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2023 – LIST OF PAPERS AND ABSTRACTS (PUBLISHED IN 2023)

AUTOMATICA AND INFORMATICS 2023 No. 1

AUTOMATICA

M. Hadjiski. 30th Anniversary Symposium on Control of Energy, Industrial and Environmental Systems. 2023, No. 1, 5-10.

Key Words: Control praxis; ecology; energy; engineering; industrial automation; innovation.

Abstract. The presented overview represents a general view of the successfully held 30th edition of the International Symposium on Control of Energy, Industrial and Environmental Systems. This was not a narrowly specialized forum, it was a search for a possible way to build a bridge between theoretical achievements and their practical implementation in industrial automation. The main automation engineering companies and the relevant organizational structures in industry and business in Bulgaria have invariably been active participants and sponsors of the symposium. The total number of reports and company presentations published in the proceedings of the symposium exceeded 500. During the three decades of its existence the symposium was constantly evolving following the rapid progress of theoretical achievements, new technical devices and advanced software, emerging innovative technologies based on Big Data and Artificial Intelligence. The symposium was a place for productive discussions, exchange of experience and mutual enrichment of specialists with different profiles. It was a suitable environment for creating new contacts, which in many cases grew into long-term business cooperation. The symposium was a forum for popularizing the scientific and practical achievements of industrial automation in Bulgaria. It was often a place for first appearance and publication of young specialists from scientific circles and industry.

MODELING OF ENERGY SYSTEMS

I. Simeonov, N. Pan, H. Wang, Y. Tian, E. Chorukova, N. Christov. Energy Yields Comparative Study for One-Stage and Two-Stage Anaerobic Digestion Processes. 2023, No. 1, 11-15.

Key Words: Anaerobic digestion; one-stage anaerobic digestion processes; two-stage anaerobic digestion processes; mathematical modeling; static characteristics; biogas yields; energy yield.

Abstract. Compared to traditional one-stage anaerobic digestion processes (OSAD) with biomethane production, this paper focuses on the study of energy yield of the two-stage anaerobic digestion processes (TSAD), which are able to produce simultaneously biohydrogen and biomethane. In TSAD, relatively fast growing acidogens and H_2 -producing bacteria are developed in the first-stage hydrogenic bioreactor and are involved in the production of volatile fatty acids (VFA) and H_2 . On the other hand, the slow growing acetogens and methanogens are developed in the second-stage methanogenic bioreactor, in which the produced VFA are further converted to CH_4 and CO_2 . This separation allows to optimize physico-chemical parameters for both groups of microorganisms which are not the same. Using mathematical models (mass balance type) developed by our team, theoretical comparative analysis of the energy yield from one-stage and two-stage anaerobic digestion systems is performed. Transforming the differential equations of these balance models, some algebraic equations called static characteristics for both bioreactors were obtained. They represent dependencies of the main process variables from the control variable (dilution rate). On the basis of these results, the theoretical maximal values of the corresponding energy carriers (hydrogen and methane) yields can be found for different values of the inlet organics (perturbation). The possible maximal biohydrogen and biomethane yields and the overall energy production are calculated by the static characteristics and extremum points of both systems. From the performed analytical and simulation studies, it can be seen that the energy obtained with TSAD is from 32% to 48% greater compared to OSAD under similar conditions (depending on the concentration of the incoming organics).

INTELLIGENT SYSTEMS

A. V. Atanasov, D. Pilev, F. Tomova. Bimodal System for Emotion Recognition Based on Deep Neural Networks. 2023, No. 1, 16-22.

Key Words: Online Learning; Deep Neural Networks; Face Recognition; Facial Emotions Recognition; Python.

