are in great demand. Users of such systems can get the main information of interest right in front of their computers.

Since economic growth gains momentum, export grows and the possibilities to apply information and telecommunication technologies expand, there are all prerequisites for the growth of international trade in Lithuania. Limited opportunities in Lithuanian local markets are the reason behind the importance for national companies to expand in foreign markets. The level of international trade expansion is expressed by the ratio of export and GDP (gross domestic product). This indicator exceeds 100 % in countries of Central and Western Europe, and makes up 40 % in Lithuania.

For more effective penetration into foreign markets the public institutions provide information and help to Lithuanian exporters. Several private companies also help to develop export and these public and private companies do not apply intelligent systems to their activities. The above facts illustrate the fluctuations in Lithuanian export, with sharp drops and rises in the observed values. Under these changing transitional conditions, a question arises – how to improve the export situation? One option could be modelled and forecasted of the Lithuanian international trade by applying databases of the best practices and intelligent automation applications. International trade is an information and knowledge based business. Various purposes, e.g. international trade expert, decision support (Export Analysis Tools and Decision Support System, Logistics Solution (export, dispatch, freight and import) and other intelligent systems can be used by the on-line regime.

Lithuanian manufacturers of construction materials are improving their skills of adaptability to changing market conditions and consumer demands for years. Marketing divisions of companies focus not only on internal market but also seek foreign partners. Export is one of opportunities for companies to expand manufacturing capacity, which means additional revenue for manufacturers of exported products.

2. CURRENT SITUATION OF THE CONSTRUCTION EXPORT

Existing web-based support systems for exporters receive considerable attention in the world. Some of them provide statistical and legal information and others provide recommendations on export of some types of goods and accumulated experience. Web-based search systems of business contacts and potential transactions are currently in demand. Users of such systems can get the main information of interest right in front of their computers.

Influence of knowledge and information on the effectiveness of construction export is analysed, because information on export is important when making decisions to enter a market, in stages of expansion and for successful decision-making in business. The research by Burpitt and Rondinelli (2000) showed that the desire to get new knowledge and skills has considerable influence on effectiveness of an enterprise and export. Application of knowledge technologies in construction export is important, because it provides additional intellectual properties to IT, which is already used; the properties help to process and analyse the existing information and knowledge and to deliver them upon necessity. Since internet technologies and knowledge systems are being implemented in international trade, a number of changes take place: the role of agents in successful export changes, the importance of monitoring of countries' markets and the significance of market concentration changes as well, etc.

Emergence of the Internet, constant improvement of telecommunications and other IT enables development of transparent and effective trade systems [G. Elias., C. Popescu, 2005]. Most stages of the traditional export process are already successfully adjusted to the virtual environment. Many branches of industry develop special websites, portals and systems for trade in more important goods [C. L. Freund, D. Weinhold, 2004]. The best examples in the construction industry are the portal of international trade *PlasticsNet* covering sales in plastic and metal goods and the portal *E-Steel*, which helps businessmen to find sales partners all over the world. There are trends of creation of such Internet portals not only in industrially developed countries.

3. METHODS OF SEARCH AND ANALYSIS OF CONSTRUCTION EXPORT MARKET

Export development is a complex process, thus when creating new methods for market analysis and search it is important to evaluate most factors of micro and macro level. In order to improve the effectiveness of export, rational methods for market analysis and market search are necessary. This chapter provides methods that are offered and describes the possibilities of their application in practice. The methods are proposed that enable:

- Analysis of competitiveness of export sectors;
- Analysis of competitiveness of exported goods;
- Analysis of potential markets.

Systems of criteria describing sectors, goods and markets are developed on the basis of ideas of other authors. Many decision-making methods are known in the world, they are applied in almost all spheres of human activities. E. K. Zavadskas analysed many multiple criteria evaluation methods for construction projects, the criteria of gambling theory, generalised criteria, methods for consistent optimisation, methods for determination of priorities, selection of non-dominant variants and synthesis in his works. The method for analysis of competitiveness of sectors of construction export is based on works of V. M. Ozernoy (1986) and A. Goechea (1999); however, the integrated multiple criteria proportional evaluation method proposed by E. K. Zavadskas and A. Kaklauskas (1999) is used as the foundation. The systems of criteria must reflect extensively the current state of analysed sectors, goods and markets and their development perspectives. Positive and negative aspects of the analysed sectors, goods and markets must be considered when determining values and importance of criteria.

An important stage in analysis of the competitiveness of export sectors is determination of values and importance of criteria describing alternatives. Analysis of the competitiveness of export sectors must be integrated and performed by comparing their effectiveness with analogous sectors of foreign countries. The results of the comparison of variants are provided as a decision matrix, where columns represent analysed variants (sectors, goods, markets), and rows quantitative and conceptual information which extensively describes the analysed alternatives. When alternatives are described in quantitative and conceptual forms, information describing various aspects (economic, technical, technological, infrastructure, qualitative, legal, social) is provided. Quantitative information includes systems of criteria, measurement units, values and initial importance and the minimising or maximising criterion. When analysed variants are described in conceptual form and by text, schemes, charts, diagrams, drawings, etc., conceptual information about variants and criteria describing the variants extensively are provided.

Effectiveness of export sectors may be evaluated using the following system of criteria: size of export; size of export per capita; share of the global market; changes in the share of the global market; diversification of goods; changes in diversification of goods; diversification of markets; changes in diversification of markets; imports and export ratio, etc.; index of corruption.

Priority and importance of variants analysed using this method is determined by direct proportion and depends on the system of criteria describing alternatives adequately and on values and importance of criteria. Once a table is filled in the computer (by inputting it to the database) it may be corrected. Having performed multiple criteria analysis of the matrix of sectors, priority of the sector (country) is determined. It is obvious in which country the sector is the most competitive globally from the static and dynamic perspective (Fig. 1).

No	Criteria	Measuring units	*	Significance	Lithuania	Angola	Argentina	Armenia	Australia	Austria	Bahamas	Bahrain	Barbados
1	Value of exports	1000 USD	+	0,1000	0,0001	0,0000	0,0001	0,0000	0,0003	0,0023	0,0000	0,0000	0,0000
2	Export value per inhabitant	USD	+	0,1000	0,0007	0,0000	0,0001	0,0000	0,0003	0,0054	0,0017	0,0003	0,0024
3	Share in World market	%	+	0,1000	0,0001	0,0000	0,0001	0,0000	0,0003	0,0022	0,0000	0,0000	0,0000
4	Change of share in World market	%	+	0,1000	0,0031	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
5	Product diversificat.	Equiv.	+	0,0500	0,0001	0,0001	0,0004	0,0001	0,0014	0,0012	0,0001	0,0002	0,0001
6	Change of product diversificat.	Equiv.	+	0,0500	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
7	Market diversificat.	Equiv.	+	0,0500	0,0003	0,0002	0,0004	0,0001	0,0006	0,0004	0,0001	0,0004	0,0010
8	Change of market diversificat.	Equiv.	+	0,0500	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
9	Index of corruption		-	0,0200	0,0002	0,0004	0,0002	0,0004	0,0001	0,0001	0,0001	0,0001	0,0002
The sums of weighted normalized maximizing indices					0.0044	0.0003	0.0011	0.0002	0.0029	0.0115	0.0019	0.0009	0.0035
The sums of weighted normalized minimizing indices					0.0002	0.0004	0.0002	0.0004	0.0001	0.0001	0.0001	0.0001	0.0002
Significance Q_j					0.0045	0.0004	0.0012	0.0003	0.0032	0.0118	0.0022	0.0012	0.0036
Utility degree N_j					13%	1%	4%	1%	10%	35%	7%	4%	11%
Priority					43	97	74	104	55	10	61	76	51

Fig. 1. *Results of the multiple criteria analysis of the competitiveness of sectors in construction export*

Just as in case of competitiveness of construction export markets, calculations may be performed manually (analogous sequence) or using multiple criteria analysis system developed in Internet. Having performed multiple criteria analysis of the matrix of exported goods, the list of priorities of goods is compiled (it is obvious why one kind or another kind of goods is more competitive).

The first places in the priority list are occupied by goods which meet global requirements and the analysed country is well prepared for their export.

On the basis of the compiled matrixes it is possible to make an integrated analysis of markets by analysing both pessimistic and optimistic variants. Since the situation is changing every year, this analysis can easily be repeated annually after making a database. When one has comprehensive conceptual and quantitative information and the aforementioned results of multiple criteria analysis of sectors, goods and markets, it is possible to have more effective negotiations with potential importers.

When analysing potential markets of construction sector, the author offers to use the following system of criteria: size of export; export growth; stability of export growth in the analysed period; market share in export in Lithuania; market share in export in the world; changes in share of global market; changes in global imports market; the ratio of price and quality of goods; changes in imports tariffs; favour of the existing consumption styles to Lithuanian products; the level of prices in the market; market safety and reliability; solvency and purchasing power of consumers; trends of increase/decrease of solvable demand in the analysed markets; size of the market; level of demand and supply; distance; economic, financial and political risks; barriers to entering markets (quotas, customs); evaluation of perspectives.

