

Data Stream Mining & Processing

Proceedings of
IEEE Third International Conference on
Data Stream Mining & Processing



August 21-25, 2020
Lviv, Ukraine



MANHATTAN
COLLEGE



Proceedings of the 2020 IEEE Third International Conference on Data Stream Mining & Processing (DSMP)

Organized by

IEEE Ukraine Section

IEEE Ukraine Section (Kharkiv) SP/AP/C/EMC/COM Societies Joint Chapter

IEEE Ukraine Section (West) AP/ED/MTT/CPMT/SSC Societies Joint Chapter

IEEE Ukraine Section IM/CIS Societies Joint Chapter

Ukrainian Catholic University

Manhattan College

Kharkiv National University of Radio Electronics

Lviv, Ukraine
August 21-25, 2020

Copyright and Reprint Permission: Abstracting is permitted with credit to the source. Libraries are permitted to photocopy beyond the limit of U.S. copyright law for private use of patrons those articles in this volume that carry a code at the bottom of the first page, provided the per-copy fee indicated in the code is paid through Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923. For reprint or republication permission, email to IEEE Copyrights Manager at pubs-permissions@ieee.org. All rights reserved. Copyright ©2020 by IEEE.

Additional copies may be ordered from:

IEEE Conference Operations

445 Hoes Lane, P.O. Box 1331, Piscataway, NJ
08855-1331 USA

DSMP'2020 Organizing Committee

E-mail: dsmp.conference@gmail.com

IEEE Catalog Number: CFP20J13-USB

ISBN: 978-1-7281-3213-6

Table of Contents

Topic #1. Hybrid Systems of Computational Intelligence	1
Olena Vynokurova, Dmytro Peleshko, Oleksandr Bondarenko, Vadim Ilyasov, Vladislav Serzhantov, Marta Peleshko. HYBRID MACHINE LEARNING SYSTEM FOR SOLVING FRAUD DETECTION TASKS	1
Eugene Fedorov, Tetyana Utkina, Olga Nechyporenko, Yaroslav Korpan. SPEECH SIGNAL STRUCTURING METHOD FOR BIOMETRIC PERSONALITY IDENTIFICATION	6
Petr Hurtik, Oleksii K. Tyshchenko. KLN: A DEEP NEURAL NETWORK ARCHITECTURE FOR KEYPOINT LOCALIZATION	12
Maksym Lupei, Alexander Mitsa, Igor Povkhan, Vasyl Sharkan. DETERMINING THE ELIGIBILITY OF CANDIDATES FOR A VACANCY USING ARTIFICIAL NEURAL NETWORKS	18
Vojtech Molek, Petr Hurtik. TRAINING NEURAL NETWORK OVER ENCRYPTED DATA	23
Peter Bidyuk, Oleksandr Gozhyj, Irina Kalinina, Victoria Vysotska, Mikhail Vasilev, Romanna Malets. FORECASTING NONLINEAR NONSTATIONARY PROCESSES IN MACHINE LEARNING TASK	28
Yevgeniy Bodyanskiy, Anastasiia Deineko, Iryna Pliss, Olha Chala, Anna Nortsova. MATRIX FUZZY-PROBABILISTIC NEURAL NETWORK IN IMAGE RECOGNITION TASK	33
Igor Povkhan, Maksym Lupei. THE ALGORITHMIC CLASSIFICATION TREES	37
Mykola Pikuliak. DEVELOPMENT OF AN ADAPTIVE MODULE OF THE DISTANCE EDUCATION SYSTEM BASED ON A HYBRID NEURO-FUZZY NETWORK	44
Vladyslav Kotsovsky, Anatoliy Batyuk, Maksym Yurchenko. NEW APPROACHES IN THE LEARNING OF COMPLEX-VALUED NEURAL NETWORKS	50
Viktor Morozov, Olga Mezentseva, Maksym Proskurin. TRAINABLE NEURAL NETWORKS MODELLING FOR A FORECASTING OF START-UP PRODUCT DEVELOPMENT	55
Olexander Belej, Liubov Halkiv. USING HYBRID NEURAL NETWORKS TO DETECT DDOS ATTACKS	61
Yevgeniy Bodyanskiy, Tymofii Antonenko. DEEP NEO-FUZZY NEURAL NETWORK AND ITS ACCELERATED LEARNING	67
Igor Aizenberg, Alexander Vasko. CONVOLUTIONAL NEURAL NETWORK WITH MULTI-VALUED NEURONS	72
Igor Aizenberg, Olivia Keohane, Alejandro Lara. MLMVN IN SPECKLE NOISE FILTERING	78
Lyudmyla Kirichenko, Tamara Radivilova, Vitalii Bulakh, Petro Zinchenko, Abed Saif Alghawli. TWO APPROACHES TO MACHINE LEARNING CLASSIFICATION OF TIME SERIES BASED ON RECURRENCE PLOTS	84