Abstract. Current study presents development of bimodal system for Facial Emotion Recognition (FER) and Body Gestures Emotion Recognition (BER). The system is based on two Deep Learning Neural Networks (DNN) each one responsible for the recognition of the emotion of the face or the body. The use of the combination of two neural networks has an amplifying synergistic effect, which increases by about 10% the accuracy of the results (recognized emotion) compared to those of the individual DNN. The selection of pre-trained DNN models for facial and body emotions recognition is based on two authors' papers, in which detailed analysis of the DNN for FER and BER has been done. Therefore in current study a brief information about selected DNN models is provided, as well information

about specific dataset used for training selected DNNs. Verification of the bimodal system is done using our private dataset.

S. Yordanov, G. Mihalev, S. Ivanov, H. Stoycheva. Intelligent Management System for Collection of Solid Waste. 2023, No. 1, 23-30.

Key Words: Waste collection; smart city; Internet of Things (IoT); intelligent transportation systems; surveillance systems.

Abstract. The paper presents the structure of an intelligent integrated system for managing the collection of solid waste in urban and suburban environments. The system can automatically maintain the box level and send information to the waste collection truck. The technologies used in the proposed system are necessary to provide real monitoring and management of waste collection processes and to obtain a green environment.

INFORMATICS

D. Parvanov, P. Tomov, T. Balabanov. Fine Tuning of LibreOffice Calc NLP Solver for Multi-Objective Optimization. 2023, No. 1, 31-34.

Key Words: LibreOffice Calc; multi-objective optimization; NLP Solver.

Abstract. There is a common difference between single-objective optimization and multi-objective optimization. In the first case, there is only a single value as a result of the optimization. In the second case, there is a set of solutions called Pareto-optimal solutions. Single-objective solvers are giving only a single value as a result, even for multimodal functions. Because of this single-objective solver is not proper for multi-objective problems. Through additional adaptation, a single-objective solver is possible to start multiple times. Taking the results of multiple starts, the Pareto front is marked. When the solver is a metaheuristic, the front itself is difficult to achieve. With fine-tuning of the solver's parameters, the solutions can be as close as possible.

AUTOMATICA AND INFORMATICS 2023 No. 2

AUTOMATICA

M. Hadjiski, N. Deliiski, P. Vitchev, D. Angelski, N. Tumbarkova. Computation of Average Moisture Content in Batches of Wood Materials during Thermal Treatment. 2023, No. 2, 6-12.

Key Words: Wood materials; average moisture content; autoclave steaming; 2D mathematical models; Table Curve 2D; veneer production.

Abstract. A method and an algorithm for computing the average moisture content of the whole quantity of wood materials in given batch subjected to thermal treatment has been suggested. This value of the average wood moisture content is needed for calculation and automatic realization of optimal energy saving regimes for such treatment of the materials. The method is based on the use of two own mathematical models: one of the 2D temperature distributions in non-frozen prismatic wood materials during their thermal treatment and another – of the heat balance of steaming autoclaves. For numerical solving of the models and practical application of the suggested method, a software program was prepared in the calculation environment of Visual FORTRAN Professional developed by Microsoft and operating under Windows. Using this program computation of the non-stationary change in the processing medium temperature in an autoclave during steaming in it of non-frozen beech prisms with different moisture content aimed at their plasticizing before cutting them into veneer have been carried out. The variables used during the simulations were equal, as follows: an initial wood temperature of 0 °C, moisture content u from 0.4 to 0.8 kg·kg⁻¹ with an interval of 0.05 kg·kg⁻¹, and cross-section dimensions of prisms 0.4×0.4 m; steaming autoclave with inner diameter of 2.4 m, length of its cylindrical part of 9.0 m, and loading level with prisms of 50%; limited heat power of 500 kW of the generator, which feeds the autoclave with saturated water steam. The calculated by the models increase of the steaming medium temperature in the beginning stage of basic regime at $u = 0.6$ kg·kg⁻¹ is compared with the real increase of that temperature at different values of u , which is periodically measured with a sensor in the automatic control system. After proper processing of the obtained differences between measured and calculated temperatures with the software package Table Curve 2D, an equation for calculating the average moisture content of the wood materials in the whole batch loaded in an autoclave is derived. The good accuracy of the suggested method is proved for the cases of autoclave steaming of non-frozen beech prisms intended for production of veneer.