4. THEORETICAL MODEL

The research of scientists from various countries in the sphere of export modelling is analysed and the list of main indicators used in research is compiled. The authors select indicators, which are considered to be suitable for modelling of Lithuanian construction export. Modelling and forecasts on future perspectives of export and the main directions of expansion help to prepare in advance for effective amendments of Lithuanian laws and changes in various organisations. It is offered to perform these actions by analysing experience and knowledge of advanced countries and adjusting them to Lithuania.

When analysing construction export, it is offered to prepare possible variants of state (organisations') export strategy, to evaluate them using multiple criteria analysis methods and to select the most effective ones. First, expert methods are used to determine factors of micro and macro level, which defining export extensively, and then the systems and subsystems of criteria defining the factors are determined. On the basis of these criteria, the state of construction export in Lithuania and advanced countries is described conceptually and quantitatively. Trends of export development in advanced countries and the differences between them and Lithuania are determined on the basis of accumulated materials. Having analysed differences of export in Lithuania and advanced countries at micro and macro levels, it is possible to determine development trends of Lithuanian construction export and to forecast the future. Analysis allows making various combinations of factors of micro and macro level, analysing the combinations and providing specific recommendations. When only a few advanced countries are analysed this may lead to considerably subjective conclusions. However, if more countries are analysed, the analysis may be more objective. It is proposed to develop a model of Lithuanian rational export on the basis of the provided stages (Fig. 2).

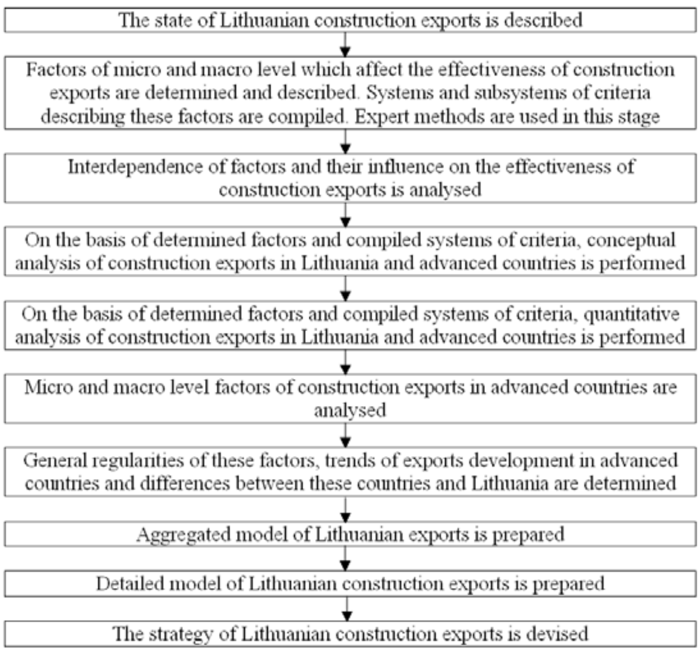

Fig. 2. *Stages of development of a theoretical model of rational construction export in Lithuania*

The quantitative and conceptual description of construction export enables to make conclusions on the state of construction export in Lithuania. It is not enough to make only a quantitative or conceptual description; both are necessary. It would be rational to explain and to detail the quantitative description in conceptual form from various perspectives. Thus in order to make a more detailed analysis of Lithuanian construction export and to provide extensive recommendations on improvement of effectiveness, it is necessary to describe trends of construction export in Lithuania and advanced countries both in quantitative and conceptual form and to select the most rational variants for Lithuania.

It is offered to make a theoretical model of Lithuanian construction export development after description of construction export in quantitative and conceptual form and determination of the main regularities and directions of export development in the world. However, specific application of the offered direction in Lithuania depends upon a specific situation. Various countries have different economic, social, legal and other conditions, thus directions of export development may have a number of alternative implementation methods and measures. When making the theoretical model of development of Lithuanian construction export, it is offered to adjust the main global trends of construction export to specific conditions of Lithuania.

The following stakeholders may use the offered methods and the model in their direct activities:

- Construction companies that intend to export and wish to find the most rational markets for their goods now and in the future.
- State institutions responsible for creation of favourable conditions for export development. State institutions strive to implement policy that would be adequate to the exported production and external environment. Limited public economic, financial, human and other resources must be used rationally while solving relevant export issues.
- Investors to Lithuanian construction industry. In order to increase competitiveness of export, investments are needed.
- In order to improve competitiveness of Lithuanian construction export, a model is developed for analysis, modelling and future forecasts in the sphere of Lithuanian construction export. Its implementation in practice will create conditions for more effective export of construction goods. The provided model offers to analyse experience and knowledge of various countries in conceptual and quantitative form and to adjust them to Lithuania's needs.

CONCLUSIONS

The models of gravity and econometrics have the following drawbacks: The above two models provide an export analysis in a too simplified way. As we know, export competitiveness is predetermined by many different factors, whereas these models exclude many indices from their calculations. The possibilities of the application of these models are reduced along with the qualitative changes in the international trade relations. For example, it is rather difficult to apply them in the countries with a transitional economy, such as in Lithuania. These qualitative changes considerably modify the trajectory of the projected indices, whereas the changes themselves are rarely accurately describable due to a lack of information.

Multiple criteria analysis of sectors determines the priority list of a country's construction sector. It is seen in which country the sector is the most competitive globally from static and dynamic perspectives.

Multiple criteria analysis of Lithuanian export of construction goods and products determines their priority. It is seen why one or another kind of goods (products) is more competitive. Goods and products that occupy the highest places in the priority list meet global requirements and Lithuania is well-prepared for their exporting.

Multiple criteria analysis of markets determines priorities of the market for specific goods. It is seen which country is the best as a target for exporting of the analysed goods.

When comprehensive conceptual and quantitative information and the afore-mentioned results of multiple criteria analysis of sectors, goods and markets are available, the negotiations with potential importers are more effective.

Effectiveness of foreign trade is influenced by the abundance of information for business support available in Internet (systems for analysis of export opportunities, contract search systems, analyses of export markets, etc.).

When solving tasks in the sphere of construction export, expert and decision support systems must be used together. When solving tasks related to construction, the weakness of expert systems is the rapidly changing environment conditions.

References

1. 32 Ways to Use the Internet to Improve Export Functions, *Ioma's Report on Managing Exports*, May 2005, pp. 2-5.
2. Cooper, T. E. Construction application of knowledge-based systems. Working Commission W89. In: *Proceedings of the CIB International Symposium on Construction Education and Modernization held in Beijing*, 1996, pp. 64-68.
3. Burpitt, W. J., Rondinelli, D. A. Small firms motivations for exporting: to earn and learn? Journal of Small Business Management, 38(4), 2000, pp. 1-14.
4. Elias, G., Popescu, C. Profiling a methodology for economic growth and convergence: learning from the EU e-procurement experience for Central and Eastern European countries, *Technovation*, Vol. 25, Issue 1, January 2005, pp. 1-14.
5. Flor, M., Oltra, M. J. The influence of firms' technological capabilities on export performance in supplier-dominated industries: the case of ceramic tiles firms, *R&D Management*, Vol. 35(3), June 2005, pp. 333-347.
6. Goechea, A., Nagy, A. Portugal's European integration and its effect on her foreign trade, *Actaa Oeconomica*, Vol. 50, No 1/2, 1999, pp. 191-222.
7. Kaklauskas, A., Zavadskas, E. K., Banaitis, A., Trinkūnas, V. Efficiency Increase of Export E-Commerce Systems by Applying Multiple Criteria DSS. In: *ACS'02 – SCM conference, Poland, October 23-25, 2002*. Poland, 2002, pp. 589-597.
8. Leonidou, L. C. Export Stimulation Research: Review, Evaluation and Integration, *International Business Review*, Vol. 4, No 2, 2000, pp. 23-30.
9. Ozernoy, V. M. A framework for choosing the most appropriate discrete alternative multiple criteria decision making method in decision support systems and expert systems, toward interactive and intelligent decision support systems. In: *Proceedings of the seventh international conference on multiple criteria decision making, Vol 2. Held at Kyoto, Japan, August 1986.* Kyoto, Japan, 1986, pp. 56-64.

ANALYSIS, MODELLING AND FORECASTING OF HOUSING IN LITHUANIA: SPECIAL EMPHASIS ON ENERGY EFFICIENCY

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The aim of the research is to produce an analytical model of the rational housing development of Lithuania with special emphasis on energy efficiency by undertaking a complex analysis of micro, meso and macro environmental factors that affect it and to present recommendations on increasing its sustainability. The research is performed by studying the expertise of advanced industrial economies and by adapting it to Lithuania by taking into consideration its specific history, development level, needs and traditions. A simulation is undertaken to provide an insight into creating an effective environment for housing by choosing rational micro, meso and macro factors.

Keywords: energy efficiency, housing

1. INTRODUCTION

The research's aim is to produce an analytical model of the rational housing development of Lithuania with special emphasis on energy efficiency by undertaking a complex analysis of micro, meso and macro environmental factors that affect it and to present recommendations on increasing its sustainability. The research is performed by studying the expertise of advanced industrial economies and by adapting it to Lithuania by taking into consideration its specific history, development level, needs and traditions. A simulation is undertaken to provide an insight into creating an effective environment for housing by choosing rational micro, meso and macro factors.