Selçuk Öğütçü. STUDENT PERFORMANCE SCORE PREDICTION USING ARTIFICIAL NEURAL NETWORK WITH THE SUPPORT OF EXPLORATORY FACTOR ANALYSIS AND CLUSTERING	90
Dmytro Uzlov, Sergiy Popov, Oleksii Vlasov, Yevgeniy Bodyanskiy. ADAPTIVE MATRIX MODEL FOR A CRIME FORECASTING TASK	96
Olena Chornovol, Galyna Kondratenko, Ievgen Sidenko, Yuriy Kondratenko. INTELLIGENT FORECASTING SYSTEM FOR NPP'S ENERGY PRODUCTION	102
Ivan Mudryk, Mykhaylo Petryk. HYBRID ARTIFICIAL INTELLIGENCE SYSTEMS FOR COMPLEX NEURAL NETWORK ANALYSIS OF ABNORMAL NEUROLOGICAL MOVEMENTS WITH MULTIPLE COGNITIVE SIGNAL NODES	108
Alexander Vlasenko, Olena Vynokurova, Nataliia Vlasenko, Dmytro Peleshko, Yuriy Rashkevych A HYBRID EMD - NEURO-FUZZY MODEL FOR FINANCIAL TIME SERIES ANALYSIS	112
Jawad Rasheed, Akhtar Jamil, Hasibe Busra Dogru. TURKISH TEXT DETECTION SYSTEM FROM VIDEOS USING MACHINE LEARNING AND DEEP LEARNING TECHNIQUES	116
Leonid Lyubchyk, Olga Kostyuk. ONLINE REDUCED-ORDER KERNEL REGRESSION FOR DATA PROCESSING IN SENSOR NETWORK	121
Maksym Korobchynskiy, Mykhailo Slonov, Myhailo Rudenko, Oleksandr Maryliv, Valentyn Pylypchuk, Volodymyr Moldovan. IMPROVEMENT OF THE ALGORITHM OF DETERMINATION PARAMETER OF PHOTOGRAPHY IN THE CONDITIONS OF LIGHT SENSITIVITY	125
Topic #2. Machine Vision and Pattern Recognition	129
Olena Vynokurova, Dmytro Peleshko. HYBRID MULTIDIMENSIONAL DEEP CONVOLUTIONAL NEURAL NETWORK FOR MULTIMODAL FUSION	131
Oleksii Gorokhovatskyi, Olena Peredrii, Volodymyr Gorokhovatskyi. INTERPRETABILITY OF NEURAL NETWORK BINARY CLASSIFICATION WITH PART ANALYSIS	136
Roman Melnyk, Yurii Havrylko, Ivan Mykulanynets. FABRIC DEFECTS DETECTION BY COMPARISON OF CLUSTERED SAMPLES	142
Nonna Kulishova, Yevgeniy Bodyanskiy, Volodymyr Timofeyev. THE FAST IMAGE RECOGNITION SYSTEM BASED ON NEURO-FUZZY UNITS AND ITS ONLINE LEARNING FOR DATA STREAM MINING TASKS	147
Vitaliy Boyun. THE PRINCIPLES OF ORGANIZING THE SEARCH FOR AN OBJECT IN AN IMAGE AND THE SELECTION OF INFORMATIVE FEATURES BASED ON THE VISUAL PERCEPTION OF A PERSON	152
Bohdan Bilonoh, Sergii Mashtalir. PARALLEL MULTI-HEAD DOT PRODUCT ATTENTION FOR VIDEO SUMMARIZATION	158

