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http://www.isarc2008.vgtu.lt/

The 25th International Symposium on Automation and Robotics in Construction

June 26–29, 2008

ISARC-2008

ADVANCED INFORMATION AND COMMUNICATION TECHNOLOGIES IN CONSTRUCTION

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ABSTRACT

Currently, construction and real estate are characterized by the intensive creation and use of information and communication technology. The authors of this paper in cooperation with other specialists developed the Construction Technology Platform of the Republic of Lithuania. Information and Communication Technology in Construction is one part of the Platform; it is briefly described in the article. Five main trends of implementation of advanced information and communication technology are analysed by authors in the Platform and in the paper: transformation of the sector of construction and real estate; construction materials, equipment and machinery; construction process; built environment and its management; training, education and adoption of experience. Brief review of intelligent and biometric systems developed by the authors in cooperation with their partners illustrates the aforementioned development trends.

KEYWORDS

Construction, Real Estate, Information and Communication Technologies, Intelligent and Biometrics Technologies.

INTRODUCTION

In Lithuania, the main problem related to IT application in construction is that the companies themselves create technology innovations and intelligent technologies as of yet. However, such technologies are of the initial level of functional integration and innovation. Software developers lack knowledge about construction and real estate peculiarities and fail to offer intelligent technology solutions able to meet specific needs of this field. Intelligent systems are scarce in the construction and real estate sector compared to other industries, although the flow of information and knowledge is enormous. The experience of numerous projects is used insufficiently. Lithuania lacks a convenient and accessible IT system enabling real estate companies to have easy administration of objects and good quality presentation of the objects to the market. Sales of constructions products are performed scarcely using the IT potential. Intelligent systems are underused and inefficiently used in Lithuanian

construction and real estate industry. Construction sites lack qualified labour force.

Contemporary environmental and construction technologies are efficiency-enabled; however, substantial investment is needed to implement such technologies. Therefore, many sectors, such as waste management and water treatment, fail to implement quickly new infrastructures meeting all requirements. New technologies are being implemented systematically.

The main factors that have negative influence on use of IT in construction: lack of common standards, norms and regulations for IT application, some construction sites lack network-enabled computers or computers in general, construction works are performed by people with different education, qualifications and work culture, common use of information by many stakeholder groups poses problems related to legal protection of intelligent property.

THE CONSTRUCTION TECHNOLOGY PLATFORM OF THE REPUBLIC OF LITHUANIA: INFORMATION AND COMMUNICATION TECHNOLOGY IN CONSTRUCTION

In cooperation with their partners, the authors of the article have created the Construction Technology Platform of the Republic of Lithuania [2]. The Platform considers the current situation in Lithuania, the vision of the European Construction Technology Platform (ECTP) until 2030, growing society needs, cohesive construction requirements and the directives of Lisbon Strategy. While creating the part on Information and Communication Technology in Construction within the Platform [2], global experience was analysed thoroughly as well [1, 3-6, 16-19, etc.].

In order to implement advance information and communication technologies in construction area, hereinafter the following five main trends of its implementation are analyzed in the Platform:

- Transformation of sector of construction and real estate.
- Construction materials, equipment and machines.
- Construction process.
- Built environment and its management.
- Training, education, experience adoption.

The trends mentioned above will be now described in more detail.

The trends for transformation of construction and real estate sector are as follows:

- Reengineer the construction and real estate sector to transform a technology-driven sector into a sustainable knowledge-based and demand-driven sector which offers new e-business and collaborative work opportunities and attractive working places to all.
- A wider use of information and communication technologies in three levels (country, organization, and project).
- Incorporate the Lithuanian SMEs into global knowledge-based construction process and application of new ideas in construction.
- Created decision support systems based on knowledge of forecasting, modeling and analysis of sector of construction and real estate.
- Development and practical application of new models of e-business and e-cooperation between stakeholders.
- Transform sector to a sector based on knowledge and sensors where all chains of value (from clients to ordinary employee) are based on knowledge.
- Create knowledge systems and knowledge bases of tacit and explicit knowledge of experts of sector of Lithuanian construction and real estate.
- Share information throughout the whole life-cycle of built environment by means of integrated information and knowledge systems encompassing all processes and stakeholders.
- Requirements and needs of stakeholders for information and communication technologies expressed in quantitative and qualitative indexes and created appropriate decision support systems (based on knowledge and sensors) for storage, processing, analysis, decision making and recommendation offering.
- Closer contacts with residents (electronic discussions forums, electronic forms and direct access to files). New democratic patterns of expression will be reached. There will be a possibility to communicate with politics representing users directly. There will be a possibility to organize electronic discussions forums where residents are