Stage I. A comparative description of the housing urban development with special emphasis on energy efficiency in developed countries and in Lithuania:

- A system of criteria characterizing the efficiency of housing urban development that was determined by means of using relevant literature and experts methods;
- Based on a system of criteria, a description of the present state of housing urban development of developed cities and in Lithuania is given in conceptual (textual, graphical, numerical, etc.) and quantitative forms.

Stage II. A comparison and contrast of housing urban development with special emphasis on energy efficiency in developed countries and in Lithuania includes:

- Identifying global development trends (general regularities) of housing urban development;
- Identification of housing urban developmental differences between developed cities and Lithuania;
- Determination of pluses and minuses of these differences in Lithuania;
- Determination of the best practices for housing urban development for Lithuania as based on the actual conditions.

Stage III. A development of some of the general recommendations as to how to improve the efficiency levels for a housing Lithuania with special emphasis on energy efficiency.

Stage IV. Submission of particular recommendations for the city of Lithuania was presented at this stage. Each of the general housing recommendations proposed in the third stage carry several particular alternatives.

Stage V. A multiple criteria analysis of housing urban developmental components and a selection of the most efficient version of housing life cycle were determined at this stage. After this stage, the received compatible and rational full housing urban components of a housing urban development were joined into the developmental process.

Figure 1. *Model for housing urban development with special emphasis on energy efficiency*

The level of efficiency and the scope of activities in housing urban development with special emphasis on energy efficiency depend on many micro, meso and macro-level variable factors and all these variable factors can be optimised. The main objective of this model is to analyse the best experiences in the field of housing, compare it to the present situation in a particular city and consequently to present specific recommendations. In this particular case, the development perspectives of Lithuania are analysed.

The word ‘model’ implies ‘a system of game rules’, and which the housing Lithuania development could use to its best advantage.

The interested parties of the housing cannot correct or alter the micro, meso and macro-level variables, but they can go into the essence of their effect and take them into consideration in their activities. Interested parties, by knowing the environment affecting their projects, can then organize their present and future activities more successfully.

In order to throw more light on the subject, a more detailed description of the development of some general recommendations as to how to prevent pollution in Lithuania and a submission of particular recommendations for Lithuania transport follow below.

2. DEVELOPMENT OF SOME GENERAL RECOMMENDATIONS AS TO HOW TO PREVENT HOUSING IN LITHUANIA

While implementing projects “Intelligent Cities” [3], e-City [4], the PHARE program (Kaklauskas, 1998) and other projects (Zavadskas et al., 1996, 1997) the experiences of different cities are analysed by the authors of this paper and it helps to determine the best practice for housing urban development with special emphasis on energy efficiency in Lithuania. Also the experience of other researchers ([1, 2, 5-14], Zavadskas et al., 1999, 2003; Jonaitis and Naimaviciene, 2004; Kelkit, 2003, etc.) has been analysed.

Highly industrialized countries are developing different pollution prevention programs. Housing prevention includes the use of processes, practices, materials or products that avoid reduce or control pollution, and which may include recycling, treatment, process changes, control mechanisms, efficient use of resources and material substitution [5]. Waste treatment, release, or disposal is not considered to be a sufficient pollution prevention method [6]. Examples of pollution prevention include non-fossil-fuel energy production (e.g. wind energy), more efficient use of fossil-fuel energy, the use of low-mercury coal, and the use of alternative products (e.g. digital thermometers instead of mercury thermometers) [7]. Pollution prevention can be achieved in many ways.

For example, the United States of America identify areas, processes, and activities, which create excessive waste products or pollutants in order to reduce or prevent them through alteration or by eliminating a process. Also, the initiated a number of voluntary programs in which industrial, or commercial or "partners" join with EPA in promoting activities that conserve energy, conserve and protect water supply, reduce emissions or find ways of utilizing them as energy resources, and reduce the waste stream. Among these are the following: Energy Star programs [8], Indoor Environments project [9], Wastewi$e [10], Energy Star Buildings and the Green Lights Partnership Program [11], etc. A short description of these programs follows.

Energy Star programs [8] promote the energy efficiency in commercial and residential buildings, office equipment, transformers, computers, office equipment, and home appliances. Improving homes to reduce energy costs will make homes more comfortable and help to protect the environment [8].

The aim of the Indoor Environments project [9] is to reduce risks from indoor-air pollution. There are many sources of indoor air pollution in any home. These include combustion sources such as oil, gas, kerosene, coal, wood and tobacco products; building materials and furnishings as diverse as deteriorated, asbestos-containing insulation, wet or damp carpets, and cabinets or furniture made from certain pressed wood products; products used for household cleaning and maintenance, personal cars, or hobbies; central heating and cooling systems and humidification devices; as well as outdoor sources such as radon, pesticides, and outdoor air pollution. High temperature and humidity levels can also increase concentrations of some pollutants. The relative importance of any single source depends on how much of a given pollutant it emits and how hazardous those emissions are. In some cases, factors, such as how old the sources are, and whether it is properly maintained are significant. For example, an improperly adjusted gas stove can emit significantly more carbon monoxide than one that is properly adjusted. Some sources, such as building materials, furnishings, and household products like air fresheners, release pollutants more or less continuously. Other sources, related to activities carried out in the home, also release pollutants intermittently. These include smoking, the use of unvented (not provided with vents) or malfunctioning stoves, furnaces, or space heaters, the use of solvents for cleaning and hobby activities, the use of paint strippers in redecorating activities, and the use of cleaning products and pesticides in house-keeping. High pollutant concentrations can remain in the air for long periods even after some of these activities have finished [9].

Project Wastewi$e's [10] aim is to reduce business-generated solid waste through prevention, reuse, and *buying recycling*. *Buying recycled* means the purchasing of recycled products (i.e. products made from recovered materials). A necessary precedent of buying recycled is that manufacturers purchase recovered materials and use them in lieu of virgin materials in the manufacture of new products. A wide variety of products are now available with recycled content, and include: paper and paperboard products, retread tires, oil, insulation, road building materials, erasable boards, mulch, geo-textiles, plastic pipes, plastic desk accessories, outdoor, benches and tables, playground equipment, bicycle racks, wall panels, sign posts, garbage bags, fibre-board, furniture, fences and fence posts, sign posts, office products, and wastebaskets. The cost-competitiveness of recovered materials and products is highly variable and dependent on the specific product or material, and the supply and demand of market forces. Today, recycled products are manufactured to meet the same performance standards as virgin products [10].

During the implementation of Energy Star Buildings and Green Lights Partnership Program [11] different organizations plan to reduce their energy consumption and air pollution emissions by installing more energy-efficient equipment. For example, the new Lexington, S.C. store, and Food Lion's first Energy Star building, houses a water heating system that uses heat from the store's refrigeration system is expected to reduce carbon dioxide emissions by 63,700 pounds a year. As of October 1998, participants reduced their energy use by 22.4 billion kWh and annually saved more than $593 million and had prevented the emissions of 35 billion pounds of carbon dioxide—equivalent to removing the pollution from 1.4 million cars [11].

The investigation carried out by the authors of this paper under "Intelligent Cities" [3], e-City [4] and PHARE program (Kaklauskas, 1998) helped to identify and describe some trends of pollution prevention in industrialized countries as well as providing recommendations for Lithuania's development. The comparative quantitative and conceptual analysis of pollution prevention in cities carried out in developed countries and in Lithuania allows the authors to identify areas where the situation in Lithuania is comparable, and partly comparable or quite different from the levels attained by the foreign developed cities. The data from this quantitative and conceptual analysis is used in identifying pollution prevention trends in Western Europe and the USA as well as providing some recommendations for Lithuania.

It should be noted that the choice of a worldwide trend of pollution prevention is highly dependent on the actual situation. Therefore, while working out an analytical model for housing development in Lithuania, major international pollution prevention trends are considered by taking into account the actual environment, economic, social, legislative, political and technological situation in Lithuania.

Each of the general recommendations proposed in Table 1 carries several particular alternatives, for example, a large number of alternatives for diminishing dust can be proposed and are as follows [8]:

- Change or clean furnace and air conditioner filters once a month or according to the filter manufacturer's instructions. Temporarily seal the filter in place with metal-back duct tape. Write the date on the tape with a marker so that you know when it was last changed.
- A clothes dryer should be vented directly to the outside. Inspect the vent duct. Make sure it is attached securely to the dryer. Check that it is clear of obstructions (e.g. lint). Check for holes that leak into the air. If the vent duct is damaged replace it with a metal duct. The vent duct should be cleaned at least once a year.
- Consider leaving shoes at the door so you don't track outside debris (often the largest source of dust) into the house..
- Sealing air leaks can help to reduce air infiltration that could be a source of dust.

- Sealing duct air leaks, especially the return duct, can help prevent dust from being circulated throughout one's house.