Marek Vajgl, Petr Hurtik. A PIPELINE FOR DETECTING AND CLASSIFYING OBJECTS IN IMAGES	163
Nonna Kulishova, Anton Paramonov, Volodymyr Tkachenko. REAL-TIME AUTOMATIC VIDEO INSPECTION SYSTEM FOR PIECE PRODUCTS MARKING	169
Nataliia Kukharska, Andrii Lagun, Orest Polotai. THE STEGANOGRAPHIC APPROACH TO DATA PROTECTION USING ARNOLD ALGORITHM AND THE PIXEL-VALUE DIFFERENCING METHOD	174
Sergei Yelmanov, Yuriy Romanyshyn. A NEW APPROACH TO IMAGE ENHANCEMENT BY NON LINEAR CONTRAST STRETCHING	178
Sergei Yelmanov, Yuriy Romanyshyn . A QUICK NO-REFERENCE QUANTIFICATION OF THE OVERALL CONTRAST OF AN IMAGE	185
Viacheslav Moskalenko, Alona Moskalenko, Zaretskyi Nikolay, Viktor Lysyuk. DEEP FEATURE EXTRACTOR WITH INFORMATION-EXTREME DECISION RULES FOR VISUAL CLASSIFICATION OF SEWER PIPE DEFECTS AND ITS TRAINING METHOD	191
Karyna Korovai, Oleksandr Marchenko. HANDWRITING STYLES CLUSTERING: FEATURE SELECTION AND FEATURE SPACE ANALYSIS BASED ON ONLINE INPUT	195
Kirill Smelyakov, Anastasia Chupryna, Oleksandr Bohomolov, Igor Ruban. THE NEURAL NETWORK TECHNOLOGIES EFFECTIVENESS FOR FACE DETECTION	201
Roman Melnyk, Ruslan Tusnytskyi, Yurii Havrylko. SURFACE DEFECTS DETECTION BY CLUSTERING AND ROTATING IMAGE ANALYSIS	206
Ruslan Timchenko, Oleksiy Grechnyev, Sergiy Skuratovskyi, Yurii Chyrka, Ievgen Gorovyi. AUGMENTED REALITY IN WEB: RESULTS AND CHALLENGES	211
Anastasiia Skoryk, Yurii Chyrka, Ievgen Gorovyi, Oleksiy Grechnyev, Pavlo Vyplavin. COMPARATIVE ANALYSIS OF CLASSIC COMPUTER VISION METHODS AND DEEP CONVOLUTIONAL NEURAL NETWORKS FOR FLOOR SEGMENTATION	217
Radiy Radutniy, Alina Nechyporenko, Victoriia Alekseeva, Ganna Titova, Dmytro Bibik, Vitaliy V. Gargin. AUTOMATED MEASUREMENT OF BONE THICKNESS ON SCT SECTIONS AND OTHER IMAGES	222
Bogdan Ivanyuk-Skulskiy, Galyna Kriukova, Andrii Dmytryshyn. GEOMETRIC PROPERTIES OF ADVERSARIAL IMAGES	227
Jan Hula, David Mojzisek, David Adamczyk, Radek Cech. ACQUIRING CUSTOM OCR SYSTEM WITH MINIMAL MANUAL ANNOTATION	231
Jan Hula. UNSUPERVISED OBJECT-AWARE LEARNING FROM VIDEOS	237
Vladimir Sherstjuk, Maryna Zharikova, Irina Dorovskaja. 3D FIRE FRONT RECONSTRUCTION IN UAV-BASED FOREST-FIRE MONITORING SYSTEM	243
Vladyslav Zinchenko, Galyna Kondratenko, Ievgen Sidenko, Yuriy Kondratenko. COMPUTER VISION IN CONTROL AND OPTIMIZATION OF ROAD TRAFFIC	249

Oleg Yakovchuk, Anastasiia Cherneha, Dmytro Zhelezniakov, Viktor Zaytsev. METHODS FOR LINES AND MATRICES SEGMENTATION IN RNN-BASED ONLINE HANDWRITING MATHEMATICAL EXPRESSION RECOGNITION SYSTEMS	255
Volodymyr Hnatushenko, Viktoriia Hnatushenko. RECOGNITION OF HIGH DIMENSIONAL MULTI-SENSOR REMOTE SENSING DATA OF VARIOUS SPATIAL RESOLUTION	262
Topic #3. Dynamic Data Mining & Data Stream Mining	266
Iryna Perova, Olha Lalymenko, Igor Zavgorodnii, Viktor Reshetnik, Nelia Miroshnychenko. THE DEFINITION OF INFLUENCE DIFFERENT DRUG EXPOSURE TYPES TO MEDICAL INDICATORS OF WHITE RATS	268
Fedir Geche, Anatoliy Batyuk, Oksana Mulesa, Veronika Voloshchuk. THE COMBINED TIME SERIES FORECASTING MODEL	272
Mykola Malyar, Miroslav Kelemen, Andriy Polishchuk, Volodymyr Polishchuk, Marianna Sharkadi. MODEL OF EVALUATION AND SELECTION OF START-UP PROJECTS BY INVESTOR GOALS	276
Dmitriy Klyushin, Irina Martynenko. NONPARAMETRIC TEST FOR CHANGE-POINT DETECTION IN DATA STREAM	281
Oleksandr Tymchenko, Bohdana Havrysh, Oleksandr O. Tymchenko, Orest Khamula, Bohdan Kovalskyi, Kateryna Havrysh. PERSON VOICE RECOGNITION METHODS	287
Vadim Shergin, Larysa Chala, Serhii Udovenko, Mariya Pogurskaya. ELASTIC SCALE-FREE NETWORKS MODEL BASED ON THE MEDIATION-DRIVEN ATTACHMENT RULE	291
Yuriy Drohobytskiy, Vitaly Brevus, Yuriy Skorenkyy. SPARK STRUCTURED STREAMING: CUSTOMIZING KAFKA STREAM PROCESSING	296
Nataliia Yehorchenkova, Oleksii Yehorchenkov. MODELING OF DECISION-MAKING PROCESSES IN PROJECT PLANNING BASED ON PREDICTIVE ANALYTIC METHOD	300
Bohdan M. Pavlyshenko. USING BAYESIAN REGRESSION FOR STACKING TIME SERIES PREDICTIVE MODELS	305
Nataliia Kuznietsova, Petro Bidyuk. HETEROSKEDASTICITY MODELS FOR FINANCIAL PROCESSES MODELLING AND FORECASTING	310
Yaroslav Sokolovskyy, Andriy Nechepurenko, Tetiana Samotii, Svitlana Yatsyshyn, Olha Mokrytska, Volodymyr Yarkun. SOFTWARE AND ALGORITHMIC SUPPORT FOR FINITE ELEMENT ANALYSIS OF SPATIAL HEAT-AND-MOISTURE TRANSFER IN ANISOTROPIC CAPILLARY-POROUS MATERIALS	316
Liubov Halkiv, Oleh Karyy, Ihor Kulyniak, Solomiya Ohinok. INNOVATIVE, SCIENTIFIC AND TECHNICAL ACTIVITIES IN UKRAINE: MODERN TRENDS AND FORECASTS	321
Anastasiya Doroshenko. ANALYSIS OF THE DISTRIBUTION OF COVID-19 IN ITALY USING CLUSTERING ALGORITHMS	325