N. Petkov. How Process Control Systems Development Supports Digital Transformation. 2023, No. 2, 13-18.

Key Words: Digital transformation; digitalization; process industries; process automation; simulation.

Abstract. The remarkable evolution of technologies in the last decade enables producers of automaton products, software, and systems to go further in their solutions. At the same time process industries are challenged by the continuously changing competitive environment, keeping new health and safety regulations, and developing environmental-friendly products. New business models are created, and producers need to fit to be successful in their markets. Digital transformation (DT) is the way how process industries could go further. Process automation systems takes significant part in that transformation using the latest developed technologies. Different studies and research in the automation control theory, especially in the last decades, provides us the available knowledge base for further technology improvement. Normally there is a timeline gap between the theory and the practice due to the complex mathematical models and algorithms which were difficult and expensive to be executed in a real production process. With the development of the new automation hardware, software technologies and edge devices, driven by Industry 4.0, the implementation of theory is more applicable, and the return of investment is more visible. Nowadays, the development of science and production processes go more and more hand in hand from the stage of conceptual design the products production. The leading role has the rapid development of artificial intelligence, supported by the availability of new computer technologies, computational algorithms, and programming languages. The aim of this paper is to show a difference in digital transformation of discrete and process industries. The focus is the DT of process automation using parallel examples from the automation control theory and currently available software and hardware solutions.

MODELING AND CONTROL OF ENERGY SYSTEMS

V. Boishina. Applying Machine Learning to Energy Objects Control. 2023, No. 2, 19-24.

Key Words: SISO; power plant; machine learning; PID control; error assessments.

Abstract. The research is focused on possibility of applying the Machine Learning (ML) approach, which is using previous data knowledge for the energy system and monitored process values for control behaviour. The main focus of the research is to make assessments for the quality of the control process by comparing the classical PID Control algorithm and Machine Learning Control (ML) one. The investigation is based on possibility to apply supervisor Machine Learning Control to Single Input Single Output (SISO) Power Plant. In the current research the previous information about the system data (manipulated, control, output variables and system states) are used for forming the training sets which is used for performing the Machine Learning Control. Some simulation results illustrating the behaviour of the power system, which is controlled via ML and PID have been presented. The research gives some assessments about the quality of the control by assumption for presence of low and big system disturbances and uncertainties, which may occur in energy system. In current paper applying the supervisor ML algorithm is only under consideration. The steady describes the basic architecture of developed software system implementing the SISO Plant Control. The research gives assessments for four cases – PID and ML control with low disturbances, PID and ML control with big disturbances. Also some assessments about system behavior have been made with possibility to overfeed the training set applying big uncorrelated data. The software system is released with java and weka ML library. Realization of system program modules and architecture of the system has been presented.

T. Radeva. Stages and Measures in Preparing an Energy Efficiency Report of an Educational Center. 2023, No. 2, 25-29.

Key Words: Energy efficiency; survey; costs.

Abstract. The object of the study is treated as an integrated system, consisting of a building, systems for ensuring the microclimate, inhabitants and modes of habitation, climatic effects of the environment. The source information required for the analysis was gathered from existing documentation and surveying. In solving the task, the following methods and procedures were used and applied: interviews with owners; inspections; modeling and simulation of energy transfer processes; calculations. The source information required for the analysis was collected from: existing documentation; recordings. Solving the task is implemented in the following sequence of actions: analysis of the existing situation; formation of the necessary database for modeling and simulation of energy transfer processes; creating models of real energy consumption; establishment of the main energy characteristics under normal mode of exploitation; simulating the energy transfer processes and revealing the potential possibilities for energy saving; generation of energy-saving measures and technical solutions for their implementation; technical-economic evaluation of prospective measures and their combinations; assessment of saved carbon dioxide emissions as a result of the implementation of measures to increase energy efficiency. The presented material reflects only the obtained results without going into detail the implementation of the individual stages.