3. HOUSING KNOWLEDGE AND DEVICE-BASED DECICION SUPPORT SYSTEM

KDDSS-RE is Housing's Knowledge and Device-based Decision Support System that is developed by the authors and can be found at the following web address: http://dss.vtu.lt/realestate/. Major KDDSS-RE functions include creating and maintaining customer's personalized housing objectives, preferences, and evaluation criteria; participation of various stakeholders (buyers, sellers, brokers, etc.) in joint determination of criteria (criteria system, values and weights) defining housing; market signalling, providing device-based data about the indoor microclimate and allergens causing allergy in the building; searching for housing alternatives, finding alternatives and making an initial negotiation table, completing a multiple criteria analysis of alternatives, making electronic negotiations based on real calculations, determining the most rational housing purchase variant including energy efficiency, and completing an analysis of the loan alternatives offered by certain banks. The KDDSS-RE consists of a Decision Support Subsystem, Knowledge Subsystem and Devices Subsystem. A more detailed description of these Subsystems follows.

Decision Support Subsystem (DSS-RE) consists of a database, a database management system, model-base, a model-base management system and a user interface (see Fig. 2). The Decision Support Subsystem is developed by using methods [15-18] that are developed by the authors, i.e. a method of complex determination of the weights of the criteria taking into account their quantitative and qualitative characteristics; a method of multiple criteria complex proportional evaluation of the projects; and a method of defining the utility and market value of a housing.

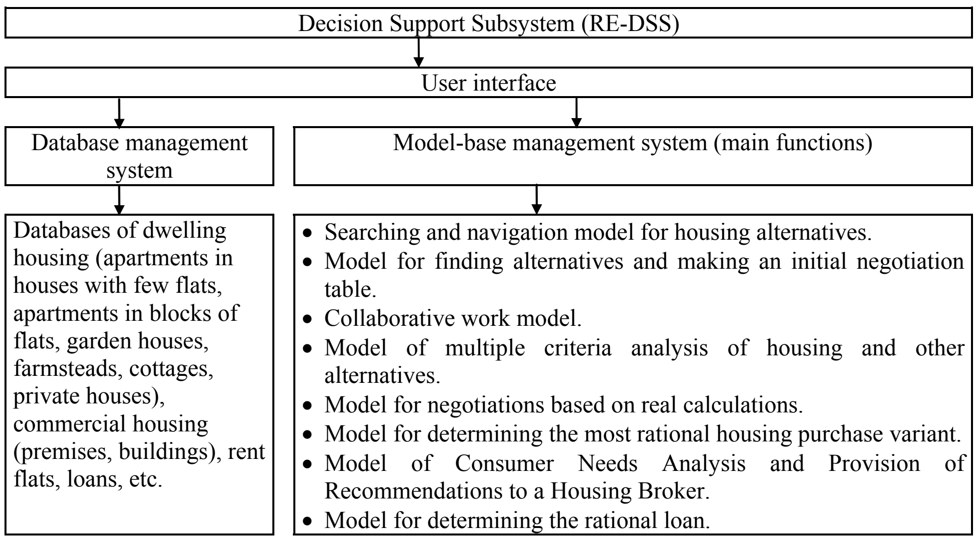

Figure 2. *Components of Decision Support Subsystem*

Housing listings are an interface for a seller to post listings. The system provides forms for completion by sellers or housing on information about their housing. Housing brokers wishing to present information on their objects must receive permission from DSS-RE administrator. Having this permission the broker then inserts all the necessary information about housing objects under sale in the DSS-RE databases according to the system's requirements (i.e. system of criteria, values and weights of criteria). Access to databases developed personally by brokers is provided only to the broker and to the DSS-RE administrator. At present the developed DSS-RE allows for the performance of nine five main functions. In order to throw more light on the DSS-RE, a more detailed description of some of the above-mentioned Subsystem functions follows.

Data Search and the Navigation Module give a buyer a search and navigational instrument to retrieve and browse exhaustive housing data and alternatives such as single family house, two, three or four-room flats in different locations and of different quality, etc. Buyers can also choose and keep/save attractive housing alternatives in a personal preferred list. This housing search and navigation module is available in the following databases: databases of dwelling housing (apartments in houses with few flats, apartments in blocks of flats, garden houses, farmsteads, cottages and private houses), commercial housing (premises, buildings), rented flats and loans, etc. A consumer may perform a search for housing alternatives from databases with different brokers. This is possible because the forms of data submissions are standardized at a specific level. Such standardization creates conditions that can be applied to special intelligent agents that are performing a search for the required housing in various databases, and for the gathering information/knowledge.

Consumers specify requirements and constraints and the system queries the information of a specific housing from a number of online brokers. The system performs the tedious, time-consuming, and repetitive tasks of searching databases, retrieving and filtering information/knowledge, and delivering it back to the user. Search results for a specific housing are submitted in a textual, photo/video and graphical information on the housing's alternatives and the initial negotiation table, which may include direct links to a broker's Web page. When submitting such a display, the multiple criteria comparisons will become more effectively supported.

The brokers or sellers offer many different housing alternatives to the market, while at the same time buyers identify their detailed requirements. First, buyers are offered a system of typical criteria on the basis of which housing evaluators and buyers evaluate housing alternatives. Buyers can offer their own system of criteria based on this system of typical criteria and on their needs. Similarly, initial weights of criteria and values of qualitative indicators are determined. Buyers receive typical weights of criteria and values of qualitative criteria describing the analysed housing. Buyers can change the offered typical weights of criteria and of qualitative indicators on the basis of their experiences and needs. In such a case, each buyer receives a personalized and specifically adjusted decision-making matrix. One person or a group of stakeholders (e.g. the whole family) can participate in the process of determining the system of criteria, their weights and values of qualitative indicators.

The Collaborative Work Module allows different stakeholders (e.g. family members) in collaborative ways to solve common tasks (development of joint criteria system, estimation of criteria weight and qualitative criteria values). The Groupware Module allows stakeholders to share ideas and to vote and select the one with the highest votes as a jointly accepted housing alternative.

By using Housing and other Alternatives Analysis Module buyers may indicate their tasks and preferences by changing criteria systems, criteria values and weight. A buyer can retrieve previously stored information from a previously developed personalized database or directly insert data through an input screen for a concrete case and activate the multiple criteria analysis process. The results are module recommended housing, loan, brokers, insurance, leasing, work, facilities management and other alternatives that personally match the buyers' tasks and preferences.

While going through the purchasing decision process a customer should examine a large number of alternatives, each of which is surrounded by a considerable amount of information/knowledge (economic, quality-architectural, aesthetic, comfort, infrastructure, and technical, legal, technological) and other factors. Following on from the gathered information and knowledge, the multiple criteria analysis is then carried out. By using multiple criteria methods [22-25, 36] as was developed by the authors, the buyer (broker) determines the initial priority, utility degree and market value of the analysed housing's alternatives During this analysis. Clicking the link "Results of Multiple Criteria Evaluation", the results of the multiple criteria evaluation of 3-room apartment's alternatives are thus demonstrated (see Fig. 3). In the lower part of the obtained result's matrix the calculated significance of the housing's alternatives their priority and utility degree are presented (see Fig. 3). The upper part of the obtained result's matrix shows the numbering of housing's alternatives (see Fig. 3 (*left*)). By clicking the blue underlined numbers it is possible to calculate the market value of a certain alternative (see Fig. 4). The table presented in Fig. 4 shows the iterations made during the calculation of the housing's market value. The same information, only in graphical form is presented in Fig. 4. Also, by moving a mouse above any column of the graphical part, the numerical value of the column can be seen. For example, the market value of the eighth alternative was calculated by making 4 iterations (see Fig. 4).

A buyer performing a multi-criteria analysis of all housing alternatives selects the objects for starting negotiations. For this purpose he/she marks (ticks a box with a mouse) the desirable negotiation objects (see Fig. 5 (*left*)). E-mail negotiations are created by the Letter Writing Subsystem and sent to all housing sellers after the selection of the desired objects is made and then *Send* is clicked.

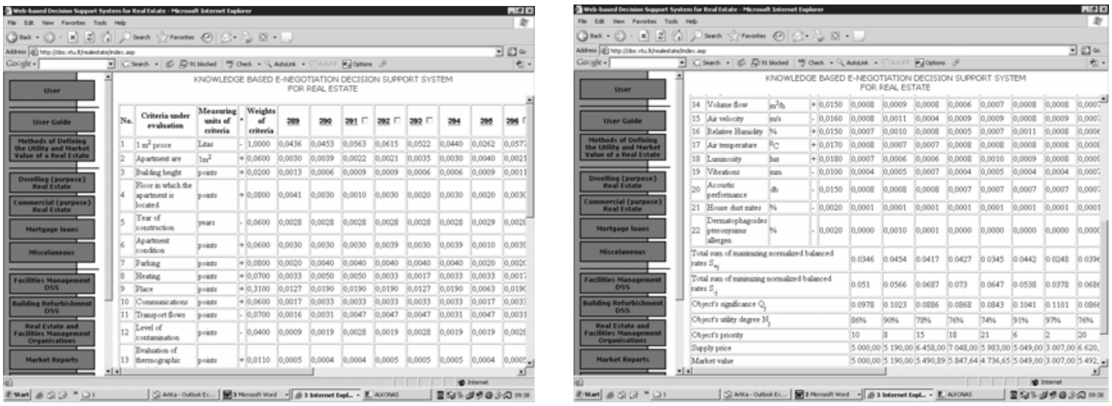

Figure 3. *Results of multiple criteria evaluation of the alternatives of 3-room apartment: upper part of matrix for the obtained results (left); lower part of matrix for the obtained results (right)*

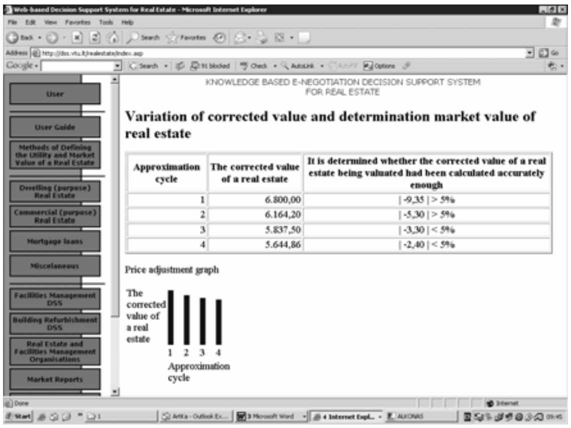

Figure 4. *Calculation of market value: presentation of market value's calculations in numerical and graphic forms*

During negotiations the buyer and the seller with the help of DSS-RE may perform real calculations (utility degree, market value and purchase priorities) of the housing. These calculations are performed on the basis of characteristics describing the housing's alternatives that are obtained during negotiations (explicit and tacit criteria system, criteria values and weights). According to the received results, the final comparative table is consequently developed. Following on from the developed final comparative table, the multiple criteria analysis and selection of the best housing buying version is carried out by using DSS-RE.