Vira Huskova, Petro Bidyuk . MODELING AND FORECASTING FINANCIAL HETEROSCEDASTIC PROCESSES	329
Ievgen Meniailov, Dmytro Chumachenko, Ksenia Bazilevych. DETERMINATION OF HEART DISEASE BASED ON ANALYSIS OF PATIENT STATISTICS USING THE FUZZY C-MEANS CLUSTERING ALGORITHM	333
Bogdan Glova, Ivan Mudryk. APPLICATION OF DEEP LEARNING IN NEUROMARKETING STUDIES OF THE EFFECTS OF UNCONSCIOUS REACTIONS ON CONSUMER BEHAVIOR	337
Mesbaholdin Salami, Farzad Movahedi Sobhani, Mohammad Sadegh Ghazizadeh. EVALUATING POWER CONSUMPTION MODEL AND LOAD DEFICIT AT DIFFERENT TEMPERATURES USING CLUSTERING TECHNIQUES AND PRESENTING A STRATEGY FOR CHANGING PRODUCTION MANAGEMENT	341
Topic #4. Big Data & Data Science Using Intelligent Approaches	346
Iryna Biskub, Lyubov Krestyanpol. THE USE OF SOCIAL ENGINEERING IN DEVELOPING THE CONCEPT OF "SMART PACKAGING"	348
Vitaly Deibuk, Ivan Yuriychuk. NOISY MULTIPLE-CONTROL FREDKIN GATE IN NUCLEAR SPIN BASED QUBITS CHAIN	352
Yuliya Kozina, Natalya Volkova, Daniil Horpenko. MOBILE DECISION SUPPORT SYSTEM TO TAKE INTO ACCOUNT QUALITATIVE ESTIMATION BY THE CRITERIA	357
Bogdan Palchevskyi, Lyubov Krestyanpol. STRATEGY OF CONSTRUCTION OF INTELLECTUAL PRODUCTION SYSTEMS	362
Serhii Brodiuk, Vasyl Palchykov, Yuriy Holovatch. EMBEDDING TECHNIQUE AND NETWORK ANALYSIS OF SCIENTIFIC INNOVATIONS EMERGENCE IN AN ARXIV-BASED CONCEPT NETWORK	366
Vasyl Lytvyn, Victoria Vysotska, Yevgen Burov, Viktor Hryhorovych. KNOWLEDGE NOVELTY ASSESSMENT DURING THE AUTOMATIC DEVELOPMENT OF ONTOLOGIES	372
Lubomyr Sikora, Natalya Lysa, Roman Martsyshyn, Yulia Miyushkovych, Rostyslav Tkachuk. INFORMATION PROCESSING SYSTEM FOR DETECTION IMPURITY IN TECHNICAL OIL BASED ON LASER	378
Yaroslav Sokolovskyy Mariana Levkovych Olha Mokrytska Yaroslav Kaspryshyn Nadiya Yavorska. INVESTIGATION ON THE PROCESSES OF DEFORMATION, HEAT- AND-MOISTURE TRANSFER IN MEDIA WITH THE PROPERTIES OF THE EFFECTS OF "MEMORY" AND SELF- SIMILARITY	382
Volodymyr Shymanskyi, Ostap Dumanskyi, Yurii Prusak. MATHEMATICAL MODELING OF NON-ISOTHERMAL MOISTURE TRANSFER PROCESS AND OPTIMIZATION OF GEOMETRIC DIMENSIONS OF THE CONSTRUCTION OF COMPOSITE MATERIALS WITH FRACTAL STRUCTURE	386