able to communicate with other residents and politics and also to discuss any concrete topics, for example development a plan of build-up of neighborhood, financing of alternative projects of municipalities.
- Create knowledge and sensors based decision support systems of sector.
- Develop electronic knowledge based auctions.
- Integrate information systems of Lithuanian construction and real-estate (e-trade of construction products, international trade of products and services related with constructions, public e-procurement, etc.).
- Creation of intelligent collaborative work systems.
- Introduction of social sciences to develop new e-business models based on stakeholder focus, and to develop human-oriented innovative construction processes.
- Knowledge is shared throughout the value chain, from the client to the construction worker.
- The construction sector develops a new image of innovation, creates new e-business opportunities and offers good working places to all.
- Develop progressive integrated methods, models and systems for hazards (earthquake, flooding, fire, storm, landslide, blast and traffic) detection, evaluation, forecasting, early determination and notification, controlling, prevention, reduction and analysis of risk. These models, methods and systems will include public information, preparation for unexpected cases, and analysis of impact on business processes, distribution of responsibilities in cases of crisis, training and competence, control of quality and efficiency.
- To use reliable and life-cycle systems to monitor and control all parameters of built environment.
- Develop intelligent construction products, capable of communicating location, orientation and condition. Develop or implement special chips and sensors which can be incorporated in any construction product. Miniature and intelligent networked wireless sensors can monitor the condition of structures and construction processes, and to incorporate all stakeholders on the construction site in the same chain of data and information.
- Integration of virtual construction and facilities management environment (3D and 4D models) with knowledge-based systems and sensors (digital model of a building or city: virtual walking around the building or city; modeling of level of street pollution; virtual design of construction; a possibility to analyze various processes of technologies in virtual reality according to its suitability to a concrete project; virtual modeling of facilities management; other virtual modeling (climate inside the building, fire, energy consumption, sound isolation characteristics, occupational safety); virtual integrated design of building life-cycle (brief, design, construction, maintenance, facilities management, demolition, utilisation), etc.).

Here are the main possible ICT development trends in the area of construction materials, equipment and machinery:
- Develop or implement programmable nano-materials and nano-constructors, bio-mimetic materials, structures and facility systems.
- Install automated production lines of construction materials and manufacture in order to transfer more construction processes to plants and minimize construction processes at a construction site. Adopt construction material to semi manufactures in order to prepare them in plants, to increase variety of product of model complexion and to increase possibility to adjust processes of industrialized construction. Accordingly, efficiency and safety of work will increase. Applying such innovations it will be possible to renovate building quicker. Occupational safety at a construction site will increase, number of accidents will decrease.
- Create new construction materials using nanotechnologies (allowing minimization of faults in construction, adjusting to any climate (climate control), and extending service life until major repairs).
- Develop Lithuanian intelligent system of international trade of construction material (market research; trades and search of business partners; financial information; juridical and technical information; information about commercial events; special suggestions, etc.).

- Optimally industrialize and automate construction processes.
- Create intelligent, robotized, interactive, new class construction machines, equipments and systems based on knowledge and sensors (cranes, excavators, tubing equipment, automatic welding aggregates, etc.).
- Create „intelligent products“ (identification sensors, sensors, diagnostic equipments) able to transfer information about state of construction process (deviations from schedule of work plan, supplying of construction material etc.), microclimate, state of bearing constructions etc.