After a variant of the housing is selected, most often a purchaser has to borrow part of money from a bank. The Loan Analysis Subsystem is created for this purpose (see Fig. 5 (*right*)).

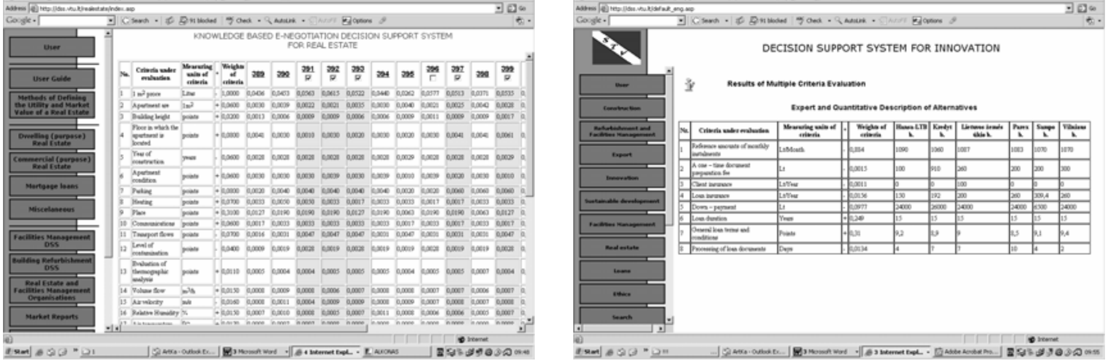

Figure 5. *Selection of housing objects for automated negotiations (left) and analysis of loan alternatives offered by certain banks (right)*

There are five main categories of rules and procedures in the housing knowledge subsystem with special emphasis on energy efficiency (RE-KS):

- Buyer oriented information rules and procedures allow buyers to develop and maintain customer‘s personalized objectives, preferences, and evaluation criteria for analysing and selecting housing, brokers, related products and services. Editing services for buyers to create personalized housing web pages that provide link to directories, annotations and notebooks to analyse related products and services are also integrated.
- Formation of the criteria describing the alternatives. This category consists of rule sets for the formation of the system of criteria that describe the alternatives and provides values and weights of these criteria.
- Development of suggestions with what broker/seller to use and for what reasons further negotiation should be carried out. With the help of a decision support subsystem (RE-DSS) having determined the sequence of priority then the degree of utility and market value of the elements of a renovated building, the rules in knowledge subsystem suggests with what broker/seller to use and for what reasons further negotiation should be carried out.
- Composition of a comprehensively reasoned negotiation e-mail for each of the selected broker/seller. By using information inherited from the previous RE-DSS calculations and predefined rules and procedures, the knowledge subsystem composes of a negotiation e-mail for each of the selected broker/seller, where it reasonably suggests that the price of housing should be decreased or a housing of better quality should be sold for the offered price. The e-mail includes references to the calculations performed by KDDSS-RE.

RE-KS also overwhelm a Market Signalling Subsystem. Links to sites with exhaustive information and analytic reviews about the situation in the Lithuanian housing market and about its development perspectives is provided. Useful information and knowledge is also presented for different stakeholders in the Market Signalling Subsystem: housing and facilities management organizations, information about collaterals and loans, insurance (housing, cars, other property), information on companies offering transportation services (furniture transportation, car transportation, etc.; offered services, vehicles and fees), recreational or residential areas for elderly people (sanatoriums, health centres, nursing homes); purchase or lease of furniture, household appliances, audio/video equipment, other household utilities; leasing companies, comparison of alternatives, various announcements, links to job search websites, facilities management services, information and forecasts on the market situation and its changes, information about activities of housing companies and associations, information about periodical information bulletins, links to other websites and articles.

Devices in the Device Subsystem measure the indoor microclimate parameters (volume flow, air velocity, air temperature, relative humidity, dew point temperature, vibration impulse amplitudes and allergens causing allergy in the dwelling (house dust mites and dermatophagoides pteronysinus allergen etc.). This data is provided in the Decision Support Subsystem and the Knowledge Subsystem.

All members of a housing market can use the created system. Members are recommended to use as much of their knowledge as possible before making decisions. For example, in order to perform the multiple criteria analysis of a housing, buyers, sellers, brokers, financial institutions, neighbours and other stakeholders’ requirements should be estimated and submitted in a quantitative form.

4. TESTING THE SYSTEM

In order to test the usefulness of the system, final semester master degree students from the Real Estate Management and Evaluation program at VGTU (Vilnius University) collected more than 250 listings. These students work as brokers in various real estate companies in Vilnius. They placed information about real estate objects that they were selling at the time into the database. This system were tested by eighteen students for areas that could be improved, e.g. process, interface, navigation, search for alternatives from different brokers’ databases, multiple criteria evaluations, calculation of market value and negotiation. A testing of KDDSS-RE was also performed by a designed questionnaire that included four organizations from real estate brokers in Vilnius. The letter that was attached to the questionnaire was as follows ‘We would like you to draw on your experience and expertise to help us to test whether the KDDSS-RE can also meet *your* needs as a user. Please read through the following questions circling your response'. A more complete study is underway to study the satisfaction of users and what current real estate agents do in order to survive.

CONCLUSIONS

The investigation carried out by the authors of this paper under "Intelligent Cities" [3], e-City [4], PHARE program (Kaklauskas, 1998) and other projects (Zavadskas et al, 1996, 1997) helps to identify and describe the major trends of housing urban development with a special emphasis on energy efficiency in industrialized countries as well as providing recommendations for Lithuania's development. The comparative quantitative and conceptual analysis of housing urban development with a special emphasis on energy efficiency that is carried out in the developed countries and in Lithuania allows the authors to identify areas where the situation in Lithuania is comparable, partly comparable or quite different from the levels attained by foreign developed cities. Data from this quantitative and conceptual analysis is used in identifying housing urban development trends with special emphasis on energy efficiency in Western Europe and in the USA as well as providing some recommendations for Lithuania.

More automated valuation processes and products have an important role to play in the future provision of valuation services. The valuation community must rise to the challenge of developing a professional class of appraisers in emerging economies.

AVMs are understood as computer programs that use real estate information, such as demographics, property characteristics, sales prices, and price trends to calculate a value for a specific property.

AVMs are preferred by appraisers because they don't have the „human" element. In this way automated valuation becomes more objective and easier understandable.

One of the major weaknesses in AVMs is a lack of a physical inspection of the properties. Methods such as verifying an address of Postal Service and using aerial photography are possible strategies for cutting down on fraud. But there is no substitute for a physical inspection.

No AVM is perfect. They all have data problems. The best AVM for a user gives the most accurate results with the most "hits", for their "comfort level" of acceptable risk. Some models perform better than others, but all depend on data to get reliable results. If AVM is used in an area with few sales, it won't be very reliable. If the AVM database has no property characteristics for the subject property, it won't run if it doesn't allow user input. If AVM runs from a vendor that also provides better data than another equivalent AVM, it will be more reliable.

Integration of neural networks, multimedia, knowledge-based, decision support, devices and other systems in the real estate sector has a very promising future in scientific research. Various forms of the integration of these systems are investigated and several architectures of systems are offered. The authors of the present research suggest the idea to integrate knowledge-based, devices-based and decision support systems. In order to demonstrate the integration decision support, knowledge and devices systems in the real estate sector a Real Estate's Knowledge and Devices-based Decision Support System are considered in the paper as an example.