Solomija Ljaskovska, Yevgen Martyn, Igor Malets, Oksana Velyka. OPTIMIZATION OF PARAMETERS OF TECHNOLOGICAL PROCESSES MEANS OF THE FLEXSIM SIMULATION SIMULATION PROGRAM	391
Yevgen Martyn, Olga Smotr, Nazarii Burak, Oleksandr Prydatko, Igor Malets. INFORMATIONAL GRAPHIC TECHNOLOGIES FOR FIRE SAFETY LEVEL DETERMINATION IN SPECIAL PURPOSE BUILDINGS	398
Olga Smotr, Solomija Ljaskovska, Igor Malets, Oksana Karabyn. INCREASING THE ANIMATION STUDY MANAGEMENT SERVICES FUNCTIONING EFFICIENCY	404
Vasyl Lytvyn, Dmytro Dosyn, Victoria Vysotska, Andrii Hryhorovych. METHOD OF ONTOLOGY USE IN OODA	409
Andrii Berko, Irina Pelekh Lyubomyr Chyrun, Ivan Dyyak. INFORMATION RESOURCES ANALYSIS SYSTEM OF DYNAMIC INTEGRATION SEMI- STRUCTURED DATA IN A WEB ENVIRONMENT	414
Irina Pelekh, Andrii Berko, Vasyl Andrunyk, Lyubomyr Chyrun, Ivan Dyyak. DESIGN OF A SYSTEM FOR DYNAMIC INTEGRATION OF WEAKLY STRUCTURED DATA BASED ON MASH-UP TECHNOLOGY	420
Andrii Cheredachuk, Galyna Kriukova, Andrii Malenko, Maksym Sarana, Oleksandr Sudakov, Sergii Vodopyan, Yevhenii Volynets. ADAPTIVE ALGORITHM FOR RADAR-SYSTEM PARAMETERS TUNING BY MEANS OF MOTION ZONE ESTIMATION	426
Andrii Berko, Irina Pelekh, Liliya Chyrun, Myroslava Bublyk, Ihor Bobyk, Yurii Matseliukh, Lyubomyr Chyrun. APPLICATION OF ONTOLOGIES AND META-MODELS FOR DYNAMIC INTEGRATION OF WEAKLY STRUCTURED DATA	432
Andriy Lutskiv, Nataliya Popovych. BIG DATA-BASED APPROACH TO AUTOMATED LINGUISTIC ANALYSIS EFFECTIVENESS	438
Anatolii Batyuk, Volodymyr Voityshyn. STREAMING PROCESS DISCOVERY METHOD FOR SEMI-STRUCTURED BUSINESS PROCESSES	444
Nataliia Manakova, Anna Vergeles. CALIBRATION OF LOW-COST IOT SENSORS IN STREAMS	449
Ruslan Skuratovskii Yevgen Osadchyy Volodymyr Osadchyy. THE TIMER COMPRESSION OF DATA AND INFORMATION	455
Anatolii Shtymak, Pavlo Mulesa, Mykola Malyar. PROCEDURE FOR DETERMINATION OF PROFESSIONAL COMPETENCE OF A HIGHER EDUCATION INSTITUTION GRADUATE	460
Author's Index	xv

Optimization of Parameters of Technological Processes Means of the FlexSim Simulation Program

Solomija Ljaskovska
Department of designing and operation of machines
Lviv Polytechnic National University
Lviv, Ukraine
solomiam@gmail.com

Igor Malets
Department of Project Management, Information Technologies and Telecommunications
Lviv State University of Life Safety
Lviv, Ukraine
igor.malets@gmail.com

Yevgen Martyn
Department of Project Management, Information Technologies and Telecommunications
Lviv State University of Life Safety
Lviv, Ukraine
evmartyn@gmail.com

Oksana Velyka
Department of designing and operation of machines
Lviv Polytechnic National University
Lviv, Ukraine
veloks@ukr.net

Abstract— the study of functional processes of mechanical multiparameter systems becomes an urgent task during the fourth industrial revolution, when data becomes the most important aspect in this field. Research of the input data influence, changes in the process of mechanical system modeling, analysis of the interplay of different parameters relationships is an important task to ensure the most efficient production operation. The article presents results of the analysis and practical application of the mechanical systems study results in the area of mechanical engineering, manufacturing of equipment for various functional purposes, as an example, electronics, processing and food industries, etc. The necessity of technological systems creation processes simulation and visualization of actual data for further analysis of their relations, the state of mechanical system operation for the mechanical equipment manufacture, as well as the analysis of production processes for the efficient use of resources and time component of processes are shown. Examples of constructing simulation models of production processes in the FlexSim environment are given to research the impact of data relations that describe the operation of each object in particular and certain affect the overall system process. Research methods of practical use of relations of many independent parameters models of the system are offered.

Keywords— *input, output, multi-parameter technical system, information graphic technology, mathematical modeling, FlexSim simulation system.*

I. INTRODUCTION

Program **Industry 4.0 (Industry 4.0)** defines the rapid development of information technology, automation of manufacturing, robotics usage in enterprises in Europe. Management of production, packaging, sorting, etc. is done in real time, using data that updates every second. It is important to take into account influence of external factors on the technological process [1, 2, 3]. Creating virtual copies of mechanical engineering objects, modeling the interaction

processes of different parameters of the system operation in general, the impact of data on each system object separately describes the general scheme of production. An important role is played by Internet technologies for the modern automated enterprise, since the **Internet of Things** has become an integral component for design optimization, assembly of a product, technological process adjustment of machine-building industry. An important step in modern production is processing of large amounts of information, data (**BigData**) using cloud and artificial intelligence (**Artificial Intelligence**) technologies. An operator who controls engineering process at any stage must receive the processed data as quickly and conveniently as possible to analyze and decide on their further use in the technological process. Given the above stages of modern production, the urgent task is to use specialized IT platforms, business process management systems, modeling different stages of production, sorting, assembly, analysis of equipment, etc. (Fig. 1).