INTELLIGENT SYSTEMS

A. V. Atanasov, D. Pilev, F. Tomova. Improving the Accuracy of Facial Emotion Recognition through Deep Neural Networks for Facial Emotions and Weather Conditions Recognition. 2023, No. 2, 30-36.

Key Words: Deep Neural Networks; Facial Emotions Recognition; Weather Condition Recognition; Python.

Abstract. Emotions are one of the main ways to communicate between people and to express their attitude towards objects, products, services, etc. Emotions are divided into two classes – verbal and non-verbal. Human speech and intonation belong to the first class, and to the second class are facial and body emotions, also known as body language. The subject of this paper is facial emotions and their relationship to the scene in which they occur. A number of studies have established that there is a strong relationship between a person's emotions and their surroundings. The latter includes meteorological conditions (weather) and other objects, such as other people, landscape, etc. Facial emotions range (FER) from seven basic emotions (joy, anger, surprise, fear, sadness, neutral and disgust and neutral) categorized by P. Ekman through his Facial Action Coding System to 26 emotions represented by Russell through his 3D Valence Arousal Dominance model. Most of the existing deep neural networks for Facial Emotions Recognition recognize mentioned seven emotions. In our previous research, we presented a pre-trained FER model with 69.85% accuracy. Weather conditions are closely related to geographic regions and vary in some cases from sunny to cloudy, or in other cases include some subset of sunny, foggy, snowy, rainy, hot, etc. In this research, we analyze deep learning neural networks, for weather conditions recognition and selected appropriate model. We combined our FER DNN with the selected weather recognition DNN and build a bimodal system, which improves facial emotion recognition to 80-83% especially in the cases when FER model provides contradictory results.

ECOLOGICAL SYSTEMS

G. Mihalev, S. Yordanov, H. Stoycheva. Beehive Condition Monitoring System Intended for Application in Beekeeping. 2023, No. 2, 37-43.

Key Words: Beehive monitoring system; precision beekeeping.

Abstract. Honey bees are one of the most important insects for human existence. They have a main role in the production of various agricultural crops, as well as in the development of nature itself. Currently, bee colonies are facing many problems related to climate change, diseases, chemical pollution and most of all human activity regarding the development, production and sustainability of the bee colony. The aim of the present development is to provide a solution or at least to partially suppress certain problems of bee families during their development in their active period, with a minimum expenditure of resources. These problems can be summarized as problems related to the health of the hive, problems related to reproduction and problems related to the production of certain bee products (honey, pollen and wax). A system for monitoring of some bee colonies parameters in real time is proposed, based on cloud services and a microprocessor system with a set of sensors. The obtained information can help the beekeeper take timely action with minimal stress to the bees in the colony. The developed system is based on an ESP32 microcontroller and measures basic parameters, such as internal and external temperature, humidity and weight of the beehive. The data is stored in a cloud structure with a good graphical presentation

environment for the purpose of subsequent analysis. Attention is paid to energy saving and communication in difficult to reach places and regions. The architecture of the system and its implementation are described in details. The developed system can be used to monitor the production of honey, prevent the process of swarming, as well as to maintain a high health status of the bee colonies. Results of actual data obtained for the observed values during the active period of development of a beehive are presented. Through the technical and economic analysis, information is given about the achieved socio-economic results.

AUTOMATICA AND INFORMATICS 2023 No. 3

INFORMATICS

P. Blagov, P. Ruskov. EBSI (European Blockchain Services Infrastructure) Development and EBSI Production Nodes. 2023, No. 3, 5-11.

Key Words: EBSI; Node Expansion.