References

1. Alshuwaikhat, H. M. Strategic environmental assessment can help solve environmental impact assessment failures in developing countries, *Environmental Impact Assessment Review*, Vol. 25, Issue 4, May 2005, pp. 307-317.
2. Couch, C and Dennemann, A Urban regeneration and housing development in Britain: The example of the Liverpool Ropewalks Partnership, *Cities*, Vol. 17 (2), 2000, pp. 137-147.
3. D'Amato, G., Liccardi, G., D'Amato, M., Cazzola, M. The role of outdoor air pollution and climatic changes on the rising trends in respiratory allergy, *Respiratory Medicine*, Vol. 95, Issue 7, July 2001, pp. 606-611.
4. Hadjieva-Zaharieva, R, Dimitrova, E and Buyle-Bodin, F. Building waste management in Bulgaria: challenges and opportunities, *Waste Management*, Vol. 23 (8), 2003, pp. 749-761.
5. Hillebrandt, P. H. *Analysis of the British construction industry*. London: Macmillan Press, 1988. 338 p.

6. Jonaitis, V., Naimavicienė, J. Social and regional aspects of housing situation in Lithuania, *International Journal of Strategic Property Management*. Vol. 8, No 4, 2004, pp. 231-239.
7. Kaklauskas, A Total life analysis, modeling and forecasting of construction in Lithuania. Research output, EC PHARE-ACE Programme, Lithuania. Project No.: P96-6708-F, 1998.
8. Kelkit, A. Environmental problems of Canakkale City and solutions, *Int. J. Environment and Pollution,* Vol. 19, No 1, 2003, pp. 66-74.
9. Kerenyi, N. A., Pandula, E., Feuer, G. Why the incidence of cancer is increasing: the role of 'light pollution', *Medical Hypotheses*, Vol. 33, Issue 2, October 1990, pp. 75-78.
10. LaGro, A Population growth beyond the urban fringe: implications for rural land use policy, *Landscape and Urban Planning,* 28 (2-3), 1994, pp. 143-158.
11. Macintyre, S., Ellaway, A., Hiscock, R., Kearns, A., Der, G. and McKay, L. What features of the home and the area might help to explain observed relationships between housing tenure and health? Evidence from the West of Scotland, *Health & Place,* Vol. 9 (3), 2003, pp. 207-218.
12. Ministry of Health Protection. HN 33-1998: Hygienic Norm 33-1998, Air Quality Standards. Ministry of Health Protection, Lithuania, 1998, pp. 1-33.
13. Pauley, S. M. Lighting for the human circadian clock: recent research indicates that lighting has become a public health issue, *Medical Hypotheses*, Vol. 63, Issue 4, 2004, pp. 588-596.
14. Piron-Frenet, M., Bureau, F., Pineau, A. Lead accumulation in surface roadside soil: its relationship to traffic density and meteorological parameters, *The Science of The Total Environment,* Vol. 144, Issues 1-3, 29 April 1994, pp. 297-304.
15. Zavadskas, E.K., Kaklauskas, A. Efficiency increase in research and studies while applying up-to-date information technologies, *Statyba* (Journal of Civil Engineering and Management), Vol. 6, No 6, 2000, pp. 397-414.
16. Zavadskas, E.K., Kaklauskas, A., Lepkova, N., Zalatorius, J. Multiple Criteria Analysis of Facilities Management, *Statyba* (Journal of Civil Engineering and Management), Vol. 7, No 6, 2001, pp. 476-484.
17. Zavadskas, E.K., Kaklauskas, A., Vainiunas, P., Kutut, V., Turskis, Z. Creation of Innovation Development Model for Lithuanian Construction Industry and Real Estate Sector, *Journal of Civil Engineering and Management*, Vol. IX, Supplement 1, 2003, pp. 17-24. (In Lithuanian)
18. Zavadskas, E.K., Rutkauskas, A.V., Kaklauskas, A. Development of Model for Rational Lithuanian Construction Industry, *Statyba* (Journal of Civil Engineering and Management), Vol. 5, No 2, 1999, pp. 123-134. (In Lithuanian)

RESEARCH OF CHANGE OF VOLUMES OF CITY TRANSPORTATIONS OF PASSENGERS IN TIME

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Functioning of the system of city passengers' transportations depends on the changes of volumes of passengers' traffic on seasons of year, days of week, hours of day and sites of a route. Knowledge of laws of size change in volumes of passengers' traffic in time for a routing network allows making the proved decisions on the organization of transportations of passengers.

Therefore it is offered to establish the developed laws of volumes change in passengers' traffic. Change of values in transportations volume on days of week is better approximated, in comparison with multinominal Furje, a sedate polynom.

The general equation which describes communication between time and volume of transportations is received.

Keywords: volume of transportations of passengers, volume change of passengers' traffic in time, city passengers' transport

The paper deals with the system of city passenger transportations. The greater influence of fluctuations of volumes of passenger traffic is on hours of day and renders distribution on length of a route. Data about size of volumes of passenger traffic allow presenting a real condition of the existing position and on this basis to do conclusions about a direction of perfection of the organization of transportations. Fluctuations of volumes of passenger traffic the certain law determines. The greatest interest is represented with fluctuations on hours of day as data about the sizes and character of hour streams form the basis for a choice of effective type of a rolling stock and its quantity; calculation of the parameters describing movement of buses; drawing up of the schedule of movement; the organizations of effective schedules of work of bus brigades.

In this connection the great value has accuracy and efficiency of directing the transportations of passengers during the concrete moment of time. Traditional methods of inspection and construction of cartograms of change of daily volumes of passenger traffic make it is possible only after some time, that is to estimate the completed process.

Development of needs can be subdivided into two elements conditionally: adjustable and casual. So the basic motive power of growth of transport needs is factors of industrial character. However alongside with them numerous random factors operate. For example, between places of residing and spatial distribution of workplaces the volume of passenger traffic is formed. The prediction of behaviour of each passenger separately is not obviously possible. At the same time the cumulative behaviour of all passengers submits to the certain law which can be described by one of likelihood laws of distribution of random variables.

Knowledge of laws of change of size of volumes of passenger traffic in time for a routing network the proved decisions on the organization of transportations of passengers allow to make.

Data about the sizes and character of hour streams form the basis for a choice of effective type of vehicles and their number, a choice of the form of movement of vehicles on routes, calculation of the parameters describing movement of vehicles, drawing up of the schedule of movement, development of effective schedules of work of bus brigades, and also allow to reach optimum conformity transporting abilities of city passenger transport to size of a volume of passenger traffic. Therefore it is necessary to have operative enough and exact data on size of the expected volume of transportations of passengers for the concrete moment of time on sites of routes. Traditional methods (inspection and construction of timetables change the volumes of passenger traffic) to make it is possible only after some time, i.e., having estimated the completed process. Therefore it is offered to establish the developed laws of change of volumes of passenger traffic.

The example of experimental data on about changes of volumes of passenger traffic in time for the separate periods is given to Gomel in the mentioned below figures.

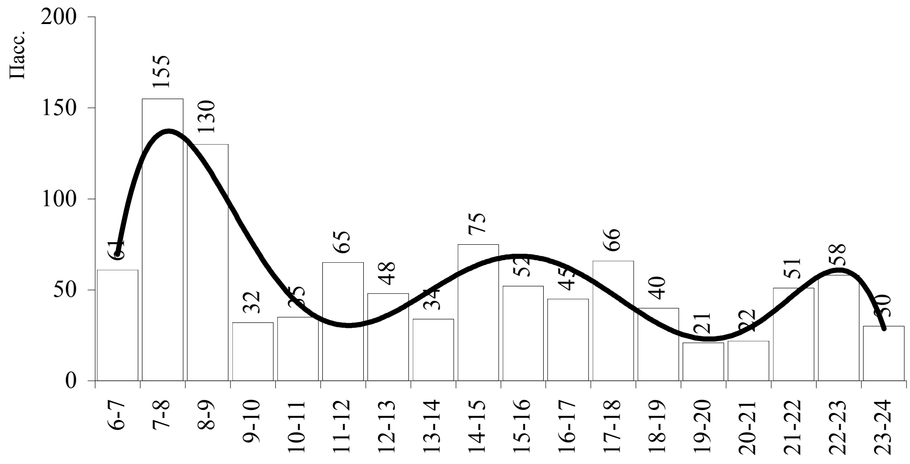

Fig. 1. *Change of volumes of passenger traffic on hours of day on a separate route*