A few possible directions of ICT use in the area of construction are available:

- Ensure juridical validity and application of common construction standards, norms and rules while exchanging electronic information.
- Develop construction sites which are effectively connected to integrated data and information networks;
- Create high technology construction processes which integrate IT services, sensors and diagnostic tools.
- Introduction of information and communication technologies at all levels of the construction process (a continuous flow of data, information that disseminates knowledge throughout all players on the construction sites; automation of construction plant and equipment, including advanced embedded electronics; advanced possibilities offered by wireless or mobile communication technology; advanced monitoring techniques and wireless intelligent sensors).
- Introduction of new services offered by satellites for positioning construction equipment, and for monitoring works and their impact.
- Create informational system of construction in Lithuania.
- Develop intelligent public e-procurement system.
- Create intelligent system for international trade modeling and penetration of Lithuanian construction to foreign markets.
- Develop intelligent Lithuanian construction permits information system.
- Implement collection of electronic data, its analysis, treatment, monitoring, control and suggestions on construction site.
- Create intelligent real time monitoring systems based on sensors of construction process that allow detecting, analyzing and controlling real situation on a construction site, allowing detecting deviations from schedule of work plan and providing reports and suggestions on real time how to finish work on time.
- Create virtual constructional environments. Reduce a number of unfortunate accidents on construction site using the newest technologies (3D and 4D modeling, intelligent sensors, equipment, smart clothes).
- Install usage of satellite and other communication technologies on construction site more rapidly.
- Use robot technologies.
- Integrate newest information to all processes of building.
- Use intelligent systems based on knowledge and sensors in all processes of construction.
- Increase responsibilities of all employees and promote efficient e-collaborative work.

The trends for transformation of built environment and its management are as follows:

- A special attention is required in meeting needs of end user, i.e. transformation process of built environment based on knowledge and sensors and oriented to the end users is implemented.
- Production and installation of intelligent sensors allowing all elements of built environment to have historical and catchall information.
- Create decision support system based on knowledge and sensors in order to model impact of pollution made to public health.
- Develop land and water monitoring systems (chemical sensors presenting real time, information about quality of groundwater, integrated technologies for protection of ground and water from critical state or drastic changes etc.).
- Create integrated intelligent systems of analysis of impact made by life-cycle building to environment (traffic noise and vibrations, air, ground and water pollution etc.) which are able to model and predict negative impact of built environment to population.

- In order to improve a life-cycle of human and built environment, intelligent systems based on knowledge and sensors are created where experience of many experts and versatile information received using sensors is used. Knowledge consultants shall help implementing life-cycle of human and built environment more efficiently.
- Develop open digital administration.
- Participation of society in processes of territorial usage, planning and design, territorial regeneration and processes of decision making in development politics is implemented by using e-democratization procedures.
- Create intelligent e-zoning system.
- Develop Lithuanian Multiple Listing Service System.
- Implement Smart Building concept in Lithuania.

A few possible directions of ICT use in the area of education, training and adoption of experience are available:

- Change the sector profile towards a knowledge-based, demand-driven sector.
- Bring high-level knowledge to the closest point of its application.
- Develop education and demonstration centers where employees of organizations (especially of small and medium size) could get familiar with options of innovative information and communication technologies in practice.
- Create intelligent lifelong learning systems (e-books, video and audio materials, intelligent tutoring systems, software of specialty, electronic case studies, tasks and operations, testing systems and similar) allowing employees of sector of construction and real estate to raise their qualification. There would be more alternatives of studies considering the needs of a student, choosing the most rational educational material, learning place and time.

WEB-BASED INTELLIGENT AND BIOMETRICS SYSTEMS DEVELOPED BY AUTHORS WITH ASSOCIATES

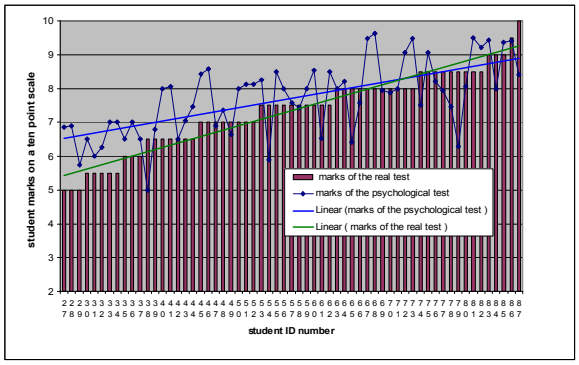
Web-based intelligent, voice stress analysis and IRIS recognition systems in construction developed by authors in cooperation with their associates are as follows:

