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## **MODERN ASPECTS OF SOFTWARE DEVELOPMENT**

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*Ivaniv A., Gaydarzhy V.*  
**Instrumental means for maintaining the  
information resource register in a cloud  
environment**

One of the most pressing problems of information technology of the last time is the use of systems of electronic information resources based on cloud technologies. In order for your files to be available to you or your team on any computer or mobile device, you may come in handy cloud storage.

Cloud storage is a data retention model where digital data is stored in logical bullets, physical storage encompasses multiple servers (and often at different locations), the physical environment is usually owned by hosting companies, they also manage this environment [1] . These suppliers of cloud storage systems are responsible for the information available and access to it, and for the work of the physical environment. Users are buying cloud storage service providers to store data there.

The research was devoted to the analysis of the possibilities of using cloud services of Amazon Web Services [2] to maintain the information resources register. Specifically, AWS S3 (Simple Storage Service) services were used to build a registry of information resources, Cognito for storing the user registry and AWS IAM

(Identity and Access Management) to configure permissions to access information resources.

AWS S3 is a storage facility offering industry-leading performance, scalability, availability and data security features. This means that our clients can be companies of any size and in any area of activity. They can use our service to store and protect any amount of data in various situations, for example, to ensure the operation of sites, mobile applications, for backup and recovery, and archiving. The Amazon S3 offers easy-to-use administrative tools that allow you to arrange data and fine-tune your access restrictions to meet the needs.

The AWS Cognito service allows you to quickly and easily add the ability to register, authorize, and control access of users to mobile and Internet applications. Amazon Cognito scales to millions of users and supports authorization through social identity vendors (Facebook, Google, Amazon), and corporate identity vendors based on SAML 2.0.

The AWS IAM service provides secure access control for AWS services and resources. Using AWS IAM you can create users and groups, manage, and use permit to allow or deny access to AWS resources. IAM is in an AWS account that is available at no additional charge. The fee is charged only for use by other users of other AWS services.

The registry of information resources should perform

a number of functions, the main of which:

- registration and authorization of the user in the system;
- formation of access groups for resources;
- uploading a resource into the S3 repository;
- breakdown the registry into categories;
- view the resource by direct link and upload the resource to the local computer.

The technology of using the registry is as follows: the user performs the registry in the system, after which the administrator must activate the account in the service AWS Cognito, give access to the directory in the service AWS IAM [3]. During authorization, the user receives access keys and indexes from the AWS Cognito User Pool (Fig. 1. Link 1). Then, using the authentication key, the user receives temporary AWS credentials from the AWS Cognito Identity Pool (Fig. 1. Link 2). In this way, the AWS technology user accesses operations on resources from AWS S3 (Fig. 1. Link 3).

User interface was implemented using the Angular 6 framework with the TypeScript language in the macOS Mojave operating system. You need to use Angular CLI to create a project. It facilitates the creation of application code and library, as well as execution of various current development tasks such as testing, assembly and deployment.

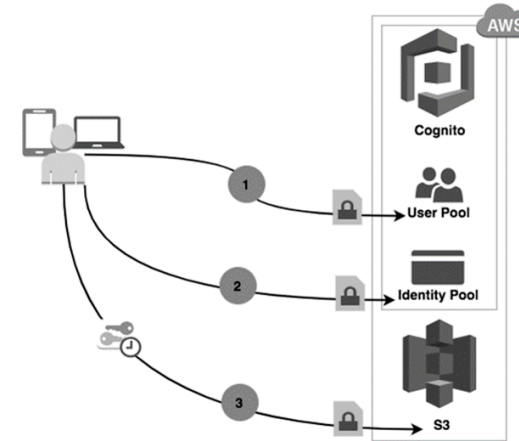


Fig. 1. Scheme of the interaction of the system and services AWS

Angular CLI sets the required Angular npm packages and other dependencies. Angular includes a server, so you can easily create and maintain your program locally. The "ng serve" command launches the server, monitors the files and rebuilds the application when you make changes to those files. The --open (or just -o) option automatically opens your browser at <http://localhost:4200/>.

Angular 6 is the best open source framework for building web and mobile applications based on the micro services architecture and was conceived as a mobile first approach. Angular 6 uses advanced JavaScript that is highly optimized, making the application and web



downloads faster [4]. Angular 2 is quickly downloaded using the component router. This helps in automatically splitting the code, so the user can download the code required by the viewer.

TypeScript is a cartography language that is compiled in JavaScript and is designed specifically for large applications. She has taken a lot from languages such as Java and C # that are more disciplined and rigorous than dynamically typed JS. Because of static typing code on TypeScript is more predictable and therefore it is easy to judge [4]. Thanks to good OOP support, modules and namespaces, the project, even at large volumes, will be ordered. The build-up compiler finds a lot of mistakes before they get into the rootkit and break something. Starting from version 2 Angular is written in TypeScript and recommends it as a development language.

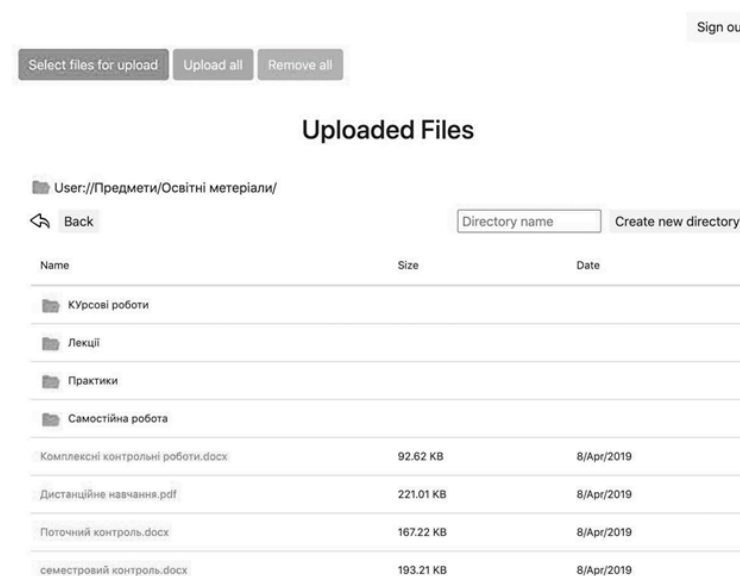
The example of the electronic resources of the scientific and educational department created a system of interfacing the web interface with cloud services AWS for the storage of electronic resources and access control [5]. For authorization purposes was created sign in page (Fig . 2.).



The sign-in form is titled "Please Sign In". It features two input fields: "Email address" and "Password". Below the password field is a link for "Forgot Password?". At the bottom is a "Sign In" button. In the top right corner, there are links for "Sign In" and "Sign Up".

Fig. 2. User sign in form

User can processed main actions with electronic resources in Upload resources page (Fig. 3.). Here he is able to create folders and upload files. If uploaded resource is an image, user interface give ability to preview it. In all other cases, files are opens by browser tools.



The "Upload resources" page includes buttons for "Select files for upload", "Upload all", and "Remove all", along with a "Sign out" button. The main section is titled "Uploaded Files" and shows the current directory path: "User:/Предмети/Освітні матеріали/". It has a "Back" button and a "Create new directory" button with a "Directory name" input field. Below is a table of uploaded files.

Name	Size	Date
Курсові роботи		
Лекції		
Практики		
Самостійна робота		
Комплексні контрольні роботи.docx	92.62 KB	8/Apr/2019
Дистанційне навчання.pdf	221.01 KB	8/Apr/2019
Поточний контроль.docx	167.22 KB	8/Apr/2019
семестровий контроль.docx	193.21 KB	8/Apr/2019

Fig. 3. User interface with main functionality

As a result application where user can upload and store information register in cloud environment AWS was implemented.

List of used resources

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*Bespala O.*

## **ANALYSIS OF MODELING CAUSES AND EFFECTS OF POLLUTION**

### **Annotation**

This article examines models that simulate the causes and effects of environmental pollution. Models that allow: emission projections and cost implications of alternative emission control scenarios; effective and environmentally safe equilibrium solution; compare land and forest management systems and their effects on environmental indicators like water availability, nitrogen and phosphorous levels in soil, and greenhouse gas emissions; analysis of the impact of land use on the carbon cycle, emissions of carbon dioxide and soil functioning; forecasting and analysis of global demographic, economic, energy, agricultural, environmental, domestic socio-political and international political systems on a long-term basis. Analyzed integration processes of modeling the causes and consequences of environmental impact in different fields of activity and impact on the ecological society.

### **Keywords**

Environmental management, modeling, and forecasting, environmental impacts, causes and effects of pollutants.

### **Introduction**

The current level of anthropogenic load on all

components of the environment requires the adoption of managerial decisions on the implementation of the principles of rational nature management.

Achieving a balance between the environment, society and the economy is considered essential to meet the needs of the present without compromising the ability of future generations to meet their needs.

Societal expectations for sustainable development, transparency and accountability have evolved with increasingly stringent legislation, growing pressures on the environment from pollution, inefficient use of resources, improper waste management, and climate change, degradation of ecosystems and loss of biodiversity. This has led organizations to adopt a systematic approach to environmental management by implementing environmental management systems with the aim of contributing to the environmental pillar of sustainability [1].

### **Aim**

Analyze the experience of modeling and forecasting the causes and consequences of environmental pollution and factors affecting the level of pollutants. Investigate the integration of models into different spheres of human activity.

### **Research results**

Organizations of all kinds are increasingly concerned

with achieving and demonstrating sound environmental performance by controlling the impacts of their activities, products, and services on the environment, consistent with their environmental policy and objectives. They do so in the context of increasingly stringent legislation, the development of economic policies and other measures that foster environmental protection, and increased concern expressed by interested parties about environmental matters and sustainable development.

Many organizations have undertaken environmental "reviews" or "audits" to assess their environmental performance. On their own, however, these "reviews" and "audits" may not be sufficient to provide an organization with the assurance that its performance not only meets but will continue to meet its legal and policy requirements. To be effective, they need to be conducted within a structured management system that is integrated within the organization [1].

To date, many models have been developed and integrated that simulate, analyze and predict the state of the environment. However, more in-depth analysis is provided by models that not only predict and analyze the state of the environment but also examine the causes and effects of pollutants on the state of the environment, as well as the impact on the economic, social, demographic, etc. Below is an example of such models.

**GAINS Model.** The Greenhouse Gas and Air Pollution Interactions and Synergies (GAINS) model is an integrated assessment model dealing with costs and potentials for air pollution control and greenhouse gas (GHG) mitigation, and assessing interactions between policies.

The GAINS model grew out of the RAINS model, which has been developed by the IIASA APD Program over some 20 years. The RAINS model is an air pollution emission and impact model that helps in analysis of policy implications of controlling emissions of major air pollutants (SO<sub>2</sub>, NO<sub>x</sub>, VOC, PM, NH<sub>3</sub>) at the national and international scales. The model identifies air pollution impacts (acidification, eutrophication, ozone, human health) and helps in preparation of cost- efficient pollution control strategies.

GAINS is an extension of the RAINS model to include major greenhouse gases, i.e. CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, and the F- gases. This makes it possible to simultaneously analyze the effects of mitigation of greenhouse gases emissions and air pollution. In this way, the most important interactions and synergies between the mitigation of climate-relevant gases and air pollution can be studied.

The GAINS web interface allows online access to the latest model implementations for various world regions. It provides interactive access to input data, emission

projections and cost implications of alternative emission control scenarios, as well as to the environmental impacts these imply. The current Version 1.0 allows access to:

- emission inventories, emission projections, and control costs for air pollutants ( SO<sub>2</sub>, NO<sub>x</sub>, VOC, PM, NH<sub>3</sub> );
- emission inventories and emission projections for greenhouse gases ( CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, and the F- gases);
- projections of underlying activity data;
- lists of control measures and their costs that need to be implemented in various policy scenarios, including cost- efficient solutions;
- display of air quality indicators (ambient concentrations and deposition of air pollutants);
- computation and display of indicators that assess the impact of air pollution on human health and natural environment;
- data management, which is an interactive interface where owner- specific data can be modified, updated, exported, and downloaded.

The GAINS Model addresses the health and ecosystem impacts of particulate pollution, acidification, eutrophication of ecosystems, and impacts of tropospheric ozone. Simultaneously, GAINS assesses the effects of various scenarios on greenhouse gases mitigation and the resulting co- benefits for air pollution. Historic emissions

of air pollutants and GHGs are estimated for each country based on international emission inventories and statistics as well as on inputs from collaborating national expert teams. Emissions are assessed on a medium- term time horizon up to the year 2030 with five-year intervals.

The model can be operated in the 'scenario analysis' mode, i.e., following the pathways of the emissions from their sources to their impacts. In this case, the model provides estimates of regional costs and environmental benefits of alternative emission control strategies. The Model can also operate in the 'optimization mode' which identifies cost- optimal allocations of emission reductions in order to achieve specified deposition levels, concentration targets, or GHG emissions ceilings. The

current version of the model can be used for viewing activity levels and emission control strategies, as well as calculating emissions and control costs for those strategies.

All results are calculated on the fly to ensure that the most recent data set is used at all times. The interface enables display and download of all input data and scenario results [2].

GAINS is now implemented for the whole world, distinguishing 165 regions including 48 European countries and 46 provinces/states in China and India. This web site provides interactive access to the implementations for the following world regions:

- Europe (for 48 countries);
- Asia, with separate implementations for China (31 provinces and India (15 States);
- For Annex I countries of the UNFCCC Convention.

GAINS is used for policy analyses under the Convention on Long-range Transboundary Air Pollution (CLRTAP), e.g., for the revision of the Gothenburg Protocol, and by the European Commission for the EU Thematic Strategy on Air Pollution and the air policy review. Scientists in many nations use GAINS as a tool to assess emission reduction potentials in their regions. For the negotiations under the United Nations Framework Convention on Climate Change (UNFCCC), a special version of GAINS has been developed to compare greenhouse gas mitigation efforts among the Annex-I countries [3].

**Integrated Emission Trading and Abatement (ETA) Model.** ETA model is an integrated stochastic emissions trading and abatement model allowing to analyze the robustness of emissions reduction policies under asymmetric information about emission trading parties, uncertainties of emissions and other inherent anthropogenic and natural uncertainties.

ETA model is an exploratory market environment for carbon emissions trading. It allows trading parties (countries or emitting entities) to investigate the conditions

of their cost-efficient trades and emissions abatements. The model suggests cost-efficient and environmentally safe equilibrium solution that can be implemented in reality. Functioning of the robust market is illustrated with numerical results involving such countries as the US, Australia, Canada, Japan, EU27, Russia, Ukraine.

Key questions the model addresses:

- Under which conditions is carbon trading environmentally safe and cost-effective in the long-term if considered in the context of a stochastic market?
- How the knowledge about uncertainties may affect the portfolios of technological and trade policies of the parties?
- If uncertainties may affect the structure of the market?
- By how much differ marginal abatement costs calculated from technology parameters and the spot carbon price in the existing stochastic market?
- By how many trading Parties may decrease the chances of lock-in solutions and "irreversible" trades at spot market?

ETA model is a prototype model of the emission trading market. It creates a computer-based modeling environment which allows trading "parties" to store in an anonymous manner their private information on cost functions, constraints, and other characteristics including

specific characteristics of uncertainties. The procedure deriving equilibrium solution is the following: two parties are picked at random ("meet") and exchange emission permits in a mutually beneficial way accounting for actual costs and uncertainties. At the next step, a new pair is picked and the procedure is repeated. At each step of the bilateral trades, the actual costs will differ between the sequential trades, but finally, the trading converges to an equilibrium solution with marginal costs of all parties equal to an equilibrium price. The model derives the solution in a decentralized manner without revealing information of the parties.

The international emission trading (IET) scheme under the Kyoto protocol was devised to lower the cost of achieving sets of greenhouse gas emission reductions for different countries with the price of tradable emissions equal to the marginal cost of emissions reductions to meet the cap. However, IET was implemented through a market similar to financial markets. "Disequilibrium" carbon prices exhibit periods of high volatility. They react to and are the result of political decisions, information disclosure, speculations, bubbles, uncertainties around emissions and emissions reduction costs. The underlying, actual cost of GHG reduction, i.e. the marginal costs of abatement technologies is only of secondary importance. The existing emission trading, therefore, does not necessarily minimize

abatement costs and achieve emission reduction goals. ETA model supports decisions regarding a trade-off between technological and economic mitigation and adaptation measures to reduce emissions and combat climate change without compromising economic development goals.

Challenges: 1. ETA model determines emissions permits prices in a decentralized manner without requiring trading parties to reveal or exchange their private information. 2. The pricing methodology is augmented with environmental constraints. 3. The methodology of emissions pricing in the presence of uncertainties and incomplete information is a rather general scheme which has analogs with Walras law describing the dynamics of prices under specific market conditions, which finally converge to the optimal (equilibrium) prices. 4. ETA incorporates concepts of emissions detectability (verifiability) and discounts. 5. ETA integrates GAINS model data and results for the USA, EU27, Australia, Canada, Japan, Russia, Ukraine, and other countries [4].

**The Environmental Policy Integrated Model (EPIC).** A model assessing how land management affects the environment. At IIASA, EPIC is used to compare land and forest management systems and their effects on environmental indicators like water availability, nitrogen and phosphorous levels in soil, and greenhouse gas

emissions.

EPIC can analyze several crop types and their management under different weather, topographical, and soil conditions. It investigates the trade-offs between plant growth and the yield on the one hand, and environmental impacts and sustainability on the other.

For example, EPIC can estimate—based on soil type and prevailing climatic conditions—the extent to which nutrients from fertilizer, such as Nitrogen (N) are leaching into a nearby river and stream networks. This problem is of growing concern as globally, two-fifths of N used in agriculture is lost to ecosystems, with harmful environmental effects.

Nitrous oxides ( $NO_X$ ) emissions are also produced when N from fertilizer is broken down by microbes in water.  $NO_X$  are now estimated to represent 6% of all greenhouse gas (GHG) emissions.

EPIC, as used at IIASA, models a wide range of biophysical processes to consider alternative land uses where land is becoming degraded or is putting natural ecosystems at risk.

It includes a full water cycle, allowing researchers to analyze how water is moving on, above, and below the Earth's surface. It can simulate different weather patterns and events, such as the effects on forest or crop production

of heavy rainfall or prolonged drought, and it can estimate plant growth and yield based on the temperature or moisture content of the soil. The effects on crop productivity of natural processes, such as erosion and sedimentation, and of human activities, such as soil tillage, can also be fully demonstrated. The impacts of land use on carbon cycling, GHG emissions, and soil functioning will be the main modeling focus for EPIC in the foreseeable future.

At IIASA, EPIC is part of the toolkit used to assess the economic and environmental effects on agricultural and forest lands of enhancing carbon sinks and GHG abatement measures.

EPIC plays a central role in IIASA's current projects including LC-IMPACT, Carbo-Extreme, ISAC, and FarmSupport.

The EPIC model was developed by the United States Department of Agriculture to assess the status of U.S. soil and water resources and has been continuously expanded and refined to better analyze the exchange of GHG fluxes between terrestrial ecosystems and the atmosphere. It is used around the world by research groups, like IIASA, who calibrate EPIC to meet their own needs.

EPIC is integrated into the major models EUFASOM and GLOBIOM, set up by IIASA's partner, the University of Natural Resources and Life Sciences (BOKU) of

Vienna, and is now operational.

The future focus of the model at IIASA will be an analysis of GHG emissions and carbon sequestration in the agricultural sector. EPIC already includes tools to analyze carbon and nitrogen in the soil, and a methane analysis module is under preparation. Links to IIASA's GAINS model are being strengthened [5].

**Felix Model.** FeliX (Functional Enviro-economic Linkages Integrated neXus), a project of the International Institute for Applied Systems Analysis, is a system dynamics model of global social, economic, and environmental Earth systems. Critical interdependencies among these systems are incorporated to recreate the complex dynamic behavior which characterizes the Anthropocene [6].

Implemented in Vensim, the model consists of stocks and flows, the interactions among which are defined by coupled differential equations. Flows define feedback loops which propagate impacts and integrate outcomes across the eight model sectors: Economy, Energy, Carbon Cycle, Climate, Biodiversity, Water, Population and Land Use. Elements of the model are calibrated to historical data [1900-2010] (as available) from the FAO, IEA, CDIAC, IPCC, World Bank, and UNIHP.

After calibration, Felix scenario outcomes project on a global scale major stock changes (e.g., depletion of natural



resources, accrual of carbon dioxide in the atmosphere) as well as the aggregate consequences of policies and technologies (e.g., afforestation, emissions reduction) over time. Independent historical data and future pathways are used to validate these projections.