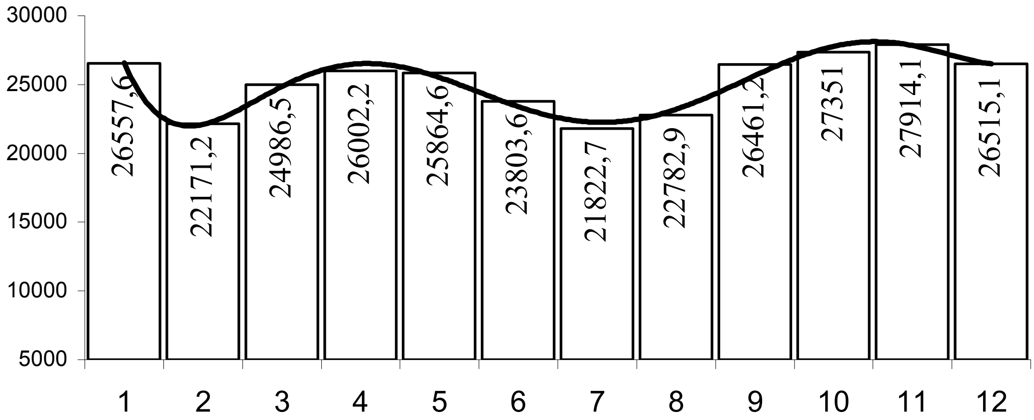

Fig. 2. *Change of volumes of passenger traffic on months 2006*

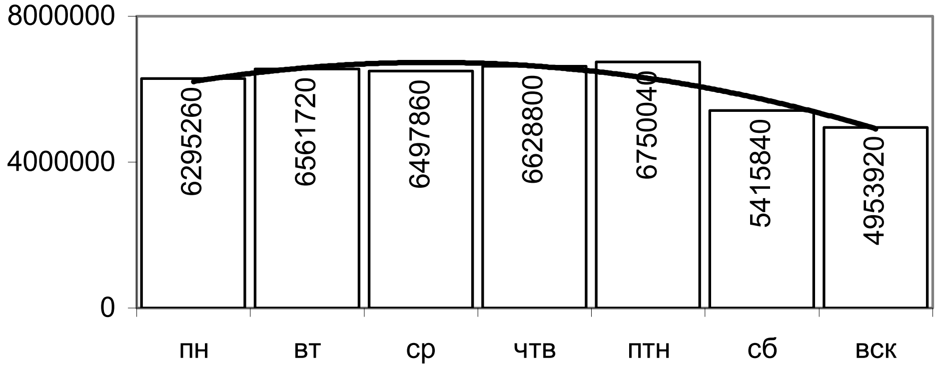

Fig. 3. *Change of volumes of passenger traffic on days of week for 1 quarter 2007*

From the resulted figures follows, that the distributions of a volume of passenger traffic on hours of day and months of year have strongly pronounced harmonious character and, hence, as any periodic process can be presented in trigonometrical form, in particular, in the form by Furje. Factors of some, certain at the statistical analysis, reflect changes of volumes of transportations of passengers with reference to the certain transport system.

Change of values of volume of transportations on days of week is better approximated, in comparison with multi-nominal Furje, a sedate polynom.

Value of volume of transportations in unit of time is offered (1 hour) to describe the following equation:

$$Z(t) = Zo + Zc(t) + Z_H(t) + Z_M(t), \tag{1}$$

where Zo – mid-annual value of volume of transportation in unit of time;

Zc (t), Z_H (t), Z_M (t) – accordingly daily, week and seasonal making fluctuations of volumes of transportations.

In turn separate components Z (t) are expressed as follows:

$$Zc(t) = \sum_{i=1}^{h_1}\left(b_{1,i}\cdot Sin\frac{2\cdot\pi\cdot i\cdot t}{24} + a_{1,i}Cos\frac{2\cdot\pi\cdot i\cdot t}{24}\right); \tag{2}$$

$$Z_H(t) = \sum_{i=1}^{h2}\left(c_{2,i}\cdot\left(7\cdot\left\{\frac{t}{168}\right\}\right)^i\right); \tag{3}$$

$$Z_M(t) = \sum_{i=1}^{h_3}\left(b_{3,i}\cdot Sin\frac{2\cdot\pi\cdot i\cdot t}{2184} + a_{3,i}Cos\frac{2\cdot\pi\cdot i\cdot t}{2184}\right). \tag{4}$$

Having substituted the equations (2)-(4) in (1) we receive the following expression:

$$Z(t) = Zo + \sum_{i=1}^{h_1}\left(b_{1,i}\cdot Sin\frac{2\cdot\pi\cdot i\cdot t}{24} + a_{1,i}Cos\frac{2\cdot\pi\cdot i\cdot t}{24}\right) + \sum_{i=1}^{h2}\left(c_{2,i}\cdot\left(7\cdot\left\{\frac{t}{168}\right\}\right)^i\right) +$$
$$+\sum_{i=1}^{h_3}\left(b_{3,i}\cdot Sin\frac{2\cdot\pi\cdot i\cdot t}{2184} + a_{3,i}Cos\frac{2\cdot\pi\cdot i\cdot t}{2184}\right), \tag{5}$$

where $b_{1,i}, b_{3,i}, a_{1,i} a_{3,i}$ – factors of multi-nominal Furje;

$c_{2,i}$ – factor of a sedate multi-nominal of i-th degree;

$h_{1,3}$ – the order of multi-nominal Furje;

h_2 – the order of a sedate multi-nominal;

t – current value of calendar time with the report from the beginning of year in hours;

24, 168, 2184 – the accepted periods of fluctuations of volumes of transportation in unit of time (an hour interval) accordingly daily, week and seasonal.

$\left\{\frac{t}{168}\right\}$ – the fractional part received as a result of division.

By calculations it is established, that change of volumes of transportations on days of week is well described by parabolic function of the second order.

Parameters (factors) of the equations of multi-nominal Furje are defined on the following dependences:

$$Zo = \frac{1}{m}\sum_{i=1}^{m} y_{эi}; \tag{6}$$

$$a_i = 2/m\sum_{i=1}^{m}(y_{эi}\cos(2\pi k\ i/m)); \tag{7}$$

$$b_i = 2/m\sum_{i=1}^{m}(y_{эi}\sin(2\pi k\ i/m)); \tag{8}$$

where $y_{эi}$ – experimental values of volume of transportations in *i* settlement points.

Parameters (factors) of sedate dependences of volumes of transportations on days of week are made with application of computer software package Statistica V.5.0.

Parameters (factors) for the equations of multi-nominal Furje are under the computer program developed by us. At carrying out of calculations of number of the harmonics, including in the equation, are accepted it is adaptive or on a maximum of value of statistics of criterion of Fisher F or on a minimum of factor of an average linear mistake of approximation E. Harmonics which cause reduction of value F or increase in value E, do not join in model of communication. Thus the top value of number of harmonics is accepted no more than n/2.

The received general equation of a kind (1) is model of communication between time and volume of transportations.

The statistics describing narrowness of communication between factors and a dependent variable, the factor of plural correlation exists.

What part of a dispersion of a dependent variable shows the factor of plural correlation speaks about the accepted regression model:

$$R = \sqrt{s^2_{об}/s^2_{п}}\ , \tag{9}$$

where $s^2_{об} = \sum_{i=1}^{m} (y_{тi} - Z_0)^2$ – the explained sum of squares of deviations from an estimation of a population mean (m – number of experiences);

$s^2_{п} = \sum_{i=1}^{m} (y_{эi} - Z_0)^2$ – the full sum of squares of deviations from an estimation of a population mean;

Z_0 – an estimation of a population mean of a random variable.

The difference between the full and explained sum of squares is the residual (not explained) sum of deviations from an estimation of a population mean

$$s^2_{ост} = s^2_{п} - s^2_{об} = \sum_{i=1}^{m} (y_{эi} - y_{тi})^2 . \tag{10}$$

Then through $s^2_{ост}$ value of factor of plural correlation pays off under the formula:

$$R = \sqrt{1 - s^2_{ост}/s^2_{п}}\ . \tag{11}$$

Values R can be within the limits of from 0 up to 1.0. At R = 0 communication between factors and a dependent variable is absent, and R = 1.0 specifies functional dependence.

For checking of a hypothesis of importance of factor of plural correlation and a coordination of the equation of regress with experiments by data the statistics of criterion of Fisher is used:

$$F = s_1^2 / s_2^2 = \frac{s^2_{об} / n}{s^2_{ост} /(m - n - 1)} = \frac{s^2_{об}(m - n - 1)}{s^2_{ост}\ n}, \tag{12}$$

or

$$F = \frac{R^2 (m - n - 1)}{(1 - R^2)\, n}, \tag{13}$$

where s_1^2 and s_1^2 – accordingly explained and residual dispersion for dependent parameter.

If there are no bases to reject a hypothesis, the experimental data will be coordinated with the received equation of the regress, the calculated statistics of criterion of Fisher should be more than tabulated value ($F > F_T$). Tabulated value F_T is defined depending on a significance value and number of degrees of freedom k1 = n and k2 = m - n-1 (n – number of factors).

The significance value (probability) is recommended to be accepted 0.01-0.05 (the less, the requirements to adequacy of model are more rigid).

If $F < F_T$ it is considered, that the equation of regress will not be coordinated with experimental data.

Let's lead necessary calculations for acknowledgement of the assumptions put forward. Calculations are executed with use of the program written specially for this purpose. Below the result of performance by the program of calculation with reduction of graphic visualization is resulted.

Result of calculation by the program of daily non-uniformity.

Table 1. Results of approximation given by Furje's number

K	**A(K)**	**B(K)**
1	+8.9989E+00	+1.6930E+01
2	+4.7537E+00	+2.3268E+01
4	-1.9572E+01	-4.7810E+00
5	-1.7289E+01	-1.6290E+01
6	+7.4446E+00	-7.1203E+00

An estimation of a population mean of a random variable Z_0=+5.7222E+01.