Abstract. The article examines the current state and the EC project for building EBSI (European Blockchain Services Infrastructure) production nodes. The main characteristics and architecture of the EBSI platform are presented. The EBSI – NE – Node Expansion project involving the authors to maintain and develop the nodes is described. The EBSI – NE – Node Expansion, Deployment of EBSI production nodes, and provision of support services to the EBSI network at the European level project will further develop the blockchain nodes in the EU and help build capacity for using the technology. The objective of the EBSI-NE consortium is to support the development and adoption of the EBSI network at the European level by increasing the number of validator nodes in the production network and the provision of support services for all relevant EBSI stakeholders. These actions will increase the robustness and maturity of the production network of EBSI, enabling the development of the prioritized EBSI cross-border use cases. The consortium is made of 24 organizations from 14 European countries including government agencies, public institutions, and academia which have extensive experience related to Distributed Ledger Technologies and past EBSI ecosystem initiatives, including the deployment of pre-production nodes. It is within the program DIGITAL-2022-DEPLOY-02, Project ID: 101102570. The tasks and expected results of the project are also presented.

INTELLIGENT SYSTEMS

R. Hrishev, N. Shakev. Embedded AI Apps in the Intelligent Cloud ERP Systems. 2023, No. 3, 12-16.

Key Words: ERP system; SAP Business Technology Platform; Cloud Oracle Infrastructure; AI services.

Abstract. SAP Business Technology Platform (BTP) and Cloud Oracle Infrastructure (OCI) are the pioneers of the modern cloud intelligent ERP systems. This article presents investigation of the embedded services with Artificial Intelligence (AI) in both ERP systems. The main functionalities with built-in AI are presented.

E. Monova. Predicting the Behavior of a Chaotic System through a Neural Network in MATLAB. 2023, No. 3, 17-21.

Key Words: Chaotic system; neural network.

Abstract. In the paper is proposed an approach for predicting the behavior of a chaotic system through a neural network trained in MATLAB. Variants of neural networks with one hidden layer and different number of neurons are also presented.

ECOLOGICAL SYSTEMS

L. Jusufi, S. Khafa. Smart Water Infrastructure Technologies for Implementation of the Smart City Project in Pristina. 2023, No. 3, 22-26.

Key Words: Smart City; Smart Water System (SWS); Smart Water Infrastructure Technologies (SWIT); GIS; DMA; NRW.

Abstract. Over the next decade, urban populations and the need for clean water will continue to grow. Cities are forced to find intelligent solutions for the rational use of clean water using Smart Water Infrastructure Technologies (SWIT). The Smart Water System is an important component, along with other components, with the particular importance to complete the implementation of the Smart City concept. Most of the Smart City projects have a relatively short history and often the level of their impact is not clear. Cities are getting smarter every day, using information and communication technologies to enrich and enhance city life. Some cities in the Western Balkans have started implementing Smart City, some are in the feasibility study phase and some are in the planning phase of starting implementation. Before implementing a Smart City project, it is necessary to understand not only the potential impact of the project but also the priorities and the specific problems that are trying to be solved. For this reason, this paper will provide information about the level of Smart Water Infrastructure Technologies that are installed in Pristina Water Company to implement a Smart City Project in Pristina. The objective of this paper is to present an assessment of the current situation in the application of Smart Water Infrastructure Technologies in the Pristina Region and to provide a summary of potential key recommendations for the integration of such technologies the Smart Water System control for Smart Cities.

Z. Radeva. Analysis of Plant Species Data in Development of an Ontology for an Intelligent System for Bulgarian Wild, Cultivated and Protected Flora. 2023, No. 3, 27-36.

Key Words: Development of Ontology; Semantic WEB; WEB Protégé; Plant Ontology; Bulgarian flora; Biodiversity; Botany; Flora-oriented plant ontology.