- Building's Refurbishment Knowledge and Sensor Based Decision Support System [9, 10, 20, 25],
- Web-Based Biometric Mouse Intelligent System for Analysis of Emotional State and Labour Productivity
- Voice Stress Analyser Decision Support System for e-Examination,
- Web-based Biometric Mouse Decision Support System
- Innovation Multiple Criteria Decision Support Web-Based System [26],
- Multiple Criteria On-Line International Trade Decision Support System [7, 26],
- Multiple Criteria Decision Support Web-Based System for Facilities Management [7],
- Cooperative Integrated Web-based Negotiation Decision Support System for Real Estate [12, 13],
- Multiple Criteria Decision Support On-Line System for Construction Products [8],
- Sustainable Development Analysis Web-Based System [26],
- Intelligent Library and Tutoring System [14, 15],
- Voice Stress Analysis System [13],
- IRIS Recognition System [13]
- Ethical Multiple Criteria Decision Support Web-Based System [11],
- Building Life Cycle Decision Support System [22, 23, 24],
- Loan Analysis Decision Support System [21],
- Foundations Analysis Decision Support System [22, 24],
- Buildings' Multivariant Design and Multiple Criteria Analysis Decision Support System [22, 24], etc.

Then the brief study of authors with their associates some of above developed voice stress analysis and IRIS recognition systems follows.

VOICE STRESS ANALYSIS DECISION SUPPORT SYSTEM FOR E-EXAMINATION

The Voice Stress Analyser Decision Support System for e-Examination (VSA-DSS-E) consists of five subsystems: Testing Subsystem, Database Management Subsystem, Equipment Subsystem, Model-base Management Subsystem and a Graphic Interface.



Legend:
y-axis: marks of students on a ten-point scale;
x-axis: students' IDs;

"marks of the e-psychological test": marks given to students during the e-psychological test prior to the e-examination using the Voice Stress Analysis System;

"marks of the real test": actual marks given to students during the e-examination using the Intelligent Testing System;

"linear (marks of the psychological test)": regression-correlation linear trend, which describes the marks given to students during the e-psychological test prior to the e-examination using the Voice Stress Analysis System.

"linear (marks of the real test)": regression-correlation linear trend, which describes the actual marks given to students during the real e-examination.

Figure 1 Comparison of marks given to students during the e-psychological test prior to the e-examination and of marks given during the e-examination itself

Currently students' knowledge can be automatically assessed (instead of an examination) by using VSA-DSS-E on the basis of student psychological tests, accumulated historic voice stress data, determined regression equation and special developed algorithm. The VSA-DSS-E automatically assesses a student's knowledge before examination according to the student's spoken/oral answers. For example, when a teacher/lecturer gives a student questions such as "Are you well-prepared for the exam?" "What mark would you give to your knowledge?", "Have you learnt everything?" etc. before an examination, the student can be assessed precisely by giving him/her a mark by using VSA-DSS-E (using a special developed algorithm). Figure 1 illustrates the comparison of marks given to students during the e-psychological test performed prior to the examination (using the VSA-DSS-E) and of marks given during the examination itself (using the Intelligent Testing Subsystem). The regression-correlation curves seen in Figure 1 show the interrelation between the marks given during the e-psychological test and the marks given during the e-examination itself.

CONCLUSIONS

In cooperation with their partners, the authors of the article have created the Construction Technology Platform of the Republic of Lithuania. The Platform considers the current situation in Lithuania, the vision of the European Construction Technology Platform (ECTP) until 2030, growing society needs, cohesive construction requirements and the directives of Lisbon Strategy. While creating the part on Information and Communication Technology in Construction within the Platform, global experience was analysed thoroughly as well. Some aspects related to development of intelligent and biometric systems and foreseen in the Platform are already being implemented in VGTU successfully. These intelligent and biometric systems are briefly reviewed in this article, as well.

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