Table 2. The kind of the multinominal is certain on the maximum of Fisher's criterion

I	**YS(I)**	**YT(I)**
1	+6.1000E+01	+5.9031E+01
2	+1.5500E+02	+1.3976E+02
3	+1.3000E+02	+1.2099E+02
4	+3.2000E+01	+3.3425E+01
5	+3.5000E+01	+4.7059E+01
6	+6.5000E+01	+8.0699E+01
7	+4.8000E+01	+3.8585E+01
8	+3.4000E+01	+2.7951E+01
9	+7.5000E+01	+5.8139E+01
10	+5.2000E+01	+5.6617E+01
11	+4.5000E+01	+6.0570E+01
12	+6.6000E+01	+7.1743E+01
13	+4.0000E+01	+4.4383E+01
14	+3.1000E+01	+1.1290E+01
15	+2.2000E+01	+1.4871E+01
16	+5.1000E+01	+5.1959E+01
17	+5.8000E+01	+7.1371E+01
18	+3.0000E+01	+4.1556E+01

Average linear mistake of approximation +2.60E-01. Fisher's criterion +1.98E+01.

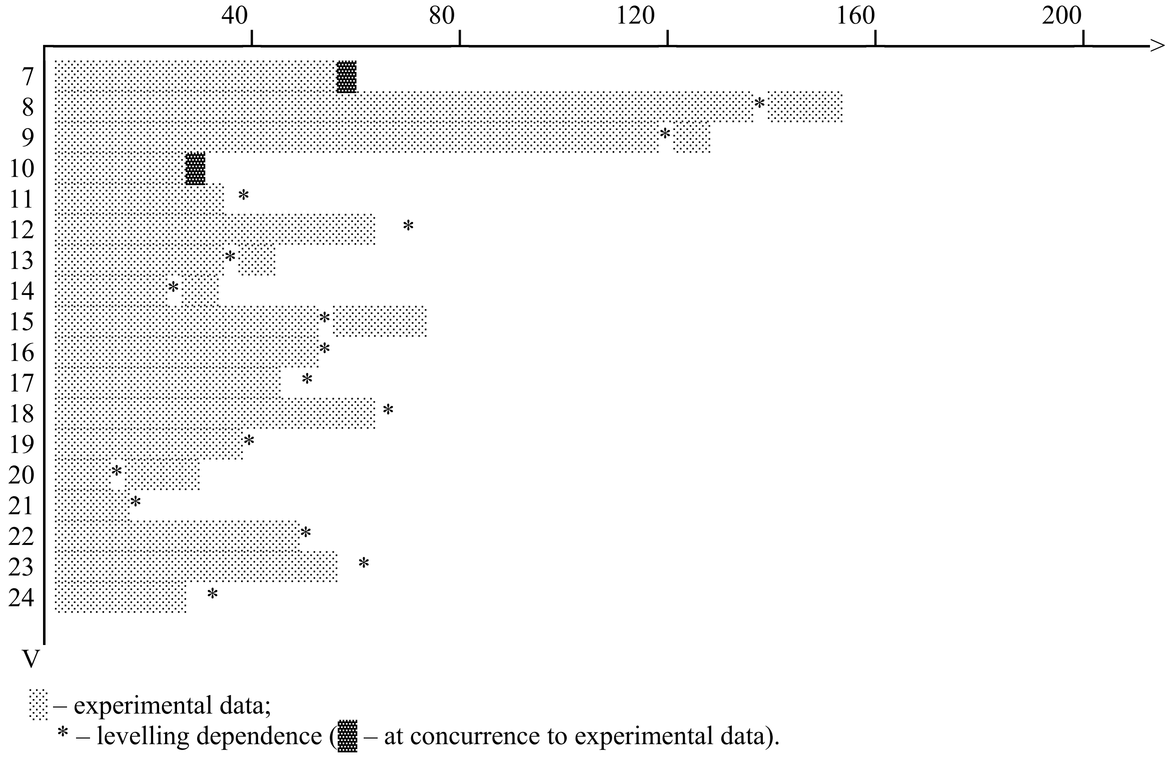

Fig. 4. *The diagram of distribution of volume of passengers' traffic*

Thus, value of transportations volume in unit of time (1 hour) describes the following expression:

$$Zc(t) = 57{,}222 + \sum_{i=1}^{6}\left(-7{,}1203\cdot Sin\frac{2\cdot\pi\cdot i\cdot t}{24} + 7{,}4446 Cos\frac{2\cdot\pi\cdot i\cdot t}{24}\right).$$

Result of calculation by the program of monthly non-uniformity.

Table 3. Results of approximation given by Furje's number

K	A(K)	B(K)
1	+1.4926E+03	-3.0483E+02
2	+1.3306E+02	-1.9914E+03
3	+3.2908E+02	+6.9342E+02
5	-4.6589E+02	+2.6136E+02

An estimation of a population mean of a random variable Z_0=+2.5186E+04.

Table 4. The kind of the multinominal is certain on the maximum of Fisher's criterion

I	YS(I)	YT(I)
1	+2.6558E+04	+2.5896E+04
2	+2.2171E+04	+2.3089E+04
3	+2.4987E+04	+2.4316E+04
4	+2.6002E+04	+2.6170E+04
5	+2.5865E+04	+2.5953E+04
6	+2.3804E+04	+2.3963E+04
7	+2.1823E+04	+2.1160E+04
8	+2.2783E+04	+2.3701E+04
9	+2.6461E+04	+2.5790E+04
10	+2.7351E+04	+2.7519E+04

I	YS(I)	YT(I)
11	+2.7914E+04	+2.8002E+04
12	+2.6515E+04	+2.6675E+04

Average linear mistake of approximation +1.84E-02. Average linear mistake of approximation +2.10E+01.

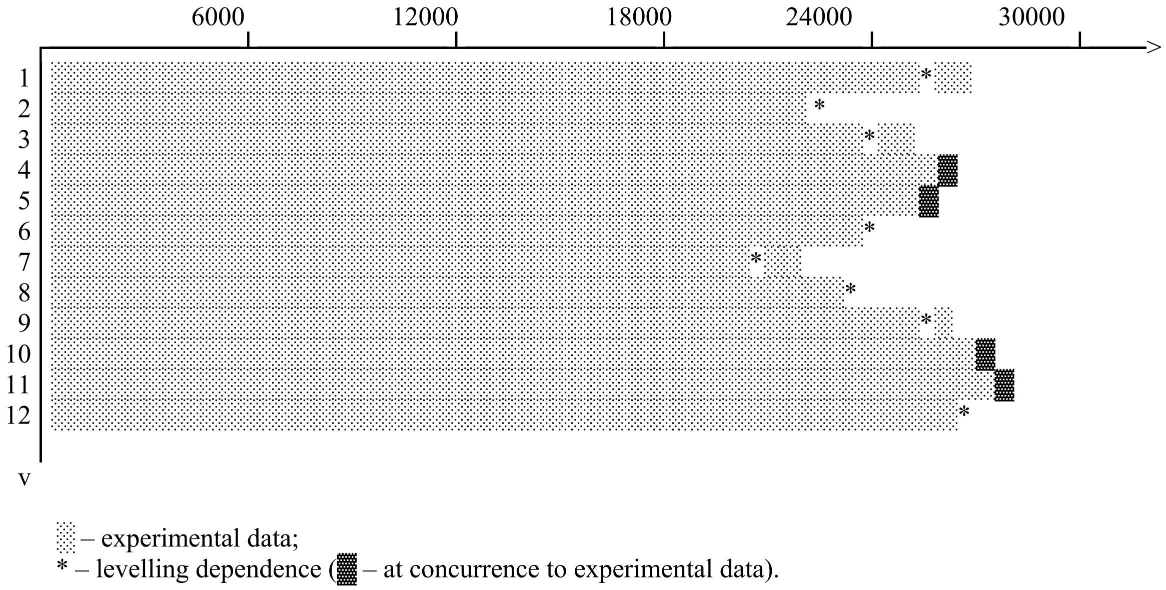

Fig. 5. *The diagram of distribution of volume of passengers' traffic*

Thus, value of volume of transportations in unit of time (1 month) describes the following expression:

$$Zc(t) = 25186 + \sum_{i=1}^{5}\left(-465{,}89 \cdot Sin\frac{2\cdot\pi\cdot i\cdot t}{12} + 261{,}36\cdot Cos\frac{2\cdot\pi\cdot i\cdot t}{12}\right).$$

CONCLUSION

The calculations executed by the results of inspections of volumes of passenger traffic on a routing network of Gomel, have confirmed by Fisher's criterion validity of a hypothesis about the description of change of volume of transportations of passengers in time on seasons of year and hours of day in the trigonometrical form of some Furje.

References

1. Zengbush, M.V., Belinsky, A.J., Dynkin, A.G. *Volume in cities*. M.: Transport, 1974. 136 p. (In Russian).
2. Zabolotsky, G.A. *Method of calculation of passengers and transport in cities*. M.: The Centre of the Scientific and Technical Information on Civil Construction and Architecture, 1968. 91 p.
3. Spirin, I.V. *City bus transportations*. M.: Transport, 1991. 238 p. (In Russian).
4. Yefremov, I.S. *Theory of city passenger transportations*. M.: The Higher School, 1980. 535 p. (In Russian).
5. Box, G.E.P., Jenkins, G. M. *The analysis of time numbers. The forecast and management*. M.: The World, 1974. 406 p. (In Russian).
6. Lvov, E.N. *Statistical methods of construction of empirical formulas.* M.: The Higher School, 1988. 239 p. (In Russian).
7. Romanovsky, P.I. *Number Furje. The theory of a field. Analytical and special functions*. M.: The Science, 1973. 336 p. (In Russian).