Abstract. On the territory of the Republic of Bulgaria there are many plants, which are known as Bulgarian flora. The diverse vascular plants in Bulgaria with estimated enormous number of no less than 3700 species. Bulgarian flora including a wide variety of plant species and their natural habitats. The existing information about them is collected in various sources with a rather heterogeneous structure for representing information about terms or specific terminology. In order to facilitate the integration and analysis of the information contained in the various sources describing the plant flora in our country, in this paper we presents our methodology for describing , gathering and development of a model of ontology, useful for context of semantic web technologies. The ontology in specific domain area,

as is in area of different types of species in Bulgarian flora give us opportunity to represent plant species through building an intelligent system for Bulgarian wild, cultivated and protected flora. The work presents the analysis of plant species data in development of an ontology for an intelligent system for Bulgarian wild, cultivated and protected flora. Domain ontologies express conceptualization that is specific for particular area and presented by greatly useful in knowledge acquisition, sharing and analysis, especially on the web discover knowledge for plant across all disciplines of botany. A mixed method was applied in organizing of the specification of conceptualizations on flora of Bulgaria using the domain analytic approach in order for developing an ontology. The model of ontology has been constructed by using ontology editor in open-source software Protégé. In this paper, we propose a prototype of model of ontology and describe the research methods including domain analysis for knowledge organization and ontology development, as results of classification of Bulgarian flora based on specialized literature and encyclopedia of plants in Bulgaria, floral characteristics and area of their distribution which are divided into different concepts of plant information. There are included block diagrams for the stages involved in the construction of an ontology for an intelligent system for Bulgarian flora are presented some conceptual terms of botany aspects of the Bulgarian plant species. The paper presents the first results of data analysis of building an intelligent system by ontology for wild, cultivated and protected flora.

AUTOMATICA AND INFORMATICS 2023 No. 4

MODELING AND CONTROL OF ENERGY SYSTEMS

N. Deliiski, L. Dzurenda, D. Angelski, P. Vitchev, K. Atanasova. Computation of Energy Consumption and Efficiency of Concrete Pits during Boiling of Logs for Veneer Production. 2023, No. 4, 5-14.

Key Words: Concrete pits; non-frozen logs; boiling; energy consumption; energy efficiency; veneer production.

Abstract. An approach for computing the energy consumption and energy efficiency of pits during boiling of non-frozen logs intended for veneer production has been presented. The approach is based on the use of two personal mathematical models: 1D non-linear model of the unsteady distribution of the temperature along the radius in the central cross section of non-frozen logs subjected to boiling at conductive boundary conditions, and model of the thermal balance of concrete pits during boiling of wood materials in them. For numerical solving of the models and practical application of the suggested approach, a software packages were prepared in the calculation environment of Visual FORTRAN Professional and in Excel respectively. With the help of the first model, the boiling times of beech logs with a diameter of 0.4 m, initial temperature of 0, 10, and 20 °C and moisture content of 0.6 kg·kg⁻¹ were determined at water temperatures in the pit equal to 70, 80, and 90 °C. Using the determined logs' boiling durations, with the help of the second model the change in energy required for the entire boiling process and that for each of the components of the thermal balance was calculated. Computer simulations were performed for a well-insulated concrete pit with working volume of 20 m³ and degree of filling it with logs 45%, 60%, and 75%. It was found that the energy consumption of the pit decreases from 159.7 to 145.3 kWh·m⁻³ when the initial temperature of the logs increases from 0 °C to 20 °C at temperature of the boiling water of 80 °C and maximum possible degree of feeling of 75%. In this case, the thermal efficiency of the pit decreases from 32.2% to 26.1%. It was found also that at the same degree of feeling of the pit the increase in the boiling water temperature from 70 °C to 90 °C causes an increase in the energy consumption of the pit from 135.3 to 170.9 kWh·m⁻³ when the initial temperature of the logs is equal to 10 °C. Under these conditions the thermal efficiency of the pit decreases from 29.9% to 28.8%. The approach can be applied to compute the energy consumption and thermal balances of concrete pits during boiling of non-frozen logs to any desired final average mass temperature required for the mechanical processing of the plasticized wood. It could be easily modified and used to calculate the energy consumption and efficiency of concrete pits of any design and construction parameters.