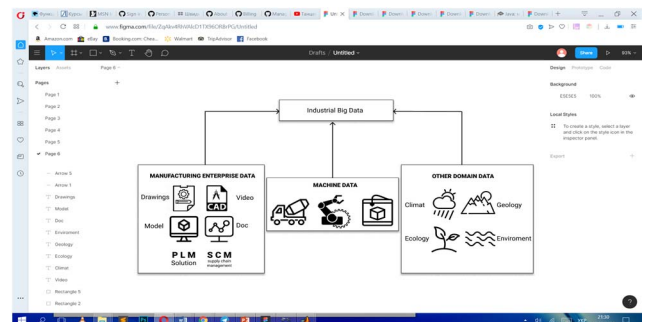


Fig. 1. Structural diagram of the factors that make up **Industrial Big Data**

Data that covers the parameters of the entire process, ie Industrial Big Data include the following components: data on the project **Manufacturing Enterprise data** (drawings of

the production object): drawings of objects **Drawings**, 3D - model, video, documentation, etc.; **PLM** solutions (**Product Lifecycle Management**) [1], product lifecycle management. These are information management systems in which data, processes, business systems and employees are combined into a single informational space. PLM systems allow you to manage important information throughout the product lifecycle – from idea, design and production stages to maintenance and disposal. Such systems mainly contain mechanical processes of the industry production cycle, managed through the implementation of **PLM** software. Therefore, being an expert in mechanical engineering, it's easy to understand and customize **PLM** software to meet industry needs;

SCM (supply chain management) [1, 2] is a management and organization strategy that approaches management of the entire data flow of raw material, materials, products, services that appear and change during the implementation of logistics, production processes. The purpose of this strategy is to obtain an economic effect (reducing delays, controlling demand for products, etc.).

The next component for **Industrial Big Data** is **Machine Data** [1, 2, 3], which we get directly from production, information about an object or process: time, pressure, speed, temperature, etc. It is **Machine Data (Time Series Data)** that is the most voluminous of all data and changes every hour, minute, second.

Other data that affects **Industrial Big Data** are environmental, ecological, climatic, terrain, and more. They determine the main characteristics of the equipment, adjusting the process of processing the object, its manufacturing, etc.

Well-known scientific studies that thoroughly investigate the processes of data collection and processing for industry, model the input and output parameters of technological enterprises. Thus, [1, 2] discusses some aspects and approaches for creating algorithms for complex hierarchical systems of industry, oriented on business analyst, the manager of enterprises, intended for individual choice of models for modeling of various practical problems, taking into account input parameters.

II. PROBLEM STATEMENT

In the structure of industry the highest share is occupied by the branches of ferrous metallurgy, mechanical engineering, electric power, chemical and food industries. Gathering and analyzing data that affects the technological process of these industries is an important element in modeling the steps of creating, processing, sorting parts, or products. Mathematical process modeling allows you to analyze the structure of work and use data to analyze predicted results, change the number of data flows, and more. Geometric modeling provides visualization of the relations between different system parameters. It is effective for multi-parameter systems where the number of system parameters exceeds three. Simulation modeling allows you to combine the two steps and create a logical, mathematical description of the process that will visually present the design results, evaluate the operation of the process and provide a direct impact on the design result in real time. Visual representation using inputs that affect the operation of each object, allows

you to better regulate the relations between the objects and to track emergency situations or changes at each stage, that lead to economic losses. Presentation of mechanical systems research results in the **FlexSim** software environment makes it possible to optimize the parameters of the system, taking into account its versatility for the study of technological systems at different stages of the product life cycle.

Therefore, the production engineer should have an overall outline of the production line and understand the impact of the data that changes over time for each step. In our opinion, this is effective when creating a simulation model of the process as a whole and separately for each stage of the technological process. The algorithm for constructing a map of processing data creation process can be :

- analysis of the input data taking into account the process features;
- creation of a mathematical model where the relations between different parameters and the interaction between the stages of the technological process are researched;
- creating a simulation model, researching possible contingencies by looking into possible combinations of data that create problem areas in the process;
- prediction of changing parameters, initial data, relations between objects, complication or simplification of technological process model of mechanical engineering to save resources, time;
- possibility to implement changes to model creation.

The development and study of the functionality of simulation models for the analysis of technological systems is an urgent task for modern production.

III. STAGES OF RESEARCH OF PRODUCTION PROBLEM AND CREATION OF ITS MODEL

In order to study the technical system of production, it is first of all necessary to process the data related to the process. Consider a system structure denoted by its **St**. It is described by many elements of the system

$$Me = \{e1, e2, e3, \dots\} \quad (1)$$

and the many relations between them

$$Z = \{z1, z2, z3, \dots\}. \quad (2)$$

Then

$$St = \{Me, Z\}. \quad (3)$$

The behavior of such system (3) is effectively investigated as a sequence in time of its states. Each state of the system is affected by certain external factors, which are also taken into account in the simulation. The use of a simulation model improves the search for rational solutions in the management of an industrial enterprise. We distinguish the main stages of research and analysis of the model:

1. Formulation of goals. Allocation of a goal (multiple goals) that must be reached during management.
2. Definition of the object of management (research). This stage involves a detailed analysis of the part of the process (or the whole process) that interests the engineer and is based on the goal. At this stage, a description of the factors influencing the technological process, the environment, select several variants of the object and choose the appropriate variant on one or more criteria.
3. Structural optimization of the model. This stage consists of the following steps: determination of input and output parameters of the object, selection of structural elements of the model, changes of parameters.
4. Correction of the whole control system, all stages of control: selection of system elements (trimming elements), changing the structure of the system (inputs / outputs of the model).

Analyzing the parameters that affect the model as a whole, we can draw up a model structure that describes the relations between different parameters that affect the flow of the industry process (Fig. 2).

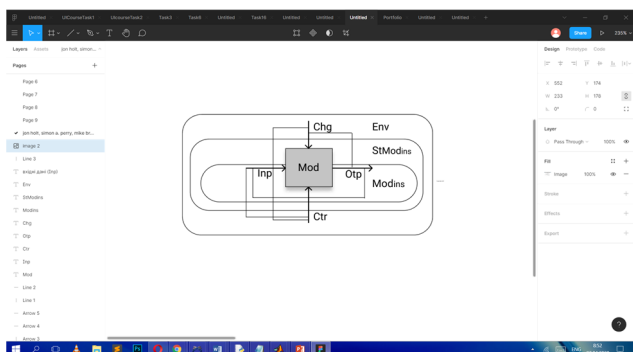


Fig. 2. Relationships between different parameters that affect the process

Consider the process modeling of industrial processes in accordance with Fig. 2.

The study of the **Mod (Model)** of the enterprise takes into account the influence of the following parameters:

Inp - (Input) input: This is information about objects managed by an industrial enterprise, an information stream that comes describing the process;

Chg - (Changes) changes made during the research process, (data entry, variables, relationships);

Ctr - (Control) control rules, their relations and the impact on the process as a whole and on the simulation results. **Chg and Ctr are interrelated**, since the quality control of the modeling processes can be done through changes in the input data that characterize the modeling objects. Output results in **Otp (Output)**, which are related to the following variables: **Inp** (input);

Chg - changes that are made during the study of the modeling process.

The set of data sets and relationships between parameters is investigated in the following spaces:

Mod ins are internal processes that take place within the model and describe the set of relationships between the various parameters that affect the **Mod** process.

Env - the influence of the environment on the process of changing external data and their impact on the processes Mod in;

StModins is a structure of a modeling process that incorporates Modins internal processes and the influence of external factors Env.

For the study of industrial lines, we have chosen the **FlexSim** environment, which is effective for simulation. Consider modeling on the example of the process of sorting products in a warehouse with the involvement of the operator [4, 5]. The model can be effective for detecting defects in batch production or checking for product quality (Fig. 3).

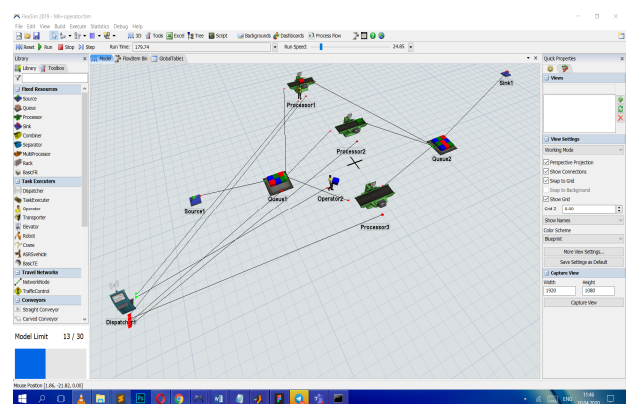


Fig. 3. Simulation model of the process of sorting products with the involvement of operators

The proposed scheme consists of the following objects:

Source1 - object creation,

Queue1, 2 - queue, assembly point,

Operator 1, 2 - operators,

Dispatcher - an object designed to control the operators.

Processor1, 2, 3 - processors,

Tote - sort object,

Slink1 - exit, process stop point.

In the properties of **Source1** (Fig. 4) we enter data on the type of products being investigated and the number of objects at the entrance. For this example, we obtain two types of output as follows:

Source - Triggers - On Creation - Set The Item Type and Color - Item Type - duniform (1, 2, getstream (current)).

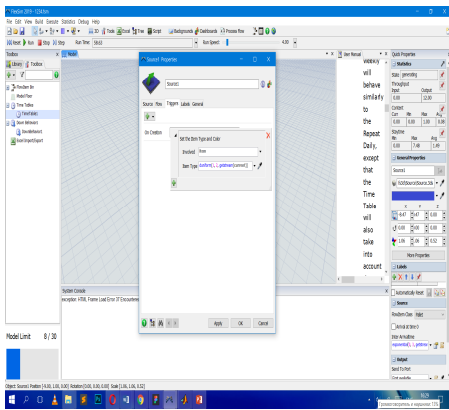


Fig. 4. Enter the initial data to work in the FlexSim environment

For each object in the FlexSim system, it is possible to choose the type of distribution (Fig. 5). The **Source** object specifies the data for the distribution of objects, information about the selected port for the movement of each object. The path to determine the port for object movement is as follows: **Source - Send To Port - First available.**

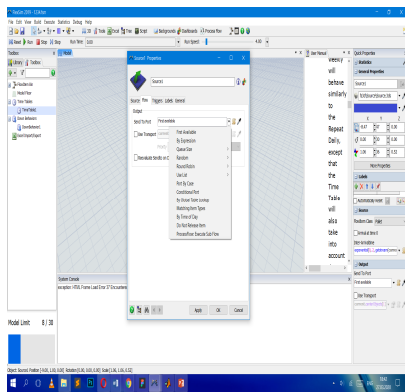


Fig. 5. Select the type of object distribution for **Source1**

During the development of a simulation model of products sorting process involving the operator, the impact of different data on each object in particular and on the system as a whole was analyzed. In Fig. 6 shows a diagram of the relation between model parameters and the display of data that affect each object in particular.

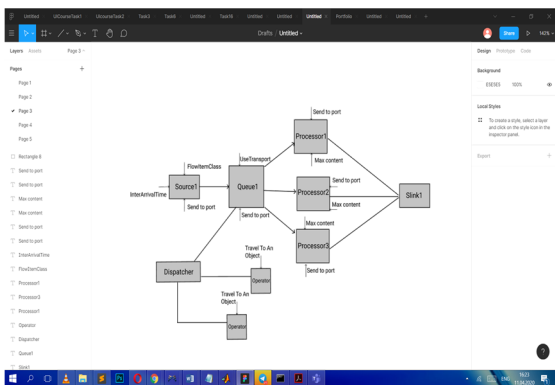


Fig. 6. Scheme of the relationship between the model parameters and the display of data that affect each object in particular

The first step is to set the input for the **Source1** object. Here are the main types: **Inter - ArrivalTime, FlowItemClass, SendToPort.**

The **Inter - ArrivalTime** option determines the time of arrival and the type of data distribution, where we select the data to be distributed as follows: **exponential (0, 2, getstream (current))**, where **num exponential (num location, num scale [, num stream])**.

Value type **num** determine how often flows are created (in seconds) that returns a unique random data stream associated with the object.

The **FlowItemClass** option allows you to select the type of objects, for example, in this case **Pallet** is selected. Among the known options is the ability to select objects of different geometric shapes (**box, cylinder, sphere, circle, pallet, track, etc.**) to study the features of technological processes taking into account the structural shape of models, parts, products, etc. The program also allows you to create your own type of object, to give it the necessary characteristics:

Source1 - Source - FlowItemClass - Go To FlowItemBin.

The data to be entered in **SendToPort** 'is responsible for the number of ports and the principle of allocation of objects or parts, respectively, for each port. The way to specify this option is as follows:

Source1 - Flow - SendToPort -GoToFlowItemBin - FirstAvailable.

FirstAvailable is a type of object allocation that does not require a port number and number of objects, a feature distribution. This type of object distribution allows them to move in one direction only, since only one port and one direction are specified. Otherwise, you must specify a condition for the distribution of objects by the given characteristics, for example: **By Expression, Queue Size, Random, Port by Case, By Global Table, By Time of Day.**

Consider the **Queue1** object (Fig. 6) for which the following data is given: **Maximum Content**, for example, 5 units is the number of units of parts or products that will accumulate at a station before moving to the next station. There are two ports connected to **Queue1**, that is, two object directions. You must specify a destination for each product type by selecting **Port by Case** or setting an arbitrary direction of travel

Source1 - Flow - Send To Port - Go To FlowItem Bin - Port by Case.

For **Processor1, Processor2, Processor3**, we enter data corresponding to the number of objects at the specified station and obtain the number of input and output ports corresponding to the number of connections (Fig. 7).

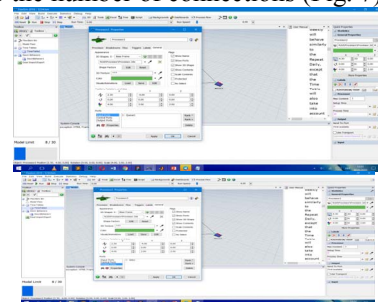


Fig. 7. Input and output ports for **Processor1, Processor 2, Processor3** objects

The **Slink1** object (Fig. 6) is a process stop, a simulation end, an exit.

In order to optimize the processes of the engineer, it is necessary to analyze how it is more efficient to move parts or objects to other stages of the technological process, whether to involve the operator, or to program the types of products sufficiently for further distribution. You need to calculate these questions, create a simulation model and compare the options. Therefore, modeling processes in the **