Though a carefully simplified 'mock-up' of complex Earth systems, the Felix model achieves a comprehensive scope, capturing vital mechanisms and facilitating insights into nine societal benefits areas (SBAs): disasters, health, energy, climate, water, weather, ecosystems, agriculture, and biodiversity. The main dynamic problems addressed by the model include (links to specific entries in the discussion section): Population Dynamics and Aging; Development jeopardized by ecosystem changes; Alternative measures of development; Increasing energy demand; Investments in energy technology and production capacity; Fossil fuels securing most of the needs for energy; Alternative sources of energy competing for market share; Food security; Deforestation; Anthropogenic emissions (energy generation and land use & land use change); Impact of rising carbon concentrations (atmospheric and oceanic); Water scarcity; Biodiversity loss [7].

International Futures (IFs) is a computer simulation that allows forecasts and analysis of global demographic, economic, energy, agricultural, environmental, domestic sociopolitical, and international political systems

throughout the twenty-first century. Detail is available for more than 200 variables across as many as 70 different countries and regions. IFs runs under Microsoft Windows with a menu-driven structure that makes scenario analysis quite simple. The acronym IF is intended to convey the importance of developing multiple if-then scenarios about the future, rather than relying on any particular forecast.

**International Futures (IFs)** is a world model or computer simulation of global development that:

- divides the world into geographic regions (up to 70 different countries or aggregated groupings of countries);
- represents the dynamics and interactions of demographics, economics, food systems, energy systems, selected environmental systems, and elements of domestic and international sociopolitical change;
- uses a dynamic equilibrium-seeking structure that allows simulation as far into the future as 2100;
- sits within a menu-driven modeling system that allows easy development and exploration of alternative if-then statements about the future (hence the acronym IFs).

IFs has six modules: demography, agriculture, energy, economics, politics, and environment.

EMIS: Environmental Management Information System for industrial estates or parks, harbors and ports, special economic zones and individual industrial enterprises.

EMIS provides a complete, largely automatic, fully integrated, state-of-the-art ICT solution for the environmental management: planning, assessment, compliance monitoring and impact assessment as well as emergency management for industrial enterprises or groups of co-located enterprises in industrial parks or zones, compliant with ISO 14001 and OHSAS 18001, and in support of the new European IPPC directive, 2008/1/EC, on Integrated Pollution Prevention and Control, including industrial emissions, and noise monitoring and management for construction, operations, and traffic.

Automatic, scheduled and event-driven tools for monitoring and reporting are combined with interactive models, embedded into a real-time expert systems framework that supports a participatory approach of all enterprises in the estate, and at the same time provides continuous quality control and quality assurance functions, implementing a TQM philosophy supported by artificial intelligence technology for optimal operational control.

The Management Information System integrates a number of advanced analytical functions for operational real-time control (based on multi-criteria optimization tools) but also scenario analysis, strategic planning, and optimization, within a shared common information basis:

The Industrial Environmental Management Information System combines advanced tools for strategic

planning (including stochastic risk analysis) and environmental impact assessment with real-time monitoring, online reporting, and operational control including emergency management options. Other embedded models address land use dynamics, air quality assessment and emission control, and coastal water quality.

Another important set of tools addresses resources (such as water, energy) efficiency and optimization as well as emission control strategies (including GHG and ) using complex multi-objective, multi-criteria optimization and techno-economic valuation. Multi-criteria optimization can be performed for each individual unit, as well as for the entire park or zone, or group of installations, identifying possibilities for synergies and net benefits from cooperative strategies towards "win-win" solutions for increased resource and energy efficiency, improved environmental compliance. Related topics are the estimation, trend analysis, and forecast of resource consumption patterns, emissions and waste streams, and the identification of saving potentials, from BAT to BATNEEC.

Implementation and business model: EMIS utilizes high-performance cluster computing for detailed quantitative analysis (dynamic, 3D distributed nested grid simulation and optimization models) with a distributed (web-based) implementation for easy access to an unlimited number of local subscribers. This makes it

possible to share the costs over a large number of users, that also cooperatively contribute to the essential updates of the information system.

Model supported monitoring (now-casting) and reporting (continuous and for user-defined periods up to multi-annual) and continuous regular forecasting (up to 120 hours) of all environmental impacts from normal operations (atmospheric and aquatic/marine releases, waste streams and hazardous waste, operations and construction noise) with continuous and scheduled online compliance reporting, alerts and alarms based on monitoring networks, cascading advanced 3D dynamic simulation models and real-time expert systems technology.

Risk assessment and emergency management in the case of accidental release of hazardous materials with different release scenarios, evaporation, chemical fires, BLEVE/explosion, soil contamination, and spills including surface-, ground- and coastal water quality. Continuous modeling and 5-day forecasts make the system immediately "ready" for emergency simulations.

Scenario analysis: Tools for simulation model based WHAT-IF analysis, environmental and strategic impact assessment (for atmospheric, aquatic, soil and groundwater, coastal marine systems, noise, solid waste), population exposure, health impact analysis (workforce and surrounding environment/population);

ISO 14001 EMS and OHSAS 18001 compliant pre-audit checklists: environmental performance, resource efficiency, occupational safety;

Efficiency and sustainability multi-criteria optimization tools for resources, energy, and economic efficiency, emission control including GHG and ;

Administrative databases of all enterprises, emission sources, MSDS and hazardous substances database, use and storage, waste streams, monitoring data analysis, embedded GIS for the industrial estates and surrounding environment and population, etc [8].

### **Conclusion.**

It's clear that no model can cover every part of the real world, but a model is still a powerful tool for understanding how the world works. Using modern information technology, simulation models designed to simulate and explore interconnections that span different industries.

An analysis of the experience of modeling the causes and effects of environmental impacts in various sectors such as economics, energy, climate change, carbon cycle, demography, land use, biodiversity, resource use, and population health shows a close link between these industries. The interest of humanity in the environmentalization of the future leads to an ever-increasing integration of such models into different fields of activity, and the study of more and more factors, the

study, research and modeling of which will lead humanity to a clean environment.

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## **Segmentation of images from onboard video cameras of robots**

For robotic systems, you need to have enough information about the environment to make the right decision. To do this, use data about surrounding objects, their structure and change their position in the space. One of the applied tasks of this industry is the semantic segmentation of images from the onboard camera of the robot. Based on the analysis of the obtained information, the robot decides to do further steps to achieve the goals. It is important to accurately recognize the information from the image, so to give an opportunity for control system correctly form a feasible model of the robot's behavior. Consequently, the task of segmentation of information on images of video stream from on-board systems is relevant and of practical importance.

Segmentation is the process of marking pixels of an image to separate regions with common properties, having the same token value [1]. Also, segmentation is considered as the search for object projections on an image. This is the fundamental task of computer vision, which is solved in various ways. Tasks of image segmentation can be divided into two main types with respect to the image area: local

segmentation (associated with a specific part or area of the image) and global segmentation (related to the segmentation of the whole image consisting of a large number of pixels). Most of the techniques of image segmentation can lead to two basic approaches.

When approaching boundaries (threshold segmentation) - the image is segmented into regions based on a certain gap in the characteristics, which give the rise to the segments edges. Based on the detection of edges, the segment falls into one of the categories that are formed due to the severity of the intensity between regions.

According to the second approach, based on the similarity detection, the images are divided into regions with a similar set of pixels.

Historically, the first approaches to machine learning were first used for semantic segmentation, such as TextonForest and Random Forest classifiers. With the advent of convolutional neural networks CNN (Convolutional Neural Network) [2] the decision of the problem of computer vision turned to a new stage of development. Architectures in which several layers of the neoprene were followed by full-wave layers of neurons were successfully applied to the classification of the image. After the successful use of CNN to classify the specified objects in images, CNN's research on image segmentation has emerged [3].

The first attempt segmentation based on CNN, was patch classification[4]. Method classify each pixel via processing patch (that contain the pixel) in convolutional layers and the decision to belong to a class make fully connected layers. Due to the increase in working hours and requirements for computers, the method has not gained popularity.

Attempts to adapt CNN classifications for segmentation tasks were not successful. In connection with the use of fully-connected layers and pooling layers. Using a fully connected layers imposes restrictions on the size of the input image - segment can only image the same size. Using pooling layers allows you to take more features from most of the image and combine them. However, information about the position of the features on the image is lost that is unacceptable for segmentation.

For the first time, these restrictions were eliminated in the work of "Fully Convolutional Network for Semantic Segmentation" [5]. The Fully Convolutional Network (FCN) (Fully Convolutional Network, FCN) is a CNN network architecture in which fully-connected layers that perform the feature classification function are replaced by the upsampling layer that locates the features. This allows you to take an image of any size to the input and generate segmentation maps. This approach works faster because it does not need to be classified. The developed architecture

of the FCN-8 became the basis for further developments by the architect who performs image segmentation.

Based on [5], most architect for segmentation are built as a combination of two networks, one of which acts as an encoder, and can be pre-trained by the classification network (VGG / ResNet or other), and the other is a decoder that upsampling features from encoder vector up to two-dimensional mask of the input image. Thus, at the first stage, the encoder determines exactly what is on the image, and the decoder determine where exactly the object is located. Different network architectures perform the decoding process differently. Among the networks intended for segmentation can be highlighted FCN, SegNet, U-Net, FC-Densenet E-Net & Link-Net, RefineNet, PSPNet, Mask-RCNN.

For each practical task, it is imperative to determine the architecture of the network and its modifications empirically. In some cases, architecture provides the optimal result for the accuracy of segment recognition, but is not acceptable for practical use due to increased work time and greater requirements for the technical characteristics of the device.

In agriculture, machine vision can be applied to intelligent control and control of weeds. In this research, the problem of segmentation of weeds in images of a fragment of a field made from a moving platform was

solved.

For segmentation of image, an architecture based on U-net[6] was constructed with a sigmoidal function for activating the last layer. It is based on FCN, however, unlike it, the used network is symmetric. This is done to completely restore the fine-grained spatial information that was lost in the pooling layers. Therefore, connections are used between the symmetrical layers of the encoder and the decoder. The U-net network was developed to solve biomedical segmentation problems. It is distinguished by the ability to study on a limited dataset and speed of work. These properties are demanded in many applications, in particular U-net used by participants in the Kaggle segmentation competition. Since the number of educational images for training was small and the task requires segmentation in real time, this architecture was chosen to solve the problem of segmentation of weeds.

During the study, when implementing the network, roller coasters were replaced with Residual blocks. So, the depth of the network has increased, which has improved the accuracy of segmentation. In total, 175 layers were used in the network.

Researchers from the University of Bonn partially posted an open source [7] dataset with photos of the sugar beet field, obtained on campus at Klein Altendorf in Bonn, Germany. The dataset consists of images of 966 by 1296

pixels of a fragment of a field from a camera located at a height of 30 cm from the ground. A set of training data was divided into: a training sample of 239 images, validation 44 and a test one of 30.

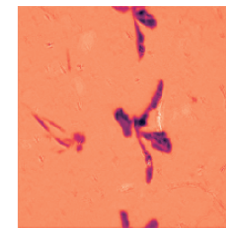
Due to the small number of dataset available in the resource [7], it was increased by augmentation based on rotation, shear, cropping, and mapping operations were used relative to the axes.

Figures 1.a show the input image. The first layer of the tensor in the intermediate layers of the U-net network is shown in Figures 1.b - 1.g.

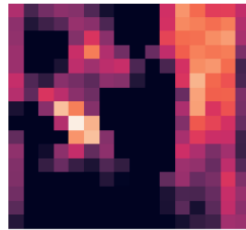
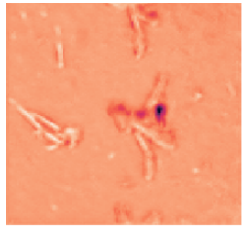
One can see how the signs of a weed were gradually removed from the input image (Fig 1.a) at the stage of the encoder (Fig. 1.b - 1.d), while the width and height of the image gradually diminished as the depths approached the deepest layers.



a - Input image Figure



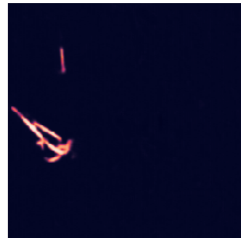
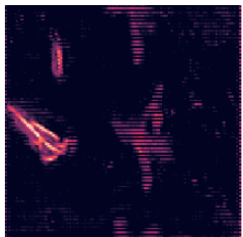
b - Image after 16 layers



c — Image after 16 layers      d — Image after 76 layers  
Figure 1 - Stages of image processing at the stage of encoder U-net

At the decoding stage (Figures 2.a and 2.b), the areas with weed were detected, and the images were returned to the input size.

When testing the network, 16 predictions for 1s 44ms have been made. Pixel prediction accuracy was 27.5% and 96.3%, according to the IoU metric and categorical\_accuracy respectively. In the future, the result can be improved by using additional information from the robot sensors, for example data from a multispectral camera.



a - Images after 140 layers      b - Image after 170 layers  
Figure 2 - Stages of image processing at the stage of

the U-net decoder

The developed network performs segmentation of weeds only in one class, which is not sufficient for real problems. In future studies, it is planned to adapt the network for multiclass segmentation.

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### **Collecting information for Industry 4.0 purposes**

The term Industry 4.0 was introduced into public use in 2011, when the community of business, political and academic circles in Germany launched an initiative under this name aimed at improving the competitiveness of German industry. Industry 4.0 is an extremely interesting and promising concept for the entire modern world, within its framework is the introduction of advanced achievements of science and technology in production, as well as forecasting their development

Kagermann describes Industry 4.0:

“In the future, business companies will organize global networks where machines and mechanisms, storage systems and production equipment will be included in the form of so-called cyber-physical systems. In the production environment, cyberphysical systems include intelligent machine tools, information storage systems and workshop equipment that, in the autonomous mode, can exchange information, launch certain actions and independently control each other. Due to this, processes in all production areas are being radically improved - technical preparation, production, use of materials, logistics of supply chains and product lifecycle management. The now emerging “smart enterprises” (Smart Factory) use a completely new

approach to production. “Smart Products” have unique identifiability, their location can be revealed at any time, they “know” their history, current status and alternative routes to their target state.

Embedded production systems operating within enterprises and factories are connected to business processes vertically across the network, and horizontally to distributed partner networks (value networks) that can be managed in real time — from the moment the order is placed and further along the entire value chain. In addition, the entire value chain is possible and requires engineering support for these systems.” [1,2]

It becomes clear that Industry 4.0 involves the processing of vast amounts of data, both for monitoring the current state of facilities and for forecasting the development of systems, for example, using data on the development of certain technologies in the world, you can compare them with developments in a particular country to decide whether to implement new technologies in place and prepare for them the necessary base or apply the data to optimize the already existing production.

There are many cases of successful application of technologies for collecting and analyzing data related to Industry 4.0 and here are some of them:

Availability of complete data from the field level

The South African gold company introduced a

different type of sensor from which it began to get more data. These new data showed some unexpected fluctuations of oxygen in the main leaching process. By eliminating this problem, the company achieved an annual production growth of 3.7%, which means an additional income of \$ 20 million.

Emerson's report (3) provides some interesting case studies using wireless sensors of various types. The Ergon oil refinery introduced acoustic wireless sensors on the steam lines, which as a result allowed to significantly reduce steam losses and recoup the system in just a few months. In another example, the introduction of smart sensors at the enterprise for gas monitoring tasks had a payback period of 5 months, ROI was 271%.

#### Predictive maintenance and increased availability

Predictive service is one of the top trends in asset management and this is a real value driver for the last 20 years. Accenture says that implementing these methods on technologies 4.0 results in a cost reduction of up to 12% (and compared with scheduled maintenance), a reduction in the total cost of maintenance by up to 30% and a reduction in breakdowns and accidents by up to 70%. For example, the leading UK utility company, Thames Water, uses sensors, analytics and real-time data to prevent failures and respond more quickly to critical situations, such as leaks, breaks or warn of weather changes.

Apache Corporation, a leading oil and gas producing company, uses a similar approach to monitoring pumping stations. Company executives say that improving their availability by 1% means an increase in oil production by an additional \$ 19 billion per year. [3]

#### Linked Open Data Cloud

Nowadays there is a problem with the collection and processing of open data, because each system, each data warehouse does not have a single access method, due to their different architecture, moreover, some systems cannot be accessed directly and a workaround is required, for example, access to information stored in the university library is possible only through the institution itself.

Such problems as Linked Open Data try to solve a similar problem, they open and systematize ways of obtaining information from open sources.

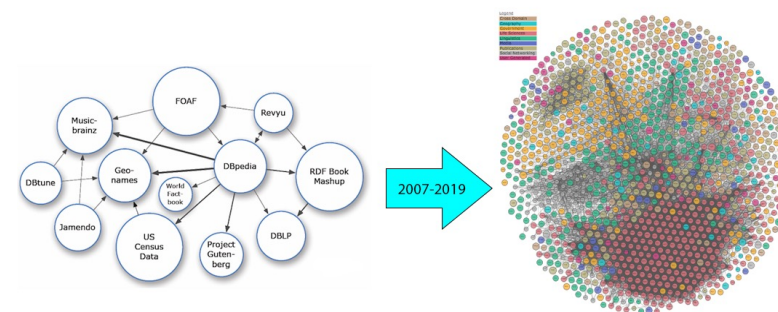


Рис. 1 Comparing of Linked Open Data Cloud in

2007 and 2019

Each object in the diagram provides an information system, and each connection is a way to access information and their interconnection in the LOD cloud generated by DBpedia.

Introduction of such systems is necessary everywhere, as it allows you to receive information about the state of any system, regardless of the specifics of its implementation, besides creating several resources like LOD cloud, it becomes possible to exchange information without using additional, unique APIs.

#### Edge computing

Another interesting technology that has recently developed is Edge computing. Although companies have long understood the need to deploy multiple sensors in an enterprise to collect data in the field, the process of increasing control over each stage of production is still underway. Edge calculations are ready to take a new step forward in this area, instead of collecting and processing data on the central server of the enterprise, they intend to process this data in places. The decentralized approach to edge computing also reduces the required bandwidth. Data processing begins at the collection point, and only the data that needs to be saved is sent to the cloud. This makes modern computing more efficient and scalable and reduces the load on the network.

For example, if you have multiple security cameras that send 1080p video through the cloud, this becomes a bandwidth problem. It is impractical and prohibitively expensive.

Downtime and intermittent connectivity are also improved through peripheral computing, since they are not dependent on the cloud for processing. This can help avoid server downtime, ensure reliable operation in remote locations, and avoid unplanned downtime. [4]

All these real solutions related to Industry 4.0 make it possible to develop new technologies and confidence in finding ways to use existing ones. For example, it is assumed the possibility of predicting the success of an enterprise based on the analysis of its internal indicators, market analysis and external factors in its development sector, using modern technologies for collecting and processing this information.

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### **Segmentation based problem solving on convolutional neural network**

The segmentation purpose is designed to automatically highlight the specified objects on an image, such as faces, license numbers, clothing parts, and characteristic features of people and animals. It is also required for the objects state analysis according to special graphical displays, such as seismic, medical and satellite images. Due to the recognition results of the image given fragment it is concluded about making further decisions and actions. Therefore, the segmentation task is relevant and has practical significance.

In modern issues of objects segmentation and classification with images it is acceptable to use convolutional neural networks (CNN), the concept of which was firstly proposed by Yann LeCun [1]. Since then, to increase the accuracy the CNN modifications were suggested. One of the latest optimizations is the use of Inception blocks [2]. The main idea of this method is to convolve filters with different dimensions and combination of their results. Another conceptual improvement is the use of Resnet blocks proposed in [3] to solve the problem of vanishing gradients in deep neural network training.

Recently, the rapid development of image analysis

based on convolutional neural networks takes place in specialized centers such as Google, Amazon, Microsoft and others, as well as in universities and software development companies. In addition, there are several platforms for machine learning competitions, the most famous of which is Kaggle [9]. The Kaggle platform was created in 2010. In 2017 it was bought by Google. The tasks provided by industrial companies are represented at Kaggle. Their solution is further used by the customer and in addition it often contributes to the invention of new methods of machine learning. The solution of each application problem requires experimental estimation of the optimal neural network architecture.

In 2018, there were held more than 20 competitions at Kaggle, in particular the Salt Identification Challenge [4], which solved the problem of salt deposits identifying in oil and gas deposits by seismic images of soil under the order of TGS - the world leading geoinformation company.

To solve this problem, it was essential to conduct research on the choice of the optimal architecture. The main architectural decisions of the segmentation problem include: Unet [5], DeepLab, DeepLab v3 , Hypercolumns, PSPNet (Pyramid Scene Parsing) [6].

The Unet software design was firstly suggested for the segmentation of biomedical images, in its name (U) reflects the presented architecture, where convolution

filters and MaxPooling alternate on the left branch, convolution filters and Deconvolution — on the right. The last layer is the activation layer, sigmoid function.

According to the results of the research carried out in this work, a satisfactory result of solving the Salt Identification Challenge problem was achieved by the use of Unet and PSPnet. Unsatisfactory results showed Deeplab and Deeplab v3. Other researchers have also suggested using Unet with Resnet blocks [7]. However, these solutions were insufficient to compete with the top participants, so further research was focused on segmentation quality improvement.

Work objective is to create acceptable architecture to increase segmentation accuracy.

The suggested solution is based on a modified Unet. The basic components of Unet include: convolution blocks (B), a max-pooling (MP) layer, deconvolution (UP) layer, concatenation (Conc) layer, the final layer is 1x1 convolution filter with the activation (Sigmoid).

The B block implementation based on Resnet and Inception-like segments was proposed (fig. 1).

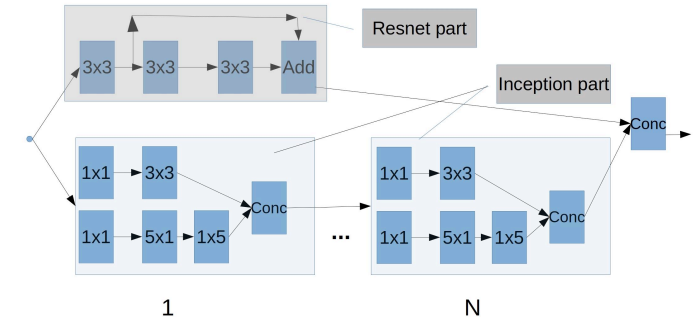


Figure 1. The basic block of the proposed architecture.

Block B has N inception-segments, where N depends on the depth of the block location. Along, the Resnet segment is calculated with Inception segments implementation. Both segments result is combined and provided to the next layer. Figure 1 represents the convolution filters measurements. The N dependence on the block location depth and the block output dimension is indicated in Table 1.

Table 1. Convolution units' characteristics

The block depth location	The number of Inception segments	The block output dimension
1	1	128*128*64
2	2	64*64*128
3	3	32*32*256
4	5	16*16*512
5	7	8*8*768

In the suggested network, as in the traditional Unet, block B is used at the input and after each max-pooling block and deconvolution layer. The suggested network is distinctive from the network with traditional Unet architecture:

1. The block architectural difference: there are only two convolutions in traditional Unet.
2. The additional layer availability with PSP-block.

The modified neural network containing a PSP block is represented in Figure 2. The PSPNet concept resides in the pulling use with different stride steps and convolution kernels, with further increase of the image dimension using bilinear interpolation with a combination of the result.

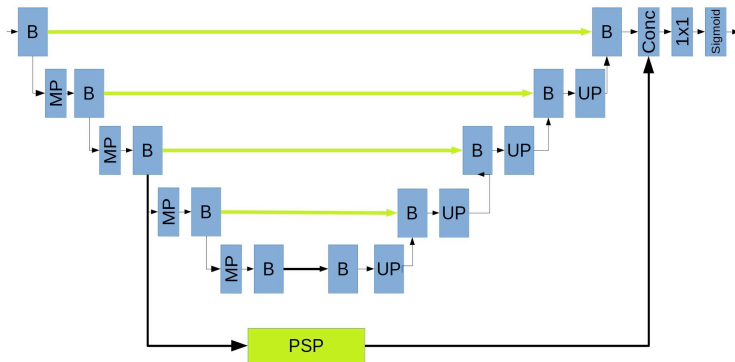


Figure 2. The modified Unet architecture

The PSP block is used after the third block B. Therefore, the PSP primary result is combined with the

Unet result. Then there is a convolution with 1\*1 filter and sigmoid activation.

Augmentation is used as a result of training quality improve. Augmentation is realized as a distortion function simultaneously applied to the input image and to the mask. As a result, it is reproduced:

- the reflection in relation to the vertical axicon;
- the image revolution through an angle of  $< 10$  degrees;
- random cropping to 80% of the image.

Typically, network training of similar architecture is carried out using binary cross-entropy (BCE).

However, it was not enough to effectively solve the problem. The network double training is suggested at the forum Kaggle [8]:

- the first is traditional, based on BCE,
- the second — by the use of the Lovász-loss and without the last activation layer.

Intersection over union (IoU) was indicated as competition measurement. In this decision, it concluded 0.86174. The winner result is 0.89646.

According to the results Salt Identification Challenge competition the suggested solution of the problem was in the top 9% and marked with a virtual bronze medal. According to the analysis of the prize-winning decisions, it is concluded that to improve the result one can change the

encoder architecture, use hypercolumn in the decoder, as well as resize the input image.

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## *Sukhodolsky A., Tytenko S.*

### **Search index building for numeric vectors with O(1) memory consumption**

#### Introduction

Nowadays, the world of information technologies produces a large amount of information, and therefore we should find new ways for its effective storage and retrieval. For classical data types (text, numbers, dates, etc.) there is a large number of algorithms that allow us to index and search for almost linear time. For a relatively young vector data representation, there is also a set of algorithms, but in most cases it is necessary to find a balance between memory consumption, search speed and quality of the results.

Vector representation of data is a representation, where each unit of data represents by one-dimensional vector with dimension shape  $d$ . Unlike classical data types, this representation is hard to interpret, but it's suitable for comparative characteristics (euclidean distance or cosine similarity). This representation can be used in searching for semantically similar images or texts that were previously processed by a neural network or another method of data vectorization. One of the most important tasks in vector data processing is the nearest neighbor search (NNS), which main goal is the accurate searching the nearest

neighbor vector by query vector in a short amount of time. The task is complicated by the fact that thousands of vectors consume a lot of memory, and the linear search of all vectors has complexity of  $O(dN)$ , where  $N$  is the vectors count. In order to simplify this task, it can be reformulated as “approximate NNS”, and this new formulation has given a lot of space for new algorithms such as Product Quantization (PQ) [1], Locality Sensitive Hashing (LSH) [2], and many others. These algorithms make an approximated search for the nearest neighbors, respectively, the accuracy of final results is not guaranteed, but the speed of the algorithm can increase to  $O(\log N)$ . However, initialization and building of a search index for these algorithms often require loading of all data into RAM, which is not possible in a case of large amount of data.

In this paper we have considered and proposed methods for building of search index for vector representation of data in  $O(1)$  memory consumption using PQ, LSH and Welford method [3] for covariation matrix and mean values finding.

### Formulation of problem

The main goal of this paper is to solve the problem of search index building for vector data with  $O(1)$  memory consumption. Index building consists of two steps: starting

initialization and data indexing. The first step is required for vectors compression using PQ algorithm and for their whitening (PCA whitening [4]). The second step builds index on input data using LSH. To achieve  $O(1)$  memory consumption, PQ and PCA whitening algorithms need to be adapted, since the first one uses K-Means clustering algorithm [5] for compression, and the second one is necessary to find the covariance matrix and the mean values along each vector’s dimension.

### Adaptation of PQ algorithm

Product Quantization algorithm uses K-Means clustering for vectors compression. To perform this, it divides each vector into  $M$  equal parts with dimension  $\hat{d} = \frac{d}{M}$ . After dividing, PQ cluster given sub-vectors into  $K$  (most often  $2^8$ , because cluster indices can fit in one byte) centroids. After all preparations, vector can be compressed by the replacement of each sub-vector by the nearest centroid index, and thus vector size can be reduced to  $M$  bytes.

The classic K-Means algorithm requires a whole bunch of data, but in this case it is appropriate to use the online version [6] of the algorithm, which incrementally updates cluster’s centroids by vectors stream. Cons of this approach are the lesser speed and instability of convergence.



## Adaptation of PCA whitening algorithm

To receive better LSH algorithm performance, input vectors should be whitened. This operation allows LSH to divide vectors by a set of hyperplanes into balanced binary tree. For PCA whitening algorithm it is necessary to find the covariance matrix  $\Sigma$  and mean values  $\mu$  for each dimension. Welford's method allows finding the covariance matrix and the mean values with  $O(1)$  memory consumption.

$$\Sigma_n = \frac{n-2}{n-1} \Sigma_{n-1} + \frac{1}{n} (x - \mu_{n-1})(x - \mu_{n-1})^T \quad (1)$$

$$\mu_n = \frac{x - \mu_{n-1}}{n-1} \quad (2)$$

To whiten the vectors, the PCA decomposition of the covariance matrix  $\Sigma = U\Lambda V^T$  needs to be found.

$$\hat{x} = \Lambda^{-1/2} U^T (x - \mu) \quad (3)$$

As a result, the vectors have the same distribution on every dimension and form the “bubble” on the hyperplane. Visualization of the whitening process is depicted in Figure. 1.

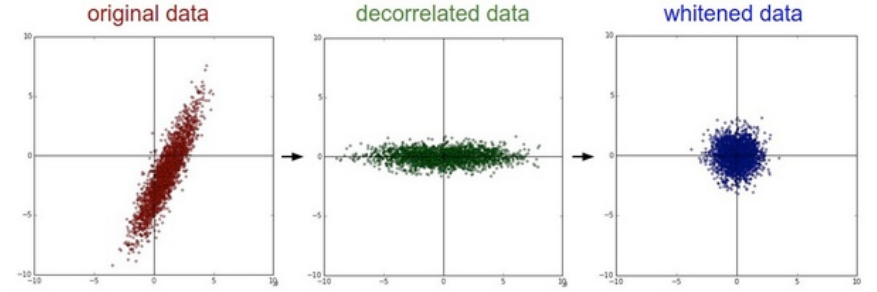


Figure 1 — Data whitening process

### Data indexing using LSH

The index building is carried out using the LSH algorithm. This algorithm defines  $\hat{N}$  hash functions that produce 0 or 1 values.

$$h_i(x) = \begin{cases} 1, & \text{if } W_i x > 0 \\ 0, & \text{otherwise} \end{cases} \quad (4)$$

where  $W_i$  is the normal vector of hyperplane  $i$ , and the sign of the expression  $W_i x$  defines the position of the vector  $x$  relatively to the hyperplane  $i$ . Since the vectors after whitening process have a “bubble” distribution, the  $W_i$  vectors can be defined as identity matrix  $W$  with shape  $N \times N$ .

The combined hash function is defined as an array of  $N$  hash functions.

$$h(x) = \{h_1(x), h_2(x), \dots, h_N(x)\} \quad (5)$$

The resulting hashes can be compared with each other using the Hamming distance [7], which is defined as

$xor(h(x_1), h(x_2))$ . The resulting value of Hamming distance correlates with the cosine similarity between input vectors, and therefore this fact can be used for an approximated search.

Since the values of the combined hash functions can collide with each other, nearest vector finds by linear search among vectors with same combined hash function result. Thus, the search speed in the best case decreases to  $O(\frac{N}{2^N})$ .

### **Conclusion**

In this paper, several methods have considered and proposed for search index initialization and constructing for vector data types with  $O(1)$  memory consumption. This approach solves the problem by finding the clusters' centroids in PQ compression step using online K-Means algorithm and finding the covariance matrix and mean values using Welford method. The disadvantages of this approach are the low quality of the found PQ centroids and low performance of initialization step.

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**INFORMATION SECURITY RISK  
ASSESSMENT OF CRITICAL  
INFRASTRUCTURE SYSTEMS: STANDARDS  
AND SOFTWARE TOOLS**

Considerable number of cyber-attacks on critical infrastructure systems (CIS) coupled with the technology-induced complexity of the system necessitate using of existing methods and software of assessing critical systems security risk exposure. So, in July 1996, Executive order of the President of the United States No. 13010 "About work to study security vulnerabilities of critical infrastructure from cyber and physical threats" were formed Commission for the protection of Critical Infrastructure in the U.S. President (President's Commission on Critical Infrastructure Protection – PCCIP) [1].

Realization of the growing terrorist threats in Europe caused the European Commission to develop and, in November 2005, publish the Green Paper on the European Programme for Critical Infrastructure Protection and subsequently, in 2006, on completion of the consultations between the EU countries, the European Programme for Critical Infrastructure Protection [2].

CIS, as referred to by the United States (US) Dept. of Homeland Security, are "the assets, systems, and networks, whether physical or virtual, so vital that their incapacitation

or destruction would have a debilitating effect on security, national economy security, national public health or safety, or any combination thereof" [3]. The USA President's Commission on Critical Infrastructure Protection (PCCIP) report proposes eight categories of critical infrastructure systems. They include Information and Communications, Electrical Power Systems, Gas and Oil Transportation and Storage, Banking and Finance, Transportation, Water Supply Systems, Emergency Services and Government Services [4].

Information Security risks relating to CIS refer to a wide range of physical, logical and technology defects in systems infrastructure setup and their environment. In that space, multiple threat sources exhibit. These include the act of human error, technical hardware failure, technical obsolescence, quality of services deviation from standard services, application/protocol attack, deliberate act of sabotage, deliberate act of information extortion. Other specific threats include Ransomware, Water Hole attack, Dropper, Rootkits, Spyware, Worms, Trojan Horses, Phishing and Spear Phishing. Effective risk assessment methodologies are the cornerstone of a successful Critical Infrastructure Protection Programme. The above shows that Risk assessment is indispensable in order to identify threats, assess vulnerabilities and evaluate the impact on assets, infrastructures or systems taking into account the

probability of the occurrence of these threats.

A critical step in the Information Security Risk Management process of CIS is the Risk Assessment. This involves the evaluation each IT risk as well as the total IT risk and giving them priorities. There is a significant number of risk assessment methodologies for critical infrastructures. In general, the approach that is used is rather common and linear, consisting of some main elements: identification and classification of threats, identification of vulnerabilities and evaluation of impact. The main result of a Risk Assessment is usually a qualitative or quantitative evaluation of the possible risks that a given complex system is exposed to, taking into consideration its context and likely threats.

There are many ISO/IEC standards related to security:

- the Australian/New Zealand Standard for Risk Management AS/NZS 4360:2004 provides a generic framework for the process of managing risks which divides the elements of the risk assessment process into several sub-processes: "Establish the context", "Identify Risks", "Analyze Risks", "Evaluate Risks" and "Treat Risks". In 2009 it was integrated into the AS/NZS ISO 3100:2009 international standard which introduces a new conceptualization of Risk: from "chance or probability of loss" to "the effect of uncertainty on objectives";
- ISO/IEC 27002:2005: Code of practice for

Information Security Management. ISO/IEC 27002 was derived from the BS7799 standard, first published in the 90's. It was subsequently integrated into the ISO/IEC 17799 standard and later renamed to its current label. The standard is aimed at "establishing guidelines and general principles for initiating, implementing, maintaining, and improving information security management within an organization";

- ISO/IEC 27005:2011: Information technology — Security techniques — Information security risk management. The first version of ISO/IEC 27005 standard was launched in 2008 as a replacement for the Management of Information and Communications Technology Security (MICTS) standards ISO/IEC TR 13335-3:1998 plus ISO/IEC TR 13335-4:2000;

- ISO/IEC 13335-1:2004: Information technology – Security techniques – Management of information and communications technology security – Part 1: Concepts and models for information and communications technology security management.

The main methods and software tools are such as:

- OCTAVE (Operationally Critical Threat, Asset, and Vulnerability Evaluation) model is a risk assessment model applicable in assessing IT risk exposure in the context of enterprises' operational and strategic drivers. Unlike the previously models, OCTAVE is a qualitative criterion,

which core target is to evaluate organization's operational risk tolerance level. There are commercial software products that implement the provisions of OCTAVE. The OCTAVE Method, documented in the OCTAVE Method Implementation Guide, v2.0 [Alberts 01a], was designed with large organizations in mind, while OCTAVE-S was developed for small organizations was developed for small organizations [5]. The OCTAVE approach is driven by two of the aspects: operational risk and security practices;

- CRAMM (CCTA Risk Analysis and Management Method) is a risk management methodology, currently on its fifth version, CRAMM Version 5.0. Siemens offers CRAMM Expert and CRAMM Express software products. CRAMM can be used to justify security investments by demonstrating need for action at management level. Secondary applications can be benchmarking the security of an organization or showing compliance to other standards (like the BS7799 - British standard for information security management). CRAMM is compatible with ISO 270001 certification, and its asset-centric approach as well as its asset valuation technique have even been integrated into other methodologies (like CORAS) [6];

- CORAS method provides a computerized tool designed to support documenting, maintaining and reporting analysis results through risk modeling. The

CORAS methodology integrates aspects from partly complementary risk analysis techniques, like HazOp, FMEA and FTA, with state-of-the-art system modeling methodology based on UML 2.0 [7]. A graphical UML-based language has been developed to support documentation and communication of security analysis results.

In modern practice, the European Network and Information Security Agency (ENISA) have developed 24 methods for assessing information security risks. When choosing a method, you need to consider all the PROs and CONs (Table 1).

Table 1 – The PROs and CONs of the foregoing methods

[Author's composition according to [6]]

Method	PROs	CONs
OCTAVE	Self-directed: can be carried out by small teams of the organization's own employees; flexible and context driven: contains several methods tailored for specific organizations and contexts; widely used method with plenty of supporting documentation and compatible third-party	Original OCTAVE is a heavyweight method, consisting of many volumes, worksheets and processes.

	tools.	
CRAMM	The complexity of the assessment can be tuned to needs; especially useful for large enterprise organizations; process is mostly automated (in software tool).	Expert knowledge required; full assessments can be lengthy or overly-complex; can only be used in conjunction with dedicated tool.
CORAS	Free tool support; facilitates iterative communication and collaboration between various stakeholders; very thorough, suitable for security-critical systems and large organizations.	Requires expert knowledge from various backgrounds; might be lengthy; no longer developed.

Finally, the reasons for the choice of techniques should be given, with regard to relevance and suitability. When integrating the results from different studies, the techniques used and outputs should be comparable. Resources and capabilities which may affect the choice of risk assessment techniques include: the skills experience capacity and capability of the risk assessment team; constraints on time and other resources within the organization; the budget available if external resources are required.

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**ENERGY SECURITY RISK ANALYSIS FOR  
TERRITORIAL MANUFACTURING SYSTEMS  
WITH APPLICATION OF INTELLIGENT  
GEOGRAPHIC INFORMATION SYSTEM**

Acceleration of the processes of world economy globalization, liberalization and integration of energy markets, possibilities and contradictions of sustainable global development make researches aimed at formation and implementation of global energy security assurance mechanism particularly important and promising [1]. Under conditions of globalized world economy and integrated energy markets, high and unstable prices for basic energy resources, limited measures of improvement of their energy consumption efficiency become risk sources for energy security of fuel and energy complex of territorial manufacturing systems in many countries of the world. In this work Territorial Manufacturing System (TMS) is considered as an area on the Earth's surface that has certain limits and spatial basis of activity and includes, in addition to manufacturing, industrial and social infrastructure, regarded as a testing area of life-sustaining activity, as a factor and resource of the territory development.

As it is pointed out in [2], effective risk management policy of manufacturing systems largely depends on the

quality of decision-making information services, including an information system of monitoring, data bank of results of monitoring of the territory condition in terms of security, pace of their development and reproduction.

Geographic information systems (GIS), provided for collection, storage, analysis and graphic representation of space-time data are traditionally used in the monitoring problems. As mentioned in [3], analytical potential of GIS makes it possible to solve a great number of spatial problems in analysis of TMS energy security risks.

Following model of information analysis system (IAS) for TMS diagnostics is suggested to analyze TMS energy security. It takes into consideration two main factors: 1) availability of reliable sources of information gathering, modern advanced software and hardware tools, technologies of data collection and transmission, information processing promptness; 2) analytical component in the software and hardware system. This factor depends on: quality of analytical program algorithms; promptness of analysis performance.

Development of the following structural components forms the basis for formation of IAS (fig. 1): 1) issue-related multidimensional data base (DB) and knowledge base (KB); 2) concept of TMS condition diagnostics in terms of energy security; 3) geographic information data processing using GIS technologies.

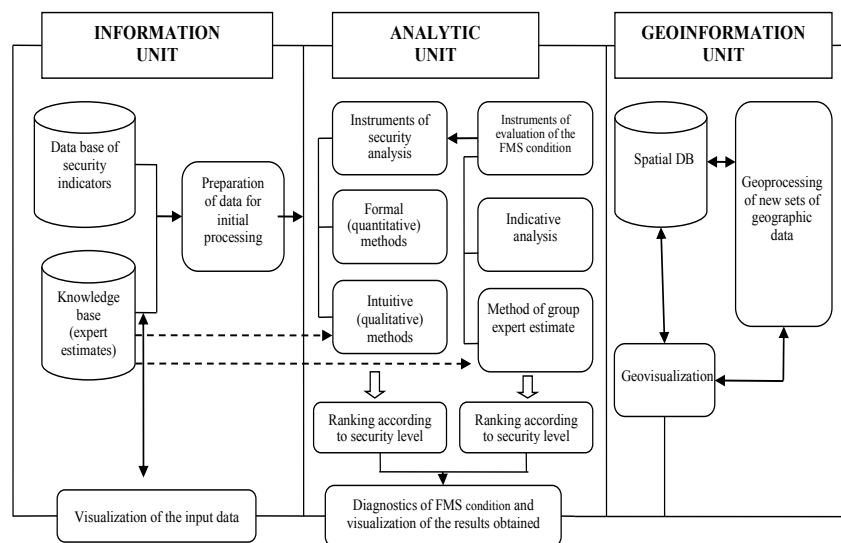


Figure 1 – Structure of the information analysis system for TMS condition diagnostics in terms of security level

Let us examine in more detail the essential features of the IAS structural elements. Issue-related DB and KB can be represented as object oriented normalized DB tables, which contain hierarchical system of interconnected indicators of energy security for the basic spheres of life-sustaining activity (energy, foreign economy, investments, finance, social, environment and the like) for particular TMSs. Analysis of existing methods and procedures of estimation of TMS energy security condition shows that as a whole they are based on the use of indices (indicators) of energy security, their standardization, comparison of their

current or forecasted values with the limit (threshold) values and the use of convoluted integrated indices. KB accumulates general theoretical knowledge and expert estimates concerning the subject of research in the form of description of classes. The essence of DB and KB concept consists in the integrated retention and differentiated use by applications of entire information about the objects of the subject area, that are of definite interest for the user. Under such circumstances, on the one hand, configuration of data presentation is described at the logical (intelligible) level for each program, but, on the other hand, all the remaining data, which are stored in DB and KB, have no relation to the specific applied program and are «transparent» for it. It means that the program is not aware of their presence. In other words, all the data are placed in the sole repository. This is ensured by immersion of DB and KB into particular software environment, that exercises the functions of access and transformation of data structures. Organization of data storage and allocation should be convenient and efficient for guaranteeing of prompt analysis and representation of the necessary data sets in accordance with queries generated by the users. It is proposed to use MySQL Server as database, while it is the most widely used database server, it ensures safe data storage, convenient data processing and rapid integration with other databases when heeded.



Concept of TMS condition diagnostics in terms of energy security should contain well-balanced needs of particular users for acquisition of analytical information, actual resources and methodological framework for support of researches of TMS economic security and convenience in connection to the system of new components of the analytic unit. Each component of the analytic unit should be designed according to the types of particular applied problems. It should include analytical data and methodology of their processing on the basis of the following methods: indicative analysis method; group expert estimates method; discriminant analysis method.

Modeling and forecasting of TMS conditions under the circumstances of risk (indeterminancy) fall into the category of multiparametric problems difficult to formalize, with underspecified information and multiple relations between parameters. For this very reason, as it is shown in [4], recently in business analysis practice of energy sector interest rises to such technologies as Data Mining, the most popular among them are neural net modeling and fuzzy logic tools [5].

For implementation of basic functions of the system it is proposed to use the means of Java-technology, namely JavaEE. Java is widely known as a modern object-oriented language, which makes it possible to develop programs, that can be run on any platform without adaptations. Server

end is proposed in the form of an EJB-project, which will make it possible to obtain rapid and reliable access to the data base. Enterprise JavaBeans (EJB) is specification of technology for writing and support of server components, which contain business logic, and it forms an integral part of Java EE. As describes [6], this technology has a number of advantages in utilization, the most important of them are: support of data storage (persistence); data should not lose integrity even upon the brake of the program; support of distributed transactions; support of competitive data replacement and multi-threading; support of naming and catalogs (JNDI); security and limited access to the data; support of automated installation on server; remote access. Each EJB component is a set of Java classes with strictly specified rules of method naming, which entirely reflect subject area of the problem, correspond to DB objects, and that's why creation of EJB project makes it possible to exchange information with the DB easily.

Architecture design of intelligent GIS is based on 4 principles of the software system (SS) construction: 1) the SS should be platform independent for user; 2) the SS should be multi-user, i.e. n users can work simultaneously; 3) data processing rate and computation results should be approximated to real time systems, i.e. data processing and problem solution time should be as short as possible; 4) output of the SS work should be visualized in user-friendly

form and be of assistance to the user in decision making.

As a conclusion, traditional systems of GIS analysis do not always make it possible to solve the problems under conditions of underspecified information, however development of hybrid intelligence system, i.e. a system that uses combination of analytical models and artificial neural networks and its integration into the GIS package for solution of problems, allows to use GIS in the new range to solve the wider circle of tasks, as it is shown in [7]. That's why synergetic of GIS with technologies of «intelligence data analysis» in the study of TMS energy security problems is on the agenda now.

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Gaydarzhy V.I., Mykhailyk K.

### Front-End part of the maintenance system of the register of information resources

**Formulation of the problem.** In today's conditions, the problem of improving the work of both the individual employee and the enterprise as a whole, which depends on a large extent on the effectiveness of the organized creation of the electronic information resources, its use, storage and protection, especially if the processing of these resources is their main activity, which this is built.

The main requirements and conditions that were set during the development of the client part of the register of information resources:

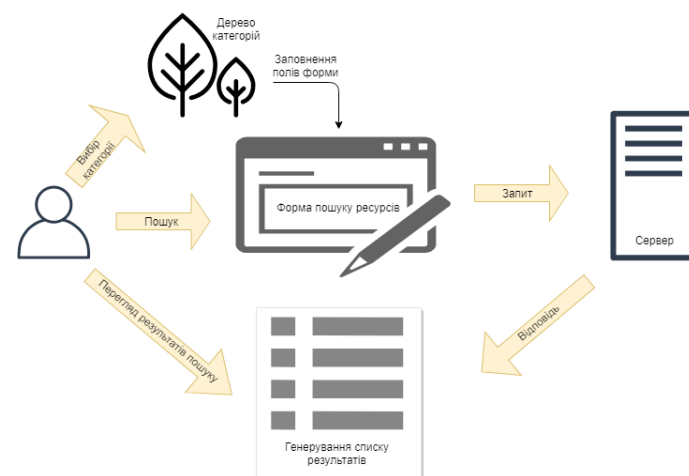
1. Display information about the created information resources, ensuring the principles of confidentiality, integrity and availability of information.
2. Providing search information about resources created in Ukrainian, Russian and English.
4. Display the directory system as a category tree.
5. Search for information resources by category tree.
6. Search for information resources according to the requisites in the form.
7. Display information about the found information resources in the form of cards.
8. When you click on the resource card, a window opens with detailed information about this resource.

9. In the window with detailed information about the resource, it is possible to open the resource using built-in browser tools or download it to a local computer.

10. The paucity of displayed results.

11. Sorting.

The model of the client part of the information resource register can be schematically presented on Picture 1.



Picture 1 – The model of the client part of the register of information resources

**A brief overview of existing technologies.** To develop the client part of the register of information resources, it was necessary to select such means, which would allow to quickly and without delay show to use search of information resources. The created application is

an example of the SPA (Single Page Web Application), which is best developed to use the JavaScript programming language, since it can help you to display the component of pages without rebooting after user-run actions, to provide more consistent experience with the use of the registry. For the client part of the application there are many frameworks that are implemented in different programming languages and developed by different companies. The comparative characteristics of the two client frameworks are shown in Table 1.

Table 1 - Comparative React and Vue characteristics

Decision point	React	Vue
Stability	Yes	Yes
Great community of developers	Yes	No
Detailed documentation	Yes	Yes
Easy to learn	No	Yes
Easy	139K	58.8K
Speed of code writing	Normal	Quick
Reactivity	Yes	No
Component approach	Yes	Yes
Architectural Templates	Yes	Unclear

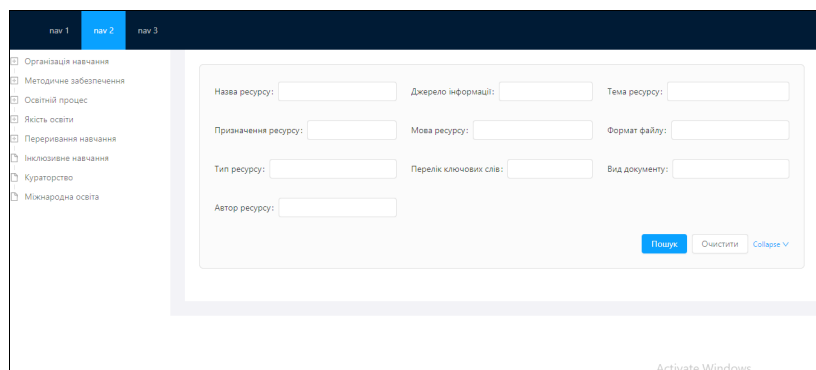
**Realization principles.** The client part of the information resource register was implemented using MVC architecture and unidirectional data flow. These approaches

were chosen because they allow you to organize a large amount of code, prevent excessive duplication of functionality and provide efficient system support. But the most important, in my opinion, is another advantage of these approaches, namely: adding and expanding the functionality.

To implement the client's part, I selected the React Library through the following benefits:

- low entrance threshold;
- Integration with the paradigm of unidirectional data flow;
- use of HTML-like JSX syntax;
- Virtual DOM for high-performance applications and quick client upgrade;
- the ability to link data;
- Easy to change and reuse code;
- there are no excess dependencies of the component;
- the ability to create high-performance applications and at high speed, regardless of their complexity;
- providing a simplified testing process;

**Operation process.** The page's working window consists of the following main elements: left sidebar with category tree, search form, main menu, list of search results (**Figure2**).



Picture 2 - Client window working window

You can search by entering data into form fields by attributes, either by categories in the side left panel, or both. As a result, the results will be displayed in the form of cards (Picture3).

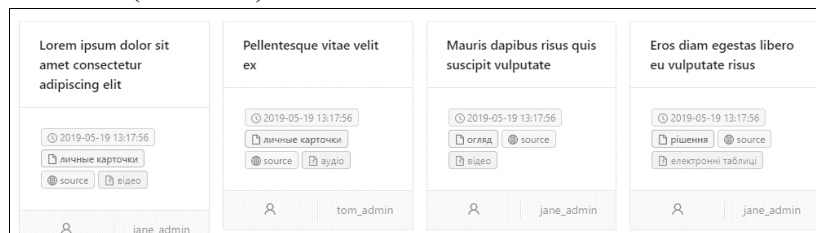


Figure 3 - Search results in the form of cards

**Conclusion.** The developed client part of the information resource registry system is designed to solve the problem of searching, viewing and access to information resources. This was realized through several functions of the system, namely: the possibility to search

information resources by category of trees was realized, the possibility of searching information resources for attributes in the form of search, representation of the found information resources in the form of cards was implemented.

## Resources

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*Osadchyy S., Gaydarzhy V.*

### **Tools for automation of remote reports on basis of 3-tier REST architecture**

Large distribution companies that operate on Ukrainian market actively use employees, that work remotely in stores of trade partners. Such remote employees do visits in retail stores of trade partners for purposes of filling shelves with products, which are promoted by distribution company on retail. Without such visits, products, which were delivered by logistic, can stay for a long period of time on goods receiving or on warehouse in retail, without been placed on shelves, which leads to lost in sales.

Modern tendencies in organizing of remote employees controlling imply using of websites, which can be used by employees to load reports about job done and can be used by supervisors to review reports and to process them (approval, payment).

Modern technology of monitoring results of trade representatives (merchandisers) in large distribution companies provides sending of photo reports from retail store of partner. Supervisor uses photo to evaluate how retail shelves, filled by products, correspond to standards of filling shelves, how wide products are represented, what percentage of retail shelves filled with products, which promoted on market, in comparison with competitor

products. One of weaknesses of existing system is that it is complicated for supervisor to check that photo is relevant to its description. Employees by mistake or intentionally can attach to report a photo that reflects job done on another date or from another place.

As a result, there is a need to develop software, which can provide relevancy of photo and report by indicators: geo coordinates and date. Software can receive geo coordinates and date from image metadata according to EXIF standard. Such metadata adds to image by digital camera by default. Mandatory organizational decision – to oblige remote employees keep on geolocation service on equipment, which uses to make photos.

Setting task.

To develop a tool for remote employees, which will allow to create reports about visits made, to edit and, if necessary, to delete. Input data: image, name of place where job was done, comments as description of job, records in database table. Output data: records in database table.

To develop a tool for supervisor, which will allow to oversee created reports about visits and will allow to approve such reports. Input data: records in database table, which used to create corresponding objects on server side and client side. Output data: updated records in database table.

Implement to form daily reports, which will be collections of approved reports about visits. Input data: records in database table about registered visits. Output data: created objects, which used on client side for visualisation of daily reports.

To develop a tool for admin, which will allow to create new users of software product. Input data: user name, password. Output data: records in database table.

Provide identification of user as employee, supervisor or admin with granting appropriate power according to role. Input data: user name, password. Output data: JSON Web Token with appropriate load.

Provide access employee exclusively to his reports. Input data: JSON Web Token. Output data: selection of records from database table with filter by employee, which used to create corresponding objects on server side and client side.

Implement receiving of visit's geo coordinate and date from image metadata, which approve fact of visit. Input data: image file. Output data: value of tags GPSTLongitude, GPSTLatitude and DateTime.

Implement visualization of visits as markers on map. Input data: records in database table, value of tags GPSTLongitude and GPSTLatitude. Output data: assigned values of properties latitude and longitude for appropriate tags <agm-marker> in template of component.

Implement saving of image files on FTP server; in database save only links to file in format "https:// ". Input data: image file. Output data: record in database table.

Develop software in REST style, with interaction of client side and server side by HTTP methods as to Figure 1.

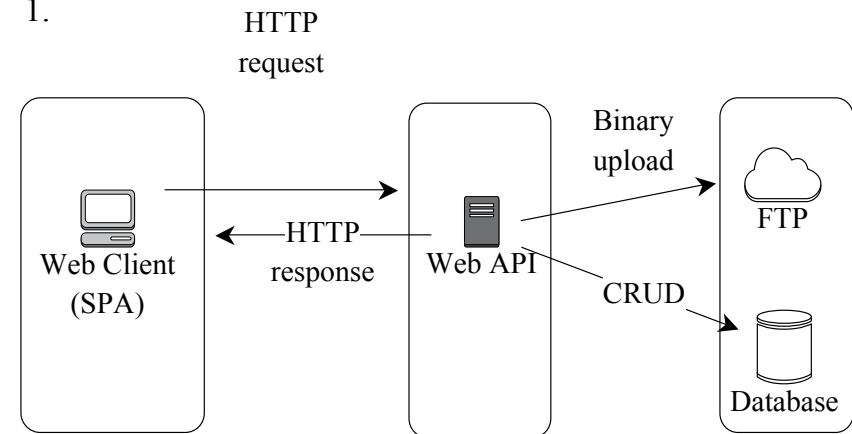


Figure 1. General scheme of software

Features of client side:

- visualisation of data for users;
- receiving input from users;
- transfer requests on server;
- processing of server responses.

Features of server side:

- processing of requests from client side;
- sending responses to client side;

- uploading of binary files on FTP server;
- interaction with database server for execution of CRUD-functions of data management «create, read, update i delete»

Features of database server:

- execution of base operations for data manipulation (such as insert, modification and deletion of data from tables);
- execution of simple and complex quires.

### User interface samples.

On Figure 2 see visualisation of reports about visits on map.

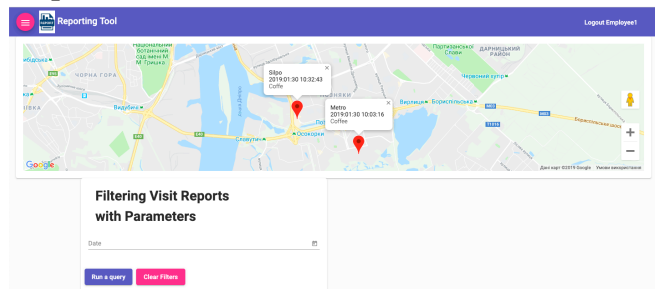


Figure 2. Form of visualisation of reports on map

On Figure 3 see list of reports about visits and filled form for creation of new report about visit.

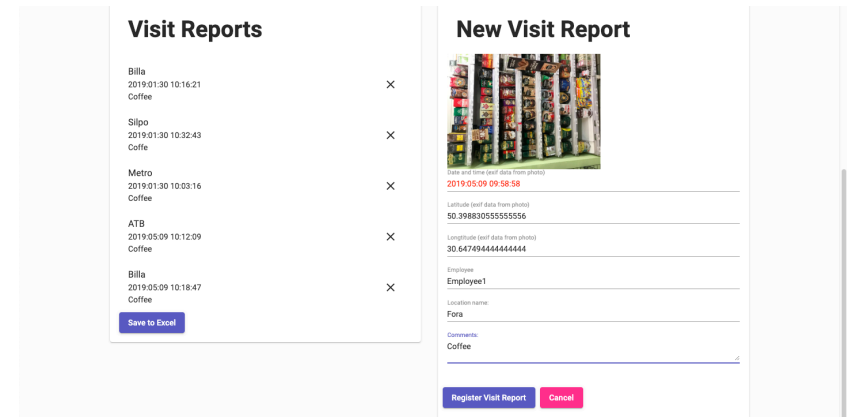


Figure 3. Form for creation of new report about visit

While filling of form for creation of new report about visit, fields “Date and time”, “Latitude” and “Longitude” are filled by software from image metadata, which approve fact of visit. Field “Employee” is filled by software as result of user identification.

### Summary.

Result of project realisation is creation of software with the following features:

- user can pass identification as admin, employee or as supervisor;
- employee can create reports about visits on retail store; also there is possibility of oversee and deletion;
- employee can access only to his reports;
- supervisor can oversee reports about visits and approve them;
- supervisor has access to reports by all employees;



- daily visit is a collection of approved visits;
- some portion of information (geo coordinates and date) about visit extracts from image metadata, which approve fact of visit;
- visit visualises on map as marker;
- image, which approve fact of visit, stores on FTP server; database stores only link to file in link format (https://).

Software built as 3-tier architecture. Software consist of client as web-client, server application as Web API and database server. Such architecture in comparison with 2-tier client-server or file-server architecture provide better scaling and better configurable.

Developed software can be used in any activity with controlling of results of remote employees with using of photo reports.

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## **DESIGNING SURFACES OF BEZIE WITH SPECIFIED CURVATIVES**

**Annotation** - The article proposes ways of designing Bezier surfaces with a given curvature.

**Keywords:** *Bezier surfaces, curvilinear.*

The Bezier surface is given by the formula [2]

$$r(u, v) = \sum_{i=0}^M B_i^m r_i(v) u^i (1-u)^{(m-i)} \quad (1)$$

where

$$B_i^m = \frac{m!}{i!(m-i)!} - \text{binomial coefficient}$$

$$r_i(v) = \sum_{j=0}^n B_j^n r_j(v) v^j (1-v)^{(n-j)} - \text{guide curves (2)}$$

$r_j$  – control points of the guide curve

In this way, we see that the Bezier surface is formed by the displacement of creature curves

$$r(u) = \sum_{i=0}^M B_i^m r_i(v) u^i (1-u)^{(m-i)}$$

according to the specified guide  $r_i(v)$ , which are determined by the same equation as the derivatives. If you apply the results of work [3], then as Bevel or Creator curves it is possible to offer Bezier curves with a given curvature. The resulting Bezier surfaces can also be given with a given curvature.

Thus, to determine the Bezier surface with a given

curvature, it is necessary to set the following boundary conditions

regional creation  $r_0(v)ir_1(v)$ , regional first derivatives  $r'_0(v)ir'_1(v)$ , as well as marginal second derivatives  $r''_0(v)ir''_1(v)$ . The first and second boundary derivatives are determined from the given laws of boundary curves  $k_0(v), k_1(v)$  by the formula [1]:

$$k^2 = \frac{\begin{vmatrix} x' & y' \\ x'' & y'' \end{vmatrix}^2 + \begin{vmatrix} y' & z' \\ y'' & z'' \end{vmatrix}^2 + \begin{vmatrix} z' & x' \\ z'' & x'' \end{vmatrix}^2}{(x'^2 + y'^2 + z'^2)^{\frac{3}{2}}} \quad (3)$$

On the basis of the given laws of boundary first and second derivatives of creations, boundary first and second derivatives of guide curves are determined. Next, the guide curves are determined by the results of work [3]. In this case, the guide Bezier curve will have a degree not less 5:

$$r(v) = \sum_{i=0}^5 B_i^5 r_i v^i (1-v)^{(5-i)}.$$

Checkpoints  $r_i$  determined on the basis of the given boundary laws  $r_0(v)ir_1(v), r'_0(v)ir'_1(v), r''_0(v)ir''_1(v)$ . Applying results of work [3], we will have for one edge of the surface:

$$r_0 = r_0(v=0), r'_0 = r'_0(v=0), r''_0 = r''_0(v=0), r_1 = r_0 + \frac{r'_0}{7}, r_2 = 2r_1 - r_0 + \frac{r''_0}{21}.$$

$$r_5 = r_1(v=0), r'_5 = r'_1(v=0), r''_5 = r''_1(v=0), r_4 = r_5 - \frac{r'_5}{7}, r_3 = 2r_4 + r_5 - \frac{r''_5}{21}.$$

for the second edge of the surface:

$$r_0 = r_0(v=1), r'_0 = r'_0(v=1), r''_0 = r''_0(v=1), r_1 = r_0 + \frac{r'_0}{7}, r_2 = 2r_1 - r_0 + \frac{r''_0}{21}.$$

$$r_5 = r_1(v=1), r'_5 = r'_1(v=1), r''_5 = r''_1(v=1), r_4 = r_5 - \frac{r'_5}{7}, r_3 = 2r_4 + r_5 - \frac{r''_5}{21}.$$

According to the results of the work, a computer program in the AutoLISP language was developed in the AutoCAD system environment. In the test example, the Bezier curve of the third degree was applied as the boundary laws of the creator  $r(v) = r_0(1-v)^3 + 3r_1(1-v)^2v + 3r_2(1-v)v^2 + r_3v^3$ .

See the results of the program. on fig. 1

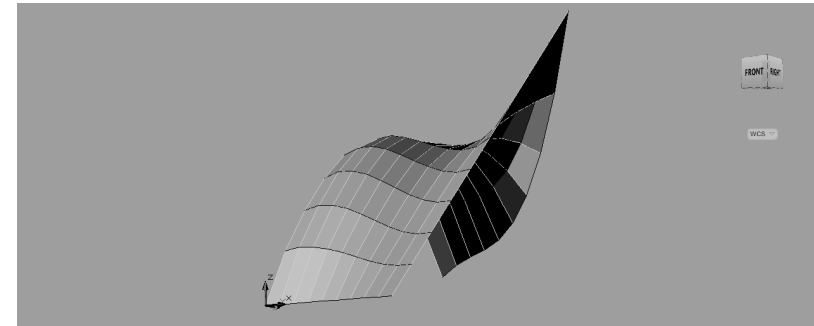


Fig.1 A test case of Bezier surface with a given curvature.

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### **Back-end part of the system for register of information resources functioning**

In the process of building the information society in Ukraine, the ability to improve systems and registries of information resources, the purpose of which is to provide a convenient and flexible tool that allows qualitatively to increase the efficiency of the use of information and information resources, optimize the costs of their storage by using metadata and attributes, is obtained. , creation of arrays, databases, registers, as well as other types of organization of information resources.

It should be noted that this problem was noticed and evaluated at the national level, as early as in 2004, the Cabinet of Ministers of Ukraine N326 of March 17, 2004 approved the provisions on the National Register of Electronic Information Resources [1], which provided for the creation of an information and telecommunication system in order to introduction of a unified system of accounting of electronic information resources of the state.

But after 15 years, only 108 resources [2] are available on the official website of the National Register of Electronic Information Resources, most of which are currently inactive, so one must admit that the system

created is not sufficiently distributed and can not solve the problems for which it was created .

It is the decision of the above problems that explains the urgency and necessity of developing and creating an instrument that would enable the integration and systematization of resources through the use of metadata on them, would give the possibility of forming rules and methods of access, taking into account the requirements of information security, and as a consequence, would increase the efficiency of use existing information resources.

Due to this problem the following tasks have been formulated and set:

- 1) Analyze the existing tools for ensuring the functioning of electronic information resources registers;
- 2) Develop a scheme for the purpose of the attributes of information resources;
- 3) Analyze the possibility of saving to a local server;
- 4) Develop an application for the register of electronic information resources.

Modern frameworks implement the MVC architecture and decide on the development of the application quickly, according to all standards, safe and predictive. The most popular and widespread PHP language development, according to GitHub, is Laravel, Symfony and Yii [3].

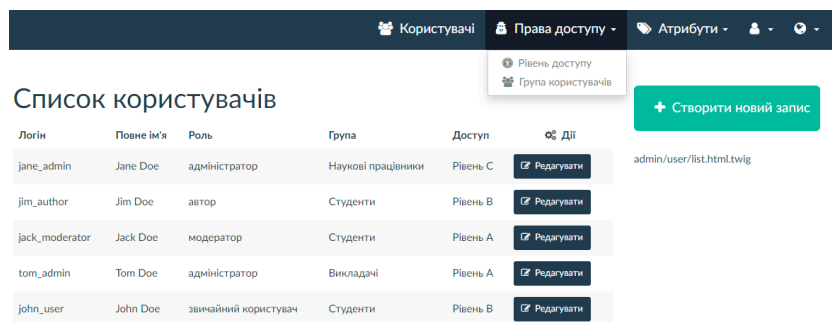
According to the analysis, for the development of medium and large projects that require long-term support and the possibility of the necessary scaling, it will be a good decision to use the Symfony framework.

A model with four roles is provided for delimitation of access rights and provision of various user functionality (Picture 1).



Picture 1 - The model of the operation of the register of electronic information resources

The administrator has the ability to manage users, modify their data, translate them into different groups, give them access to different levels, assign users roles on the system. For example, an administrator can modify, delete, add access levels (Picture 2).



Picture 2 - Administrator interface - updating the user list

The moderator keeps the registry up to date, changes the status of resources, search engine and technical metadata: keywords, categories, types and types of documents, destination, file formats, and more.

The author has the right to add the resource to the registry, as depicted in Picture 3.

#### Створення ресурсу

Figure 3 - The author's interface - adding a resource

As a final stage in working with the frameworks, an application was created using Symfony4, which is

characterized by all the main features of the consistent frameworks. It has a three-level structure Model-View-Controller, all the data contained in the application, are stored in the database through the component Doctrine. Testing and testing of modules and components is performed through the PHPUnit library.

**Conclusions.** The developed program provides functioning of the server part of the formation of the register of electronic information resources and provides the user with the following functions:

- 1) registration of new users in the system;
- 2) authentication and authorization of the user;
- 3) creation of a new electronic resource in the register;
- 4) saving metadata about the resource in the registry;
- 5) formation of access groups for resources;
- 6) loading a resource into a local repository;
- 7) review of the resource by direct link;
- 8) Unloading a resource to a local computer.

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## **PROBLEMS OF DESIGNING METHODS FOR MODELING THE HYDROACOUSTIC PROCESSES**

Key words: *hydroacoustic processes, models of hydroacoustic systems, natural and computer approaches, modeling complex.*

### **Introduction.**

Experimental research of hydroacoustic processes related to the study of the characteristics of noise emission of marine objects whose ultimate goal is the classification and identification of these objects in today's time is given considerable attention.

Classification and identification of objects takes place on the basis of the use of a number of relevant algorithms, such as signal generation, signal allocation from the current state of the general hydroacoustic field of the water, classification and final identification of objects by specific features and properties.

In this case, the classification refers to the determination of the source of radiation to the class of surface or underwater objects, and under the identification - a procedure for determining the type of detected object (for example, for a surface vessel possible types - aircraft

carrier, battleship, cruiser) and its characteristic properties.

Usually these researches are performed based on natural experiments or computer simulation tools.

Natural experiments conducted in different water areas with different objects confirm the high efficiency of the study of the spectral-energy characteristics of the isolated signals of noise-emitting marine objects. At the same time, an important procedure for assessing the effectiveness of identification, classification and probability of correct detection of objects for the tasks of constructing diverse marine security systems is important.

Experimentally determined characteristics of noise emission of marine objects allow the development of diverse marine security systems that solve the problems of determining the range, speed, course angles and construction of the route of motion of marine objects.

However, the work associated with conducting each individual field experiment is very resource-consuming and requires the availability of additional procedures: fixing the conditions of the experiment, temporarily binding events and carefully describing them for storage and further in-depth analysis and processing. These procedures can be conventionally reduced to the concept of creating and describing a modeling scene.

In addition, natural experiments provide various methods for fixing signals, the diversity of their spectral-

energy characteristics, which requires a time-bound process of conducting an experiment and the use of a thorough description of the sequence of individual steps of the experiment, which can be conventionally reduced to the procedure for organizing the scenario of the experiment.

Means of conducting computer experiments in the study of hydroacoustic processes (GAP) have a pronounced specific orientation either for the purpose of the experiment or the type of models used.

Therefore, the article proposes to use methods of computer mathematical modeling of hydroacoustic processes by incorporating them into a specially developed software and technological complex of modeling of hydroacoustic processes, which performs experiments on the basis of the scenario approach.

Such systems require the creation of diverse simulation models of GAS and the construction of adaptive to the full implementation of experiments techniques. The main attractive feature of such systems is the ability to accumulate, step-by-step development and reuse of knowledge (formalized assumptions, conclusions, patterns related to the object being studied) in the real-mode simulation process of a complex dynamic object (SDO).

For systems of this class, it is necessary to create tools for the use of diverse models, as well as to develop a management system based on the flexible setting of

conditions and the whole experiment. The listed facilities can be conventionally reduced to the concept of creating and describing a modeling scenario

Such procedures include the availability of means for identifying the conditions of the experiment, for example, the area of conducting, the parameters of the water area, a set of devices for detecting signals (their location, characteristics) ..

### **The aim of the work**

The aim of the work is to identify the problems of designing these simulation systems and describe the approaches that solve them.

### **An overview of the approaches to the modeling of hydroacoustic processes and systems**

The paper [1] presents the results of the development of intelligent autonomous unoccupied submersibles (ANPA) for entire oceanographic and geodetic studies of the seabed and shelf, monitoring of the aquatic environment, the search and detection of technical and natural objects in the marine space. This field of research with the help of field experiments, allows us to develop general approaches to the organization of navigation systems, the creation of acoustic tomography systems, to study the qualitative characteristics of detection systems and the identification of marine objects in water areas. The authors consider it expedient to use the results of

researches with systems ANPA for development and construction of simulation modeling complexes capable of generating virtual marine environment and all kinds of marine noise-emitting objects. At the same time, the authors recognize the rather cost-effective technology of this type of research.

In the paper [2] a system of computer simulation of the algorithms of the receiving-transmitter of a hydroacoustic telecommunication system of a submarine robot was developed, which was developed by employees of the Pacific State University (TOGU, Khabarovsk).

The paper presents the results of numerical and field experiments in the conditions of the shallow sea, as well as the differences between the methods of signal processing and the optimal parameters of the hydroacoustic telecommunication system.

The considered system provides the following simulation possibilities:

- Download and process real data that are presented in wav file format.
- Parametricized generation of simple harmonic and complex signals (LCHM and SPS-FM based on M-sequences and sequences of Gold [2]), taking into account different models of noise generation
- Unload processing results.

The system consists of three main blocks - the

program interface block, the signal generation unit and the signal processing unit

The model is implemented using the programming environment Matlab 2010b.

In the system, in order to accelerate the processing and presentation of large volumes of numerical and field experiments in MATLAB technology used CUDA (computing on graphic processors). For this purpose, the appropriate plugins for Matlab include the Accelerieyes Jacket - the paid CUDA plug-in for MATLAB from Accelereyes and the plug-in for MATLAB with CUDA support [3]

The system has the following limitations: the simulation is performed solely by means of the MATLAB complex, there is no experimental control system, no possibility of identifying objects based on the analysis of signals

The given review of the current state of construction of a universal system of modeling hydroacoustic processes shows the following problems that need to be addressed when designing systems of this class, namely:

- the complexity of identifying the components of the system being projected and establishing an adequate interdependence between them;
- search of effective indicators of the correspondence of mathematical models with the parameters of the



environment in which experiments are carried out;

- constant modification and scalability of the components of the system as models of the objects themselves and the parameters of the environment of their research;

- the existence of complex and weakly formalized procedures for evaluating the results of modeling;

- lack of means for a formal description of the whole experiment.

Thus, in order to solve the problems of designing means of modeling hydroacoustic experiments with the aim of analyzing and evaluating the decisive ability of algorithms for generating and analyzing hydroacoustic signals in the further implementation of the procedures for the classification and identification of marine noise reduction objects, a separate adaptive modeling system and specialized technologies for carrying out such studies,

This article is devoted to highlighting these problems.

### **Main part**

In this work it is proposed to build a specialized programmatic technological complex of hydroacoustic processes simulation using scenarios and mathematical modeling techniques and geoinformation environment technologies and presents some results of its development. The offered approaches will allow to considerably extend a circle of problems of research of hydroacoustic processes

and systems and solve problems connected with a variety of methods of fixation of signals, analysis of their spectral-energy characteristics.

In addition, the use of the scenario approach in conducting research will ensure the construction of a reliable system for fixing the parameters of experiments and the possibility of forming rules for evaluating the results of simulation.

The general objective of constructing a simulation complex is to form estimates of various computer models of hydroacoustic processes from the point of view of their adequacy to the real physical processes of the propagation of acoustic signals, as well as the processing and improvement of their recognition algorithms and, on this basis, the classification and identification of radiating objects in observation areas.

The software complex is designed to solve the following simulation tasks:

1. computer simulation of processes of propagation of acoustic signals in a hydro medium;
2. simulation of the processes of allocation of signals received from various noise-emitting objects;
3. Simulation of the processes of classification and identification of objects - sources of radiation

In addition, the complex must solve the tasks of organizing the research process, which consists in

conducting a number of experiments, including tasks such as the recording of experiments, the organization of scenes, the formation of scenarios, the evaluation of tested in the system of models. In this direction the complex solves the main task of managing work on the basis of the decision of the following tasks:

1. the inclusion of scene-modeling procedures that allows to: document the scene properties (registration, modification, and deletion); the formation of using a typical geographic information system for filling the scene-parameters (coordinates, depth, temperature, pressure, etc.), noise- objects and hydroacoustic devices for fixing noise;

2. using script management mechanisms (a sequence of simulation steps) when performing an experiment that executes script documentation procedures, step-by-step or complex implementation of the individual simulation steps included in the script with fixing the evaluations of their execution;

3. maintaining a library of models with the ability to register, modify, delete and activate certain mathematical models;

4. Inclusion of model research mechanisms separately outside the scenario;

5. formation and maintenance of a database describing the experiments and system directories;

6. inclusion of tools for evaluating the results of an

experiment based on the use of procedures for the formation and use of knowledge base.

The design of the modeling complex was based on an ontological approach and included such otological entities

The structural and functional scheme of the modeling complex can be provided in the form of the following concepts:

$$\text{STRUK (MK)} = \langle C^{(\text{Marin\_param})}, R^{(\text{Hidro\_Sys})}, T^{(\text{Clas\_Ident})}, G^{(\text{Anal\_Obj})}, S^{(\text{Sevr})}, P^{(\text{Rizon})} \rangle$$

, where:

–**C**<sup>(Marin-param)</sup> – Concepts of setting parameters of the simulation environment;

–**R**<sup>(HidroSys)</sup> – concepts of description of objects of noise emission and hydroacoustic systems (GAS) of their registration and definition;

–**T**<sup>(Clas\_Ident)</sup> – library of algorithms for classification of objects and their identification;

–**G**<sup>(Anal\_Obj)</sup> – concepts for describing the patterns of signal generation;

–**B**<sup>(Data\_Znanyaj)</sup> – database and knowledge of simulation processes and their quality assessment;

–**S**<sup>(Serv)</sup> – management tools of the complex;

–**P**<sup>(Rizon)</sup> – Concepts of the rules of assessment and recommendations on conducted experiments.

Concepts are conventionally united in the following

components of the complex, the detailed view of which is shown in Figure 1.

- The Marine Environment Modeling component includes the concept  $C^{(Marin-param)}$  and performs the task of describing the experiment, forming a modeling scene, and a scenario for conducting the research with the input of the simulation environment parameters (sea noise, bottom parameters, coastline, water temperature, depth of immersion etc.) and parameters of marine objects (coordinates, directions and speed of movement, type, size);

- The component "Modeling of the hydroacoustic system" will combine the concepts of  $R^{(HidroSys)}$  describing the marine object and GAS and specifies the configuration of generating objects and fixing devices and their parameters (type, size, sensitivity

- Component "Modeling and analysis of the hydroacoustic signal of the object" includes the concepts  $G^{(Anal\_Obj)}$  describing the models of signal generation and their analysis tools and represents the tools and methods of signal analysis (FFT, digital filtering, spectral, frequency, correlation analysis and other );

- Component "Recognition and Identification of Marine Objects" is compiled by the concept  $T^{(ClasI\_Ident)}$  and contains a set of tools for detecting objects, classifying and defining parameters of motion of objects, including

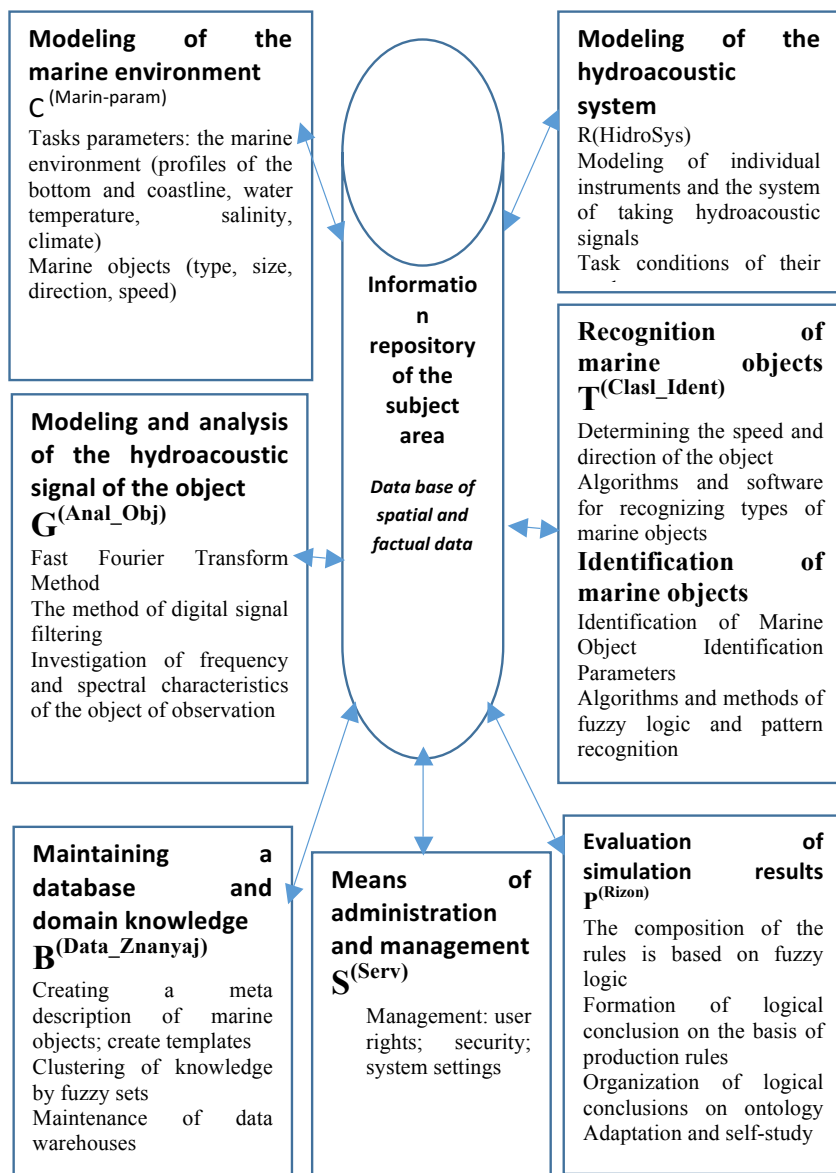
methods of fuzzy logic;

- Component «Knowledge management of the domain» includes the concept  $B^{(Data\_Znanyaj)}$  and performs the functions of introducing accumulated experience, creating templates, ontologies, meta-records of marine objects, clustering knowledge;

- The "Evaluation of Modeling Results" component includes the concepts of  $P^{(Rizon)}$  - the algorithms of evaluation and development of recommendations and is designed to organize the logical deduction of recommendations based on the accumulated knowledge, including means of composition rules of production rules, self-study and adaptation;

- Information repository is a link that unites the structural components of the simulation system and contains both direct data for the description of the subject area, as well as links to Web services for processing, analysis, identification and classification of data subject area;

- Administration and management tools meet the  $S^{(Serv)}$  concept and provide customization of services and applications, user rights management to information resources, security management and performance modeling systems.



### Modeling technique

The whole complex of researches represents a certain system of conducting model hydroacoustic experiments using elements of the scenario approach.

The essence of the scenario approach is to create scenarios for analyzing various simulation processes, that is, some formalized fixation of the sequence of application of modeling tools and procedures for evaluating the quality of selected models with the task parameters that determine the rules for their use. The system should include means for fixing scenarios, organizing their implementation, and also form a step-by-step assessment of both the resolution of methods to perform their tasks and the evaluation of the results obtained with their help.

The general scheme of experiments using the scenario approach is shown in Figure 2.

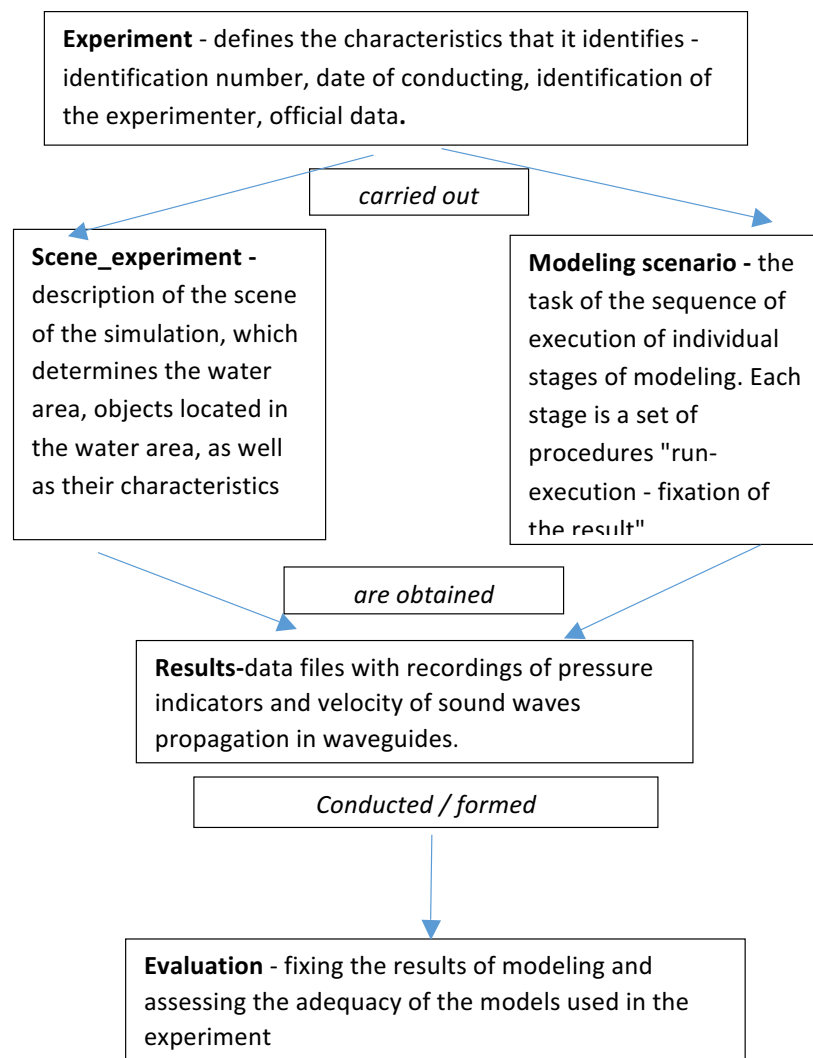


Fig. 2 General scheme of experiments using the scenario approach

Research technology developed by means of modeling complex

View of the working screen of the simulation system with the dedicated elements of the definition of the elements: a scene, a script, and a description of the entire experiment (Fig. 3).

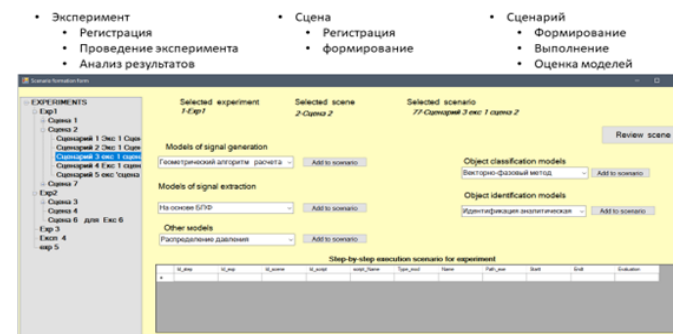


Fig. 3 Working screen with elements of the scenario approach

Formation of the operational field

In the modeling complex formation of the operational field occurs by fixing the experiment to determine the scene of the experiment - part of the water area and the location of objects on it two species (Figure 4)

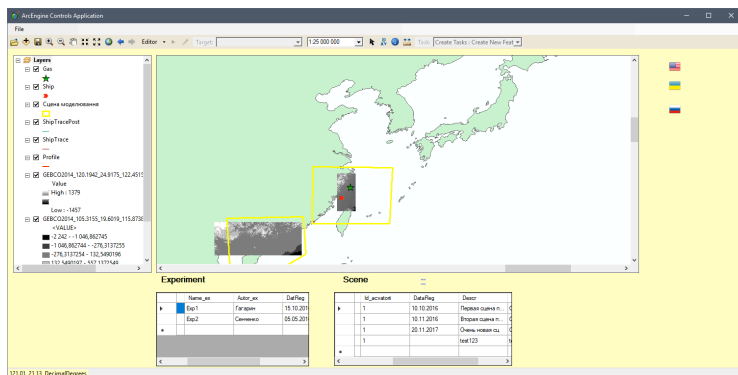


Fig.4 Task of the scene of the experiment

Determining the implementation of a scenario with analytical activity

The most complex, difficult formalizes part of the process, which involves the choice of analytical tools, the sequence of their application and task parameters that determine their use. The main point when constructing a script is to clearly record the purpose of using the script and the state of the system during its execution.

In the general case, it is possible to use different tools to achieve the goal, which is the main reason for using the scenario approach.

In the simulation set-up, the scenario involves choosing a specific set of acoustic signal processing methods (algorithms), as well as a set of methods (algorithms) for their classification and identification in order to recognize the object emitting the signal. The

presence of various algorithms for processing signals and objects determines the set of possible scenarios. In complex algorithms themselves provide the opportunity to task the necessary parameters

The form of script creation and organization of its implementation is presented in fig. 4

ID	step	ID_exp	ID_scene	Type	Name	Path	Start	End	Descr
500	1	1	1	5	Компьютеризован...	D:\GIS_HydroAc...			Метод вычисления...
5021	1	1	1	2	Вычисление...	D:\MODEL_CO...			Алгоритм...
5022	1	1	1	5	Компьютеризован...	D:\GIS_HydroAc...			Результат...

Fig. 4 Form for script creation

Formation of assessment of the steps of the script

Assessment of the execution can be formed "by hand" by the researcher, or by the corresponding software module in the case of a formalized evaluation algorithm and a program for its implementation.

The modeling complex provides both possibilities (Fig. 4)

Fig.5 Fixing the results of individual stages of the experiment

Formation of the final evaluation of the experiment

In the modeling complex it is formed in the form of a protocol of assessments in steps with the formation of a general conclusion (Fig. 6)

Id_step	Id_exp	Id_scene	Type_mod	Name	Path_exe	Start	Endt	Descr
5020	1	1	5	Комбинирован...	D:\GIS_HydroAc...			Метод выдает а...
5021	1	1	2	Выделение_сиг...	D:\MODEL_CO...			Алгоритм моде...
5022	1	1	5	Комбинирован...	D:\GIS_HydroAc...			Результат треб...

Fig. 6 General conclusion on the experiment

## Conclusions

The article describes the author's proposed approach to the creation of modeling systems, which is based on the integration of service-oriented methods of information processing, including methods of intellectual processing of knowledge and its step-by-step implementation, which allows to organize an efficient intellectual environment for the conduct of simulation.

The approach is applied to the creation of a complex for the modeling of hydroacoustic processes, while providing for the adaptation of methods and algorithms for modeling to find efficient solutions that are produced

during the simulation process, including in real time.

During the development of the complex, some approaches to solving the above problems of modeling of hydroacoustic processes are proposed, namely:

- the problem of the complexity of identifying the components of the system being designed and establishing an adequate interdependence between its elements to solve ontological approaches, namely: to define the basic concepts for the domain, to build sets of individuals with their properties and to identify their links with the mechanisms for constructing queries. At the same time, the means of automatic information retrieval based on the rules of compiled ontology can more effectively detect hidden interdependencies and non-obvious connections.

- the problem of the conformity of mathematical models of hydroacoustic processes to the parameters of the environment in which the experiments are carried out through the provision of technological means for the formation and conservation of a plurality of different models with clear and formalized procedures for fixing and evaluating the results of experiments.

- the problems of the constant updating of the information components of the system, in particular, the models of the objects on which the experiments are carried out, as well as the parameters of the environment in which the model experiments are carried out are solved by using:

- set of facilities for the creation of these models (experiments, water areas, objects, GAS) ;

- special technological procedures for models actualization.

- the problem of the complexity of the procedures for evaluating the results of modeling (weak formalization or absence of appropriate algorithms in general) to be solved by introducing procedures for gradually transforming the textual description by the experimenter of the results of research on the resolution of the models used to constructing, in the future, formal production rules based on predicates for correlation of the results with the formally described the goals of the experiment.

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## **Generation of tests of various complexity levels in e-learning system based on educational text formalization model**

### ***Introduction***

Modern learning tools are widely based on the use of Internet space, stimulating further development of distance learning systems components. One of the key components of distance learning is monitoring and verification of knowledge. The most common way of testing knowledge in educational systems is testing. A significant amount of research in the field of testing knowledge focuses on quality and validity of tests [1]. However modern speed of updating professional branches determines the significance of automated test composition and test tasks, which will accelerate the preparation of training courses and environments in modern areas of study. The method of automated composition of testing tools on the basis of didactic text formalization model [2,3] was proposed. The method represents formalization of educational materials on the basis of conceptual-theses model with further application of algorithms for generation and test tasks testing. Further studies of CTM application for knowledge control, its modifications and close alternatives were

mainly focused on improving the quality of generated tasks [4—6]. This article [5] describes the method of generating test tasks based on decomposition of statements from the educational text using the system of semantic classes. It offers tools for managing complexity of tasks. Therefore the presented method greatly complicates the previous formalization of didactic text in comparison with the basic model of CTM and requires a large number of homogeneous language constructs in the educational text. The matter of differentiation of tests complexity in the CTM requires additional research.

In accordance with revised taxonomy of Bloom [7], the results of educational activities are differentiated by an ordered scale of cognitive purposes. Learning objectives are arranged in the following ways: to know, understand, apply, analyze, evaluate and create [7]. There's actual functional possibility of a testing system that will determine the level of the subject assimilation in accordance with taxonomy of pedagogical purposes. The full accomplishment of this task by means of testing, especially on the basis of automatically generated tasks, is difficult to achieve, while progress in this direction is necessary and relevant. Consequently, the generation of test tasks on CTM basis needs to be revised to implement the differentiation of tests complexity, which will allow assessing the level of knowledge in accordance with

cognitive goals.

### ***Goal description***

The purpose of this work is to improve the methods of automated construction of tests of various complexity on the basis of the conceptual-theses model. The task is to ensure that the types of test tasks correspond to different cognitive levels of the Bloom scale [7], to formulate test models that differentiate according to the level of complexity, and to carry out an empirical review of the proposed solutions.

### ***The conceptual-theses model of the formalization of didactic text***

CT-elements include concepts and theses [2]. The concept describes the meaning of the subject matter. The set of concepts:  $C = \{c_1, c_2, \dots, c_n\}$ . Abstracts are a natural expression of knowledge in the subject area in the form of fragments of educational text and media content. The thesis is an info or statement about the concept. A set of abstracts:  $T = \{t_1, t_2, \dots, t_n\}$ . Each thesis relates to one concept, and this connection is given by the relation:  $CT: T \rightarrow C$ . In return, each concept can have an arbitrary number of abstracts, which is described by the relation:  $TC: C \rightarrow 2T$ .

### ***Templates and types of test tasks***

To automate the creation of test tasks, we will use the templates which we will describe with the set:  $TTempI = \{tt_1, tt_2, \dots, tt_n\}$ . In previously proposed implementation of

testing on the basis of CTM the templates were divided into two main types: 1) the basis of the question — a thesis, based on the variety of answers — the concept; 2) the basis of the question — a concept, variants of answers are theses [2]. Templates [2] describe the essence of the questioning element (concept or thesis), admissible classes for the questioning element and the response elements. It is proposed to diversify the use of a similar template structure to generate different types of test tasks.

All test tasks belonged to the type that involves choosing one correct answer, which is not enough to cover the Bloom scale [7]. The set of tasks is denoted as follows:  $Task = \{task_i\}$ , and the set of their types:  $TType = \{CO, CS, WA, MI, GF, RW\}$ . We will provide a description for each type of task:

- *CO* — multiple-choice task demanding only one correct answer;
- *CS* — multi-choice task demanding several correct answers;
- *WA* — is an open-type task in which you need to insert the concept-answer to the thesis definition that is specified in the question;
- *MI* — task for matching sets of corresponding CT-elements;
- *GF* — is an open type task where it is necessary to fill the gap in the statement;

- *RW* — is a multi-choice task with the requirement to specify incorrect answer variants.

Types of tasks available for generating on the basis of this template, we will describe the following way:  
 $TTemplTypes: TTempl \rightarrow 2^{TType}$

Thus, the attributes of the template  $tti$ :

- $TQEntity(tti)$  — the CT-element that underlies the issue;
- $TQStr(tti)$  — template text that corresponds to the query of the test task;
- $TQClasses(tti)$  — allowable classes of CT-elements, which underlie the question that can be used for the template;
- $TQNotClasses(tti)$  — inappropriate CT-element classes underlying the issue;
- $TAClasses(tti)$  — allowable classes of the CT-element, which are the basis of the answer;
- $TANotClasses(tti)$  — the classes of the CT-element that underlies the response that can not be used for the template;
- $TTemplTypes(tti)$  — is a new field in the template structure, which specifies the set of tasks types that can be generated on the basis of this template.

In each template, the *TQStr* field also stores the marker to fill the CT-element. If there is no such marker, then the CT-element is inserted at the end of the line

$TQStr(tt_i)$ . Note that for queries  $\{MI, GF, RW\}$ , the query line will not contain the CT-element.

### **Generation of a test task with differentiation in terms of complexity**

We will describe different cognitive goals according to the modified Bloom scale [7] by the set  $KT = \{Remember, Understand, Apply, Analyze, Evaluate, Create\}$ . The level of complexity of the tests will be divided into low, medium and complex, we will denote them by the following set:  $Complexity = \{Low, Middle, Hard\}$ . This type of division will allow the task to be divided in terms of complexity, and then to conduct a differentiated testing. We can indicate the connection between the complexity of the test depending on the type of knowledge per the Bloom scale [7]:  $ComplexityKT: Complexity \rightarrow 2^{KT}$ . This dependence can be described as a system as well:

$$ComplexityKT(cl) = \begin{cases} \{Remember, Understand\}, cl = Low \\ \{Remember, Understand, Apply\}, cl = Middle \\ \{Remember, Understand, Apply, Analyze\}, cl = Hard \end{cases}$$

Types of tasks that are generated, depending on the complexity of the test are described as follows:

$$TypesByComplexity(cl) = \begin{cases} \{CO, CS, WA\}, cl = Low \\ \{CO, CS, WA, MI\}, cl = Middle \\ \{CO, CS, WA, MI, GF, RW\}, cl = Hard \end{cases}$$

Modified algorithm to create a test task contains the

following steps:

1. **Select a control area of the content.** A selected set of content elements from a set of content  $V$  form a control area of the test  $test$ :  $SuffControlA \subseteq V$ . Here we can also perform check of the data sufficiency to create the test:

$$(|\{t: t \in T \wedge VT(t) \in SuffControlA\}| \geq rta) \rightarrow content\_valid(SuffControlA)$$

where  $rta$ —minimum required number of thesis to ensure the generation of test tasks, is established heuristic.

2. **Select complexity of the test**  $cl_{test} \in Complexity$ .

3. **Generation of the required number of test tasks according to the complexity of the test.** From the set of admissible types of tasks for this complexity level, we form the required number of test tasks in a loop.

#### **Generation of test task.**

3.1. **Choosing one of the acceptable types of test tasks**  $tType$ :

$$tType \in TypesByComplexity(cl_{test}).$$

3.2. **Select a template that is suitable for generating a type task**  $tType$ . Looking for a template  $tt_i$ , satisfying the condition  $tType \in TTemplTypes(tt_i)$ .

3.3. **Find valid CT-elements for a given**  $tt_i$  **template located in the control area**  $SuffControlA$ . The set of concepts and theses of the  $SuffControlA$  area will be

defined as follows:

$$SCControlA = \{c: VC(c) \cap SuffControlA \neq \emptyset\},$$

$$STControlA = \{t: VT(t) \in SuffControlA\}.$$

For the set of tasks of all types, except for *MI*, the operator of permissible questionable CT-elements choice for a given template  $tt_i$  for the case when  $TQEntity(tt_i) = Thesis$ , looks like this:

looks like this:

$$STQEntities(tt_i) = \left\{ \left\{ \begin{array}{l} t : t \in T \wedge t \in STControlA \wedge \\ \left( \begin{array}{l} TClass(t) \in TQClasses(tt_i) \\ \vee TQClasses(tt_i) = 0 \end{array} \right) \wedge \\ TClass(t) \notin TQNotClasses(tt_i) \end{array} \right\}, TQEntity(tt_i) = Thesis \right. \\ \left. \left\{ \begin{array}{l} c : c \in C \wedge c \in SCControlA \wedge \\ \left( \begin{array}{l} CClass(c) \in TQClasses(tt_i) \\ \vee TQClasses(tt_i) = 0 \end{array} \right) \wedge \\ CClass(c) \notin TQNotClasses(tt_i) \end{array} \right\}, TQEntity(tt_i) = Concept \right\}$$

If the set of  $STQEntities(tt_i)$  is nonempty, we select a random element from the  $STQEntities(tt_i)$  set, denote its  $STQEntity$ .

For a type of task in comparison *MI*  $TQEntity(tt_i)$  can only be a concept, and within a single task it is necessary to get a set of different concepts for which the corresponding set of theses for matching will be chosen similarly to the next steps of the algorithm.

If the set of  $STQEntities(tt_i)$  was empty, then the  $tti$

template was either inadmissible or in the educational fragment relating to the *SuffControlA* set, the CT- elements did not fit the selection criteria. In this case, the transition to p.3.2 takes place. If you can not find any template for the task  $tType$ , the transition to p.3.1. takes place to select another type of task.

**3.4. Search for the right answer variants.** The CT-essence for the answer variants is conventionally denoted as *Entity*:

$$Entity = (ent: ent \in (CTEntity \setminus TQEntity(tt_i)))$$

The set of corresponding CT-elements:

$$E = \begin{cases} C, Entity = Concept \\ T, Entity = Thesis \end{cases}$$

Conditionally we denote the corresponding sets of classes of CT-elements as *EClass*.

Correctness of variants is specified by their relation to the questionable CT- element. The predicate  $correcponds(e,a)$  formalizes the statement that the argument-thesis really relates to the argument-concept:

$$\left( \begin{array}{l} (e \in C \wedge a \in T \wedge CT(a) = e) \\ (e \in T \wedge a \in C \wedge CT(e) = a) \end{array} \right) \rightarrow correcponds(e,a).$$

An operator of choice the set of possible correct answer variants for all types of tasks except  $tType=GF$ :

$$RTAEntities(tt_i) = \left\{ e: e \in E \wedge corresponds(e, STQEntity) \wedge \left( EClass(e) \in TAClasses(tt_i) \vee TAClasses(tt_i) = \emptyset \right) \wedge EClass(e) \notin TANotClasses(tt_i) \right\}$$

For the type of task to fill the gap in the statement, where  $tType = GF, TQEntity(tt_i) = Concept$ , generalized search operator for admissible theses-statements:

$$RTAEntities(tt_i) = \{ e: e \in E \wedge corresponds(e, STQEntity) \wedge Entity = Thesis \wedge isSubstring(STQEntity, e) \wedge (EClass(e) \in TAClasses(tt_i) \vee TAClasses(tt_i) = \emptyset) \wedge EClass(e) \notin TANotClasses(tt_i) \}.$$

**3.5. Search for distractors.** Distractors are searched for types of tasks *CO*, *CS*, *RW*. The search operator looks like that:

$$WTAEntities(tt_i) = \{ e: e \in E \wedge (EClass(e) \in TAClasses(tt_i) \vee TAClasses(tt_i) = \emptyset) \wedge EClass(e) \notin TANotClasses(tt_i) \wedge \neg corresponds(e, STQEntity) \}$$

The test task is constructed. Transition to the construction of the next test task (p.3). If the required number of test tasks is constructed, the test construction is complete.

### Testing results

Testing was performed for 29 second-year students in engineering software disciplines. The subjects covered by testing were mostly related to subjects learned by this group during the previous year of study, some topics were related to the current semester. The test results were evaluated as a percentage of the correct and false responses. When passing a test based on *Low* complexity model, the results of testing in the majority corresponded to a score of 90%. At the *Middle* level – 75%, while on *Hard* – 65%. The *Low* level checks knowledge type of *Understand and Remember*. At this test level difficult tasks were rarely encountered, mostly they needed skills of memorization and orientation in the control area. The *Middle* level, due to the task of *MI* comparing, verifies knowledge type of *Apply*. It took more time to comprehend the issue, as well as skills were necessary for knowledge application. This can be explained that concepts from various training fragments of a controlled set of content were used, that required a student to have a deep understanding of the subject area. The *Hard* level because of *GF* tasks and, in particular, *RW* ones tests Knowledge type *Analyze*. The user needed to understand the principle necessary to remove the extra answers, that required the ability to analyze the statements and possess analytical skills in the subject area. It should be noted that the

students who showed the highest level of semester education, in general, had a higher percentage in *Hard* level testing. So, we can confirm the success of differentiated testing on the basis of the proposed model and the need for its further research to fully cover the modified Bloom scale [7].

### **Conclusion**

In this paper the modification of the method of automated test construction based on the conceptual-theses model was proposed, that provided differentiation of control per the level of complexity with verification of cognitive goals achievement in accordance with the modified Bloom scale [7]. New types of tasks were introduced, the structure of the test task templates was modified and a formal model of the test generation based on the complexity level was presented. A software implementation of the proposed formal apparatus was carried out and initial test was performed, which confirmed the adequacy and the perspective of the implemented modifications. Among the areas of further research there is the detailed formalization of the task solving of data sufficiency for the generation of the test, the improvement of the quality of test tasks of different types and the construction of new task templates. Particular attention is required to provide additional means for checking the achievement of cognitive goals in accordance with the

entire Bloom scale [7].

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## **Searching an integrative model of respiratory and cardiovascular control in sleep-disordered breathing**

### **1. Introduction**

Sleep disordered breathing (SDB) describes a group of disorders characterized by abnormal respiratory patterns (e.g. the presence of apneas or hypopneas); or insufficient ventilation during sleep. Sleep disordered breathing disrupts the patient's sleep pattern, night after night, which not only makes the patient tired and exhausted the next day, but may also put excessive strain on the patient's nervous system and major organs.

There is accumulating evidence that chronic exposure to these repetitive swings in autonomic outflow and intermittent hypoxia can lead ultimately to the development of systemic hypertension, heart failure, myocardial infarction and stroke [1].

Present knowledge about the mechanisms that link sleepdisordered breathing to cardiovascular disease remains incomplete. The multifactorial dynamics and closed-loop aspects of the physiological events that underlie respiratory and state instability during sleep apnoea make it difficult to distinguish cause from effect

under such conditions. By employing a mathematical modeling approach, it is possible to extricate the influences of the various interacting physiological mechanisms and thus attain a more lucid understanding of how they contribute to the complex dynamics that characterize cardiorespiratory control in the different forms of sleep-disordered breathing. This information can potentially be used to facilitate the identification of particular physiological defects, and the prediction or evaluation of specific outcomes for a given therapy

One of the ways to treat various types of respiratory failure is hypoxia therapy [2], during which one of the major problems is the choice of optimal oxygen regime. Therefore, the development of software for assessing the effectiveness of the influence of oxygen regimes on the state of the respiratory and cardiovascular systems in sleep-disordered breathing in order to support the process of selection of solutions is relevant.

### **2. Formulation of problem**

The main goal of this paper is to solve the problem of searching an integrative model of respiratory and cardiovascular control in sleep-disordered breathing for the development of software for assessing the effectiveness of the influence of oxygen regimes on the state of the respiratory and cardiovascular systems in sleep-disordered breathing. An integrative model must incorporate the



essential features from existing submodels of cardiovascular, respiratory and sleep regulation and allow us to examine the interactions among these subsystems.

### **3. Respiratory subsystem**

The respiratory subsystem allows simulation of both mechanical and gas exchange characteristics of breathing. The compartment representing respiratory mechanics receives input (total respiratory drive) from the central neural control subsystem and generates the airflow based on the curvilinear relationship between the respiratory muscles and the lung volume according to the Younes model [3]. Pleural and alveolar pressures are obtained by solving the lumped-parameter equations that take into consideration the viscous and elastic properties of the chest wall and lung tissues [4]. Compared to other published models, the advantages of model [5] are that: (1) it is able to generate pleural pressure by itself such that the model does not need any external input, and (2) it is able to run by itself in closed-loop mode.

### **4. Cardiovascular subsystem**

The cardiovascular subsystem is capable of simulating the pulsatile nature of the heart and blood flow through the pulmonary and systemic circulations. Included in the model [5] are descriptions of atria-ventricular mechanics, hemodynamics of the systemic and pulmonary circulations, SA node, change of total peripheral resistance and

baroreflex. The models of the pulsatile heart, pulmonary circulation and systemic circulation, splanchnic, extrasplanchnic, muscular, coronary and cerebral peripheral circulations are based largely on the work of Ursino but have been modified in terms of different sleep–wake states [6].

### **5. Sleep mechanism**

The sleep mechanism is a two process model from the Borbely group [7]. The processes underlying sleep regulation consist of 1) a homeostatic process responsible for the rise of sleep propensity during waking and its dissipation during sleep; 2) a circadian process that is basically independent of prior sleep and waking, and is responsible for the alternation of periods with high and low sleep propensity; and 3) an ultradian process occurring within the sleep episode and representing the alternation of the two basic sleep states non REM sleep and REM sleep. But none have addressed the integrated cardiovascular and respiratory responses that accompany normal or pathological sleep.

### **6. Conclusion**

While many physiological control models exist in the literature, none thus far has focused on characterizing the interactions among the respiratory, cardiovascular and sleep–wake regulation systems that occur in sleep-disordered breathing. The model [5] introduced in this

paper integrates the autonomic control of the cardiovascular system, chemoreflex and state-related control of respiration, including respiratory and upper airway mechanics, along with a model of circadian and sleep–wake regulation.

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### **Blockchain as a digital economy promotion tool in energy industry**

The development of IT technologies offers the world new tools to optimize business processes daily. One of the latest such tools is blockchain technology. The term "blockchain" became widely known due to the popularity of Bitcoin (Bitcoin) - the most famous cryptocurrency in the world. Satoshi Nakamoto is considered to be the author of the blockchain technology, who in 2008 spoke about the basic principles of building a decentralized payment system in which transactions between participants are carried out without intermediary agents [1]. According to the author, the proposed system is not based on trust. It is decentralized, open and cryptographically protected.

The purpose of this article is to systematize information about the blockchain technology, analyze its advantages and disadvantages and predict the results of its introduction into the energy industry since the blockchain can completely change the structure of the energy market, reduce the cost of services and remove intermediaries from the power supply market.

The technology has become widely known in the context of cryptocurrency, but experts claim that the blockchain can potentially be useful in any environment

where there is no trust between the participants.

The main principle of blockchain technology is the constant calculation of the encrypted hash function [2, p.448]. Hashing is conversion to an n-bit string (n is set) of an arbitrary input using a hash function, for example, into a 256-bit hash string. If the input message changes (at least one sign), the result obtained by using the hash function changes completely (this ensures the stability of the cryptocypher).

An example of a hash function is division of an input by a multinomial modulus 2:

$$h(n,m)=n \bmod m,$$

where  $n$  is the input (“key”),  $m$  is the number of inputs (“hashes”),  $\bmod$  is an integer division index.

You can represent the hash function as a set of multinomial indexes. To do this, divide the input data modulus by 2,  $m$  - degree 2, binary keys

$$K = K_{n-1} \ K_{n-2} \dots K_0$$

are represent by multinomials, and the hash code - by the values of the indexes.

$$a_{m-1}, a_{m-2}, \dots, a_0$$

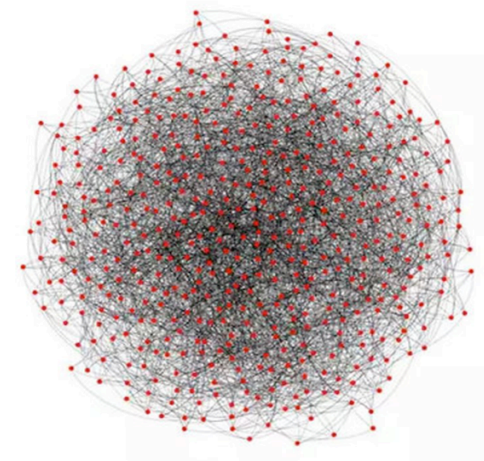
A multinomial obtained as the remainder of division of multinomial  $K(x)$  by another, set multinomial of degree  $m$ :

$$K(x) \bmod P(x) = a_{m-1}x^{m-1} + a_{m-2}x^{m-2} + \dots + a_1x^1 + a_0,$$

$$h(x) = a_{m-1}, a_{m-2}, \dots, a_1 a_0.$$

The mining of bitcoins is based on the SHA-256 cryptalgorithm (calculation of a cryptographic using a hash function, with 256-bit strings values).

Visual representation of a decentralized blockchain server [2].

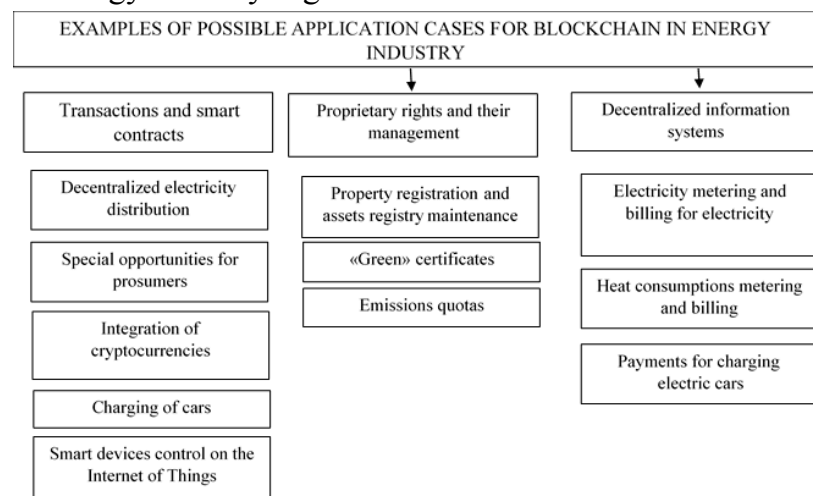


The technology is impossible to crack. The data is encrypted with a cryptographic algorithm and is entered without intermediary agents. The whole chain is broken into constituents using computers all around the world. A central server that could be broken or hacked to harm the system does not exist. The new technology allows the seller and the buyer of electricity, who are connected to the blockchain network via the Internet, to interact with each

other, conducting payments. Traditional intermediaries, such as banks and payment systems, are unnecessary in this model, since all the other constituents of the network register every transaction and can confirm its details.

The growth of distributed generation and other trends present a new challenge for the power industry: energy market participants need to organize an intelligent transaction system that can provide services to a rapidly growing number of players with whom the centralized commercial operator is unable to cope effectively. Due to all of this, the concerned power engineers turned their attention to the blockchain technology used for financial transactions made in cryptocurrencies, such as Bitcoin.

Examples of possible application cases for blockchain in energy industry Fig. 1.



The blockchain technology is capable of providing the basis for a decentralized power supply system. In the future, we are waiting for the simplification of the existing multi-level system which consists of electricity generating facilities, transmission network operators, power grid operators and electricity providers, as well as electricity consumers, and owners of renewable energy sources (RES). If conditions are created under which producers and consumers interact directly, performing transactions to pay for energy consumed within the local grid directly on the Internet, electricity will become cheap.

What is required for blockchain based energy industry is a combination of innovative ideas and a new technological system.

Blockchain technology is best used in the plants that generate "green", that is environmentally friendly and inexhaustible energy of the sun, wind, moon, water, geysers, and so on. To adapt RES to everyday life, automation of the system with the help of special equipment of a new type is required.

Necessary components of the blockchain-based power system:

Smart home is a high-tech system that allows you to combine all communications into centralized nod and set it under the control of artificial intelligence, programmable and customizable for all the needs and wishes of the owner.

Smart meter - electricity metering device with remote data transmission function. All cost information is automatically registered by the system itself, then the information is transmitted to the main server. After the ubiquitous introduction of the smart meter system, the blockchain will become the tool for processing meter readings and providing information for electricity bills. The main aspect is the enhanced control options that consumers will receive in regards to their electricity supply contracts, as well as data on electricity consumption.

Sensor technology - devices that respond to touch. In the blockchain-power system it is necessary to perform all operations for regulating processes.

Applications for smartphones — programs that will control energy transfer. Consumers need automated software solutions for easy management of the entire system.

Considering all of the stated above, it is possible to determine such prospects of the blockchain technology in Ukraine.

1. The implementation of the blockchain into the power industry will take quite a considerable amount of time.

2. Considering the lack of standards, working platforms, scalable distributed coordinated systems and interaction mechanisms the introduction of technology at

this stage is very risky.

3. Blockchain is not just a new database. The concept of the blockchain does not have the facility to create, read, update and delete information.

4. There are no ready premade viable solutions. Today there are a lot of pilot designs and interesting startups, but unfortunately there are no ready-made software products that could be launched into real business processes.

5. The state should act as an initiator and customer in the implementation of a distributed registry technology and receive feedback from citizens, participate in “smart” contracts.

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The technology has become widely known in the context of cryptocurrency, but experts claim that the blockchain can potentially be useful in any environment where there is no trust between the participants.

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## **Virtual exploration of solar systems using a Mobile Augmented Reality app – a problem- based learning approach**

### **Abstract**

This paper presents a mobile augmented reality application targeted to promote learning about the Universe in general, and Solar System proportions in particular. The PlanetarySystemGO is an evolution of a previous version initially designed to promote STEM learning in the framework of our Solar System. The new version provides the experience of interacting with any planetary system of the Universe. To achieve this goal, it was necessary to redesign the architecture of the system in order to accommodate the new functionalities. With this new architecture, it is possible for the user to have different experiences every time he plays the game. Also, in this new version, teachers may choose the planetary system they intend to present to their students. Furthermore, they can introduce information about the star and planets, and develop a set of multiple-choice questions to assess student

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learning about the subject. Besides playing the game in a ludic way, with these new functionalities, PlanetarySystemGO can be performed in formal learning environments and can be adapted by the teacher to any level of school syllabus. The implementation of this system is furthermore the corollary of the work developed by three students of the Computer Engineering BSc degree of the Polytechnic Institute of Tomar, as a final project challenge. Despite the demands of the project, the students succeeded in the creation of a Mobile Augmented Reality game. In the course of the application development, the game designers had the opportunity to perform several experiences with primary school students in order to test their feedback about the game and improve it after each experience in the field.

Keywords – mobile games; gamification; augmented reality; engineering education, problem-based learning.

### **1. Introduction**

In this work we summarize the features of a Mobile Augmented Reality (MAR) application (app) targeted at promoting learning about the Universe. The PlanetarySystemGO is an evolution of a previous version initially designed to promote STEM learning in the framework of our Solar System (Costa, Patrício, Carrança,

& Farropo, 2018; Huang, Po-Sheng, Liu, & Tzung-Shi, 2011; Stoffova, 2016). The previous version consisted in a location-based MAR game, in which the players starting from a given coordinate (the Sun), and guided by the *app*, find the orbits and the planets of our Solar System. After finding the planet a multiple-choice question needs to be answered. At each stage of the game (finding the orbit, “hunting” the planet and answering the question) the players gain points (Figure 1). As can be seen in the figure 1, the game is an outdoor version, where the player holding a smartphone, with the MAR, application walks in order to find orbits and planets.

The PlanetarySystemGO version includes the possibility of providing the experience of interacting with any planetary system of the Universe. To achieve this goal, it was necessary to redesign the architecture of the system in order to accommodate the new functionalities. In this regard, the development of a web based back-end system was crucial to support the introduction of new planetary systems in the application. The planetary systems are introduced into the system through a back-office and are made available to the application in the form of JavaScript Object Notation (JSON) files.

With this new architecture it is possible to provide the user with different experiences every time he plays the game. Also, in this new version, teachers may choose the

planetary system they intend to present to their students. Furthermore, they can introduce information about universe bodies, such as stars or planets, and develop a set of multiple-choice questions to assess student learning about the subject. Finally, after playing the game, the data collected by the application is sent to the information system, that processes it and makes it available to teachers.

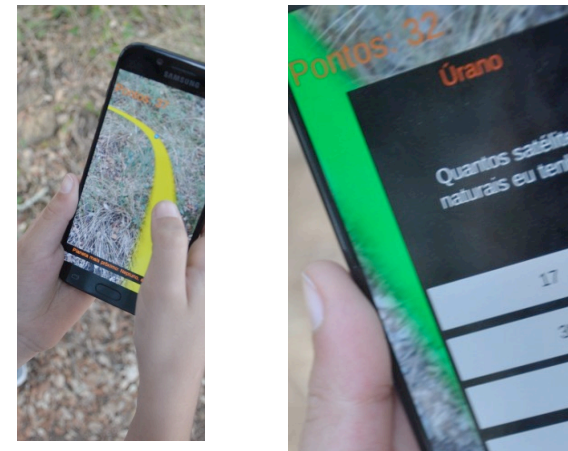


Figure 1: Finding Uranus and respective question: How many natural satellites do I have? This player has 32 points.

In this paper, we begin by introducing the background and context of this study that is framed in a broader pedagogical interdisciplinary intervention project, which is based on a constructivist approach of learning (<http://www.academiacap.ipt.pt/>). Next, we present the background and literature review concerning mobile augmented reality technologies. After, we describe the

architecture of the PlanetarySystemGO, and finally, future work and conclusions are presented.

## 2. Background and context

In this section, we present the broader pedagogical intervention project and, in particular, the PlanetarySystemGO game.

The Academy of Science, Arts and Heritage (AcademySAH) is a pedagogical intervention project that focuses on establishing a constructivist approach of knowledge of the students, with higher education teachers' supervision, in a laboratory environment (Costa & Loureiro, Learning by experimentation: Children's laboratory experiences at the Polytechnic Institute of Tomar, 2016). This project was proposed to the Instituto Politécnico de Tomar (IPT), in central Portugal, by the first author of this paper and approved by the IPT Directive Board at 2013.

This is an interdisciplinary project related to STEAMH (Science, Technology, Engineering, Arts, Mathematics and Heritage) subjects that is coordinated by the second author of this paper (Costa & Domingos, Promoting STEAMH at primary school: a collaborative interdisciplinary project: new trends and issues, 2018). The team members are higher education teachers in the areas of electrical and computer engineering, mathematics, biology, physics and chemistry, graphic arts, arqueology, amongst

others. Besides promoting hands-on activities during students' holidays at a Polytechnic Institute campus and at primary schools, the AcademySAH also welcomes projects of higher education students under the supervision of the team's project staff. In this context, several hands-on experiments and prototypes, including mobile games, are designed to promote STEAMH learning. Examples are "Sonicpaper" (Ferreira, Neves, Costa, & Teramo, 2017) and "SolarSystemGO" (Costa, Patrício, Carrança, & Farropo, 2018).

Concerning the SolarSystemGO game, in (Costa, Patrício, Carrança, & Farropo, 2018) the authors present a preliminary study about the implementation of this first version that was performed in an informal learning environment, during students' school holidays in the Polytechnic's campus. First conclusions are that this approach is very efficient to catch children's attention and promotes learning of interdisciplinary subject matters related to our Solar System. With this experience in the field, our next challenge was to upgrade the game in order to provide the users with more diversified experiences. Also, our aim is to perform the game in formal learning environments and finally in a teachers' professional development context.

Emergent technologies that are gaining more prominence in the last years are mobile technologies



(Huang, Po-Sheng, Liu, & Tzung-Shi, 2011). According to (Koutromanos, Sofos, & Avraamidou, 2015), mobile technologies such as mobile games can be a learning tool in a variety of formal and informal learning environments.

Augmented Reality (AR) has potential to combine the real world with virtual objects (Azuma, 1997; Hwang, Wu, Chen, & Tu, 2016), which gives a more realistic experience to the player. Furthermore, AR may improve students' academic performance and increase their engagement and motivation to learn in the context of formal education (Saltan & Arslan, 2017). A discussion on the impact of AR and video-games on the learning performance of students is beyond the scope of this work. The interested reader may find information on this in (Fotaris, Pellas, Kazanidis, & Smith, 2017; Wei, Weng, Liu, & Wang, 2015; WePC, 2018; Adkins, 2016; Muriel & Crawford, 2018).

Latest advances in mobile technologies permits to include AR, which allows a more interesting use of this tool (Huang, Hui, Peylo, & Chatzopoulos, 2013). In the case of the PlanetarySystemGO *app*, components such as camera, gyroscope, accelerometer and Global Position System (GPS) are required to perform the game. The real world is the environment, where the player is inserted, that is captured by the camera. The digital objects that are superposed on this environment are celestial bodies such as stars and planets. Although there are location-based MAR

apps in the market, such as the well-known PokeMonGO, to our knowledge our system features an innovative contribution, in the sense that it is the first to use the AR location-based paradigm for educational purposes.

A preliminary version, named SolarSystemGO, was implemented with children in formal and informal learning environments such as in a primary school and during their school holidays in a Polytechnic campus, in the framework of a project that intends to raise awareness of STEM to younger children (Costa & Loureiro, Learning by experimentation: Children's laboratory experiences at the Polytechnic Institute of Tomar, 2016). First conclusions about this version are that the game capture childrens' attention and promotes learning of subject matters (Costa, Patricio, Carrana, & Farropo, 2018; Costa, et al., 2018) in the framework of our Solar System.

The motivation to redesign the previous *app* comes from the existence of exoplanets and their planetary systems. Despite scientific speculations, only our Solar System was known until the first exoplanet was discovered to orbit the star 51 Pegasi by Didier Queloz at 1990. After this discover much more appeared thanks to the technology provided by the Kepler telescope and its successors, namely the Transiting Exoplanet Survey Satellite (TESS).

Another motivation rises from the acknowledgement of the fact that, while it has becoming increasingly easy to

develop generic mobile apps, even for the non-experts, using systems such as MIT's App Inventor (MIT, s.d.) or Google's Flutter (Google, s.d.), that allows the creation of apps that in their essence are cross-platform, i.e., run both on Android and iOS, the situation is quite different in what concerns with MAR apps. The evolution from SolarSystemGO to PlanetarySystemGO not only enables the integration of real or fictional solar systems, but, due to its features, can also be regarded as a contribution for the creation of a generic MAR apps development system, that aims at being as intuitive as possible.

### 3. The system architecture

PlanetarySystemGO is a Mobile Augmented Reality game that was born as an upgrade of a previous product, SolarSystemGO. The new system major contribution lies on the existence of a back-end system that allows the instructor to insert, or create, planetary systems at will – SolarSystemGO, entirely built in Unity3D (Unity3D, s.d.), was static in this regard, and the only planetary system that could be used was indeed our own Solar System. Furthermore, the set of questions that were made to the players was static and embedded in the app; for this reason, it was quite cumbersome for the instructor to make changes on these questions.

In order to overcome these difficulties and allow the instructor to interactively embed new planetary systems

and new questions, the underlying MAR architecture received the addition of a back-end that comprises three layers: web services, back-office and storage. We now present their implementation. Figure 2 shows how these services interact among each other and with the MAR layer.

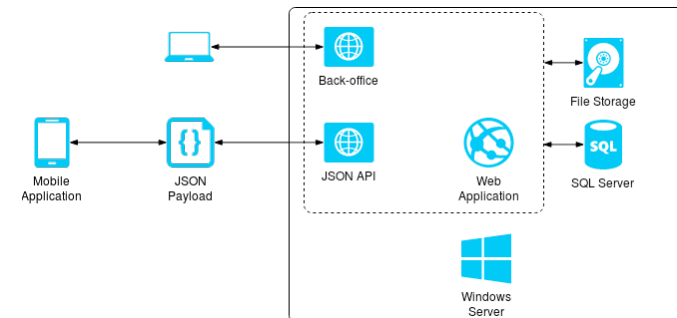


Figure 2: The back-end architecture of PlanetarySystemGO.

The Web Services implements a JSON (Sriparasa, 2013) API for interfacing with the MAR layer and was developed using .NET Web API 2 from Microsoft. Data is transmitted to and from the Mobile App via serialized and deserialized JSON payloads. Furthermore, in order to reduce memory requirements and CPU load during the encoding and decoding from binary format to Base-64 format (RFC 4648 - The Base16, Base32, and Base64 Data Encodings, 2006), images, such as the 3D representations of celestial bodies, are sent to the MAR app separately from the remaining data.

The back-office layer implements the views necessary

to manipulate the data used by the MAR app, such as *Solar Systems*, *Planets* and *Events*. The *Solar Systems* view has to do with the set of celestial bodies the players are interacting with during a given instance of the game, *Planets* correspond to each of the celestial bodies, and *Events* corresponds to the set of *Solar Systems* together with the questions and respective answers, as selected by the instructor. This particular layer is implemented using ASP .NET MVC 5, ASP .NET Identity, jQuery (Bibeault & Katz, 2008), Bootstrap Javascript plugin and Razor. Authentication – required to ensure trust in the interaction with the system – is done via Forms, while Cookies allow persistence of the authentication credentials. The subsequent Authorization is achieved using Role-Based access control (Sandhu, 1998).

The storage layer is comprised of a relational database (Elmasri & Navathe, 2010), written in SQL (Dubois, 1999), running, in this case, on SQL Server Express, interfaced with Entity Framework 6 Object-Relational Mapper (Ambler, 1997), to store information subject to query about the data used by the MAR app previously mentioned. Images and attachments related to entities managed by the system are stored in a separate file system, to prevent performance bottlenecks associated with the database-based file storage. Figure 3 shows the data model that supports the information system.

This system is deployed in a single Virtual Machine (VM) running Windows Server 2012 R2 Standard, using Internet Information Services to host the web services and back-office. Although set by default in the same VM, the storage layer can be moved to other VMs for scalability. Web services and back-office can also be distributed across several VMs, since these layers are fully stateless (the authorization cookie contains the claims required to decode the users' identity and is also encrypted and signed). The most remarkable feature of this new version was the possibility to show in AR any planetary system, real or imaginary, in a playful and educational way. This evolution led to the appearance of the information system of figure 2, which permits to support new planetary systems in the game.

The planets are stored by a set of characteristics that allows the app to make its virtual representation and its evolution in AR.



Figure 3:

Graphical representation of the planet.

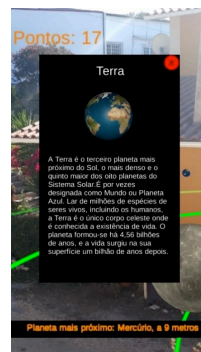


Figure 4:

Information about the Earth.

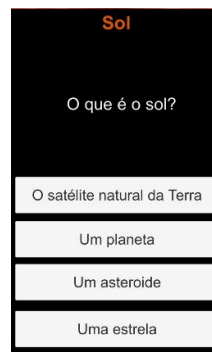


Figure 5: Multiple

choice question about the Sun.

In order to promote students learning about astronomy, information about the planet they found is provided. This information is supplied by the touch in the planet in the screen of the smartphone when the player sees it (Figures 3 and 4).

When the planet is "hunted" the student is presented with a multiple-choice question for the student to answer (Figure 5). To guaranty students' motivation and engagement to play the game, he receives points whenever he finds objects such as orbits, the planets and when they answer the questions. When the player finds the orbit, for the first time, he gets one point. Following the orbit, they find the planet and get another point. When the planet is captured, a menu with a question and four possible answers appear in the screen. When he selects the right answer in

the first option, he gets four points. If it is at the second choice, he receives three points, and so on until one point, which means he always receives points.

Whenever the orbit is found, it changes its colour from yellow to green (Figures 3 and 4). Also, when the planet is captured it receives a flag with a logo from the broader project (Costa & Loureiro, Learning by experimentation: Children's laboratory experiences at the Polytechnic Institute of Tomar, 2016). This way, when students perform the game, they know which orbits and planets were captured.

In the end of the game the data collected by the application is sent to the information system, that processes it and makes it available to teachers.

In order to design the mobile app, the option was to use the Unity engine, which uses C# programming language. To acquire the skills required to fulfil the proposed challenge, the three BSc students involved in the project had to conduct knowledge research from their curricular units, which they did as a team by assigning tasks among them. To learn Unity and C# programming language they used several tutorials available on the Internet.

During this process, some meetings were conducted with the supervisors to place questions and decide the next steps. After this stage, they were challenged to start

developing the app and to bring a version to test in the IPT campus. After several tests and upgrades, the first big challenge was to implement the game in the World Children's Day, that took place in June 1st 2018, at Mata dos Sete Montes (Tomar city). In this experience, five groups of children, accompanied by their teachers had the opportunity to play the game (Table 1). A second experience in the field happened a few weeks later in a full afternoon during the AcademySAH summer edition, with nineteen children at the Polytechnic campus. After these two important implementation tests in the field, where the students observed and reflected about the game performance, they had the opportunity to fix some problems that were diagnosed and to keep upgrading the game until it finally was ready to be implemented in a formal learning environment, which finally took place on October 2018, in a 4th grade primary school class, with twenty students, their teacher and a second teacher interested in assisting the experience (Table 1).

Table 1. Implementation tests of the game.

	Date	Location	Children	Teachers
World Children's Day	2018, 1 June	Mata dos Sete Montes	76	11
AcademySAH summer edition	2018, 26 June	Polytechnic campus	19	-
Visit to a Primary school class	2018, october	Santarem district	20	2

This last experience was also the last task required to

students (proposed in the initially project's tasks) before writing the final report, that was developed and presented in a public examination.

#### 4. Conclusions and future work

This paper presents a MAR app targeted to promote learning about the Universe. The PlanetarySystemGO app consists of a location-based MAR game, in which the players starting from a star, and guided by the app, find the orbits and the planets of a planetary system. At each stage of the game (finding the orbit, “hunting” the planet and answering the question) the players gain points (Figure 1).

The initial objectives of this project were achieved, namely the introduction of any planetary system in a dynamic way. The images (Figures 1 and 3) reflect tests of the app with primary school students. Last test was performed with 19 students of a 4th grade class in a primary school. Figure 6 shows the results of the answers to one of the questions included in the inquiries applied to the students after playing the game.

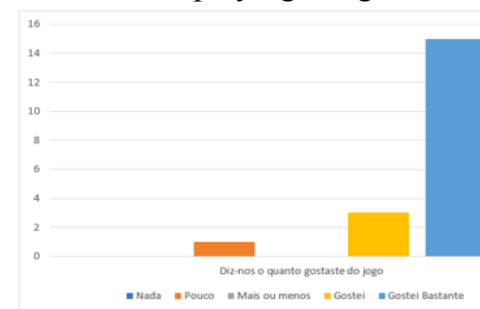


Figure 6: Results of the answers of the students to the question: How much did you like the game?

Only one student answered “little” (orange color), three students “liked it” (yellow color) and fifteen students “I really liked it” (light blue color). Also, the teacher answered a questionnaire, where she referred that the game provided the students with a real experience that improved their learning about the Solar System.

Regardless of the good results about the implementation of the game, in the course of this work several technological difficulties related to its performance were diagnosed. For example, GPS instability and incorrect gyroscope readings can seriously limit the user experience. These aspects have been identified in the literature as the major obstacles for a more widespread mobile AR adoption (PerkinsCoie, 2018). This will be one of the focus of our future work.

Other future work is related to the introduction of elliptical orbits, asteroids and moons in the next iterations of the game that is already being upgraded. These improvements will surely lead to a more appealing game experience. The back-office also needs improvement in order to provide the information to the students and the teachers in a more convenient way.

Another key aspect that we consider of utmost importance is the publication of the software system,

namely through the Android store. For a successful experience, multi-language support will be introduced in future versions of PlanetarySystemGO, allowing instructors to set questionnaires in their own language, thus reaching audiences at a more global level. The globalization of this product will have, as an interesting consequence, the raising of the pertinence of, at the back-office level, the collection of several performance indicators, such as the number of downloads, active users, user time, among other relevant statistics.

We believe that, with the introduction of these new functionalities, PlanetarySystemGO can be performed in formal learning environments and can be adapted by the teachers to any grade level of school syllabus. Furthermore, PlanetSystemGO can be regarded as a contribution for the development of a generic and configurable MAR platform, that will allow instructors to, in a quite simple way, create and expand systems that can profit from the hardware offered by modern smartphones, not only for Astronomy, but also for the teaching of other Sciences and Technologies, for various levels.

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## **Development and Evaluation of an App to Promote Reading Competence**

### **1. Introduction**

Technological innovation and its application in educational contexts has created the necessary conditions to answer to several needs of students as well as teachers. One of the problems that recurrently emerges, in the very first years of schooling, is the student's difficulties in developing reading and comprehension skills. This leads to poor academic performance and motivation problems. Several papers have pointed out the need to overcome these difficulties, as soon as possible, by identifying the problem and acting upon it by resorting to the promotion of reading efficient study programs [1].

However, schools are not provided with human resources



able to supply individual monitoring to all students. Therefore, the use of digital tools, which may be able to promote the development of reading skills, is extremely important to understand the students' difficulties, on an early stage. This may help preventing some problems and address others, as some authors have defended [2].

In the Portuguese market, there are some computer applications in the reading field but none of them allow the selection of texts adequate to the student's needs, neither for the monitoring of their learning process. Therefore, the Polytechnic Institute of Tomar and the Artur Gonçalves Group of Schools, have designed an information system (*Letrinhas*) to promote oral reading fluency - a key indicator of reading proficiency. This system explores information and communication technologies' potential, namely mobile devices, respecting students' learning rhythm and allowing them to learn anytime and anywhere through interactive contents [3].

In order to evaluate the impact of *Letrinhas*' system through the analysis of learning results as well as students

and teachers satisfaction in a classroom context, we have undertaken a study which has been carried out in the school year of 2017/2018 and continued in the school year of 2018/2019, involving teachers and students of 9 Groups of the Schools of the Center Region in Portugal.

In this paper we present the system *Letrinhas* and describe the research done in the domain of reading promotion.

## **2. Theoretical Background**

The use of mobile devices in school contexts raises an enormous challenge, as “we can learn anywhere, at any time and in very different ways” (p. 30) [4]. Within this educational environment, a new learning model unfolds, the m-learning that according to Salmon [5], becomes the fourth generation of contexts in electronical learning, within an educational context. Also Wagner [6] refers that “the value of deploying mobile technologies in the service of learning and teaching seems to be both self-evident and unavoidable” (p. 42). The use of mobile devices and technologies is even more considerable when we talk about

foreign language skills, as it may help to get some basic competences, lead to the development of others and achieving very good results. This is both true regarding the Portuguese language and foreign ones. For example, the GraphoGame, developed by Jyväskylä University in cooperation within Niilo Mäki Institute [7]. This application is conceived to children with dyslexia issues, but also to any child with reading difficulties.

The results presented by Lan, Sung and Chang [8], that have developed a new English learning system, show that “MPAL [mobile-device-supported peer-assisted learning] seemed to reduce anxiety in elementary English as a Foreign Language (EFL) learners, promote motivation to learn, and enhance oral reading confidence” (p. 142). Also, Thoermer and Williams [9] refer that “reading instruction that incorporates digital texts can serve to motivate students to want to read and help increase students’ reading fluency in the classroom today” (p. 441).

### **3. Creation and Development of *Letrinhas***

*Letrinhas* allows for the evaluation of student reading proficiency through voice recordings, which teachers later correct and evaluate. This information system consists of a server, a Backoffice and an App (Figure 1). The Server is the invisible part of the system and is intended to provide the authentication services for the Backoffice and for the App, as well as the service of storage, access and data processing. The Backoffice is a Web application that does data management of the reading learning support system. The Backoffice allows for the management of users, students and teachers. Likewise, it allows for the management of the educational content. The App allows the student to perform reading tests using the multimedia capabilities of the devices. The technologies used for its implementation enable the app to be made available on various platforms (e.g. Android, iOS) and different sizes of mobile devices.



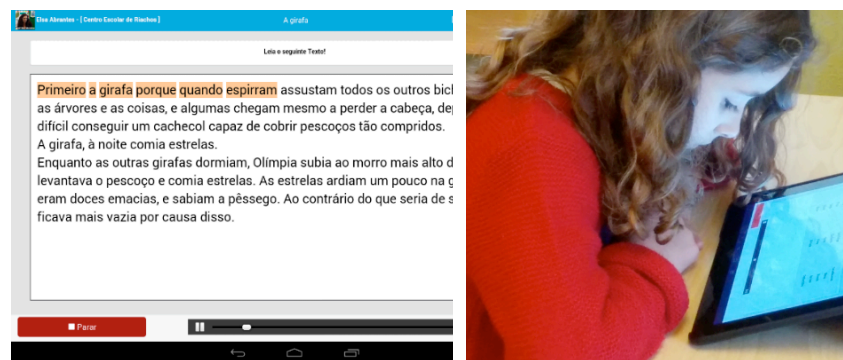
Figure 1. Architecture of Letrinhas

In the identification of the initial requirements it was acknowledged the need for the system to have an interface for devices controlled by the touch, regardless of the operating system and of the necessity for this application to operate in non-networked environments of data. The first requirement was satisfied with the use of the Cordova framework that supported the compilation of the mobile application for Android and iOS. The second requirement has proved more complicated to solve due to the need for data synchronization between the system components. By

reason of the multimedia characteristics of the data, it was decided to use a non-relational database and the choice fell on CouchDB on the server side and on PouchDB on the app side. This solution allowed for automatic synchronization of data between all system components. The implementation of the system on the field shocked with the poor quality of the school data networks and automatic data synchronization worked poorly. In order to overcome these difficulties, we chose to use relational databases, MySQL, and the synchronization started to be made by events triggered by the App. This solution is the most appropriate to the technological reality where the information system is being used and has proved to be quite robust and resilient in the field.

The *Letrinhas*' test includes the recorded voice of the teacher that grants the student access to a correct reading in terms of intonation, speed and prosody. This will be the reading model that the student will try to reproduce with his own voice. The student can listen to the teacher's reading as often as s/he deems necessary and the text has a

synchronization system with the voice that encourages the student to associate the words that are being heard with those that are written in the text. In the test, the student reads the text and the system records his voice, which can then be heard. Students can repeat the test if they are not satisfied with the result. The fact that they can hear their own voice allows them to identify their difficulties and try to correct them autonomously.



a) b)  
Figure 2. Performing a Reading test: a) Reading test b) Test resolution.

In figure 2 we can see an example of a reading test and its resolution by a student. The reading test, figure 2 a) is defined by the teachers according to the specific difficulties of the student, which after being carried out will be sent to

the Backoffice where it will be corrected and evaluated.

In the correction of the tests the teacher has access to the audio recording made by the students which favors a detailed evaluation of the reading along with an easier identification of the students' difficulties. The system also shows the evolution of student learning with the resolution of several tests.

*Letrinhas* was originally designed for reading proficiency assessment but it has extended its capabilities. The current version of the system allows for the acquisition and evaluation of other didactic contents that are part of the students' curriculum.

#### 4. Learning outcomes

In the research we have developed, the methodological model used was the case study, which involved an intense and more detailed work of one entity. To gather data, we used several techniques, such as observation and surveys. This study took place in 9 School Districts in the Center Region of Portugal. It involved 37 teachers, from 22

different schools, and 65 students from either 2nd or 3rd years. Of the student sample, 34 students were male and 31 female, all of them about 8 years old. To analyze the accuracy and precision, as well as other characteristics of their reading competence, we have used the REI test because it has already been approved [1]. This test was conducted before and after the study. To implement this study, two groups were organized: one that used *Letrinhas* (experimental group, with 33 students) and another one, that used the traditional method (control group, with 32 students), using the U de Mann–Whitney test to validate the standard of groups.

Starting with the analysis of REI test evaluation, each teacher of the testing group would identify the different types of difficulties and establish a strategy for each student (by conceiving a reading plan, choosing specific vocabulary, defining reading speed, etc.). The control group used more conventional methodologies.

The differences found between the two teaching methods of reading are statistically significant. The impact of the

*Letrinhas* software on the reading fluency and precision of students in the second and third years of elementary school is considerable, given the magnitude of the effects obtained [10].

## 5. Conclusions

The development of the *Letrinhas* information system began in 2014 with the creation of a prototype for the validation of the concept. The prototype developed proved to be effective and in the following year the production version was developed and used in a real context situation in a school of Artur Gonçalves Group of Schools. In 2016 the evaluation of the production version was made, having been necessary to make corrections to optimize some functionalities and to add new ones. The current version was introduced in 2017 in order to improve the stability and scalability of the system.

The use of mobile devices in learning contexts has become a reality and all researches performed point out to their importance in increasing learning skills, either by

motivation or by earning facilitation.

The results achieved with this study make it clear that the *Letrinhas* system had a very positive impact. All the students using this method improved their performance and had better results than the students using more traditional ways of learning.

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