T. Radeva. Use of Photovoltaic Energy for Own Needs for an Educational Center for Out-Of-Class Activities and Culture. 2023, No. 4, 15-22.

Key Words: Photovoltaic systems; solar power generation; educational institutions; design engineering; energy management.

Abstract. The solar modules that are produced have a rather fragile structure and must therefore be mechanically protected on both sides. For this purpose, a so-called sandwich structure is used, in which the photovoltaics are placed on a solid base and covered with a transparent upper protective layer. The coefficient of thermal expansion of the materials of the upper and lower protective layers must be the same and, moreover, comparable to that of the photovoltaic cell and the bonding resin used. Currently, the most widely used materials are glass and plastic. Photocells sealed under glass have the advantage that they do not change their optical, mechanical and electrical properties during prolonged outdoor operation. Polymers cannot prevent the penetration of moisture, so they are only suitable when the photovoltaics and metal contacts are protected by an anti-corrosion coating. Plastics are lighter than glass, but they have the effect of aging with prolonged exposure to atmospheric conditions, which strongly affects their qualities. The upper transparent protective layer allows easy cleaning of the solar cells, but during their installation, they must be placed in such a way as to avoid their heavy contamination and the retention of snow on them. This is practically achieved by the southern orientation of the panels and their placement at an angle corresponding to the latitude of the site, as well as taking into account the season of operation. Some panels are oriented to the southwest so that they can produce the necessary energy for the afternoon maximum. For most locations, a slope angle close to horizontal will provide the most energy year-round. The cells used today have an efficiency of 3-20% in converting solar energy into electricity. A photovoltaic generator is a set of modules that convert solar energy into direct current (DC) electricity. It consists of a module formed by several photovoltaic cells, connecting several such modules form a panel, and several panels connected together form an array. Connecting several arrays electrically in parallel forms a photovoltaic generator or photovoltaic park. By connecting a certain number of photovoltaic cells in parallel and in series, any desired power can be obtained. The main element of the photovoltaic generator is the photovoltaic cell, where the conversion of solar radiation into flowing electric current takes place. The present work presents a practical task of a photovoltaic energy system for a public educational building. The purpose of the case study is to provide technical measures to improve the energy efficiency of the building, according to the technical specification and the current regulations. Public school buildings are mainly used during the daylight hours, where solar energy will be used for self-consumption.

EDUCATION AND QUALIFICATION

M. Hadjiski, R. Kaltenborn. Personalized Learning Based on Artificial Intelligence as a Challenge for Modern Education Systems. 2023, No. 4, 23-40.

Key Words: *Personalized learning in education; evolution of modern personalized education; potential possibilities of personalized learning systems; possible ways to implement effective personalized training; artificial intelligence.*

Abstract. *The article provides a critical analysis of the achievements and insufficiently convincing results of the multi-year attempts to introduce personalized education in educational structures of different types. The evolution of personalized learning systems with varying degrees of student involvement in the functioning of the system is discussed. The great potential possibilities of personalized learning systems emphasizing the active role of students are discussed. Two variants of metastructures have been developed for the implementation of personalized training – component and functional. The main dimensions within which personalized learning systems can be treated with a view to determining their weights in multifactor optimization are derived. Possible ways to implement effective personalized training are analyzed. The notion that personalized learning can meet the challenges of the time is substantiated if it is treated as a holistic problem with a large dimension, with student-centered functioning, with finding an optimal combination of algorithms, applications and procedures in technological implementation, with a new level of competence of teachers and students in the field of artificial intelligence, with direct corporate interest for a long time horizon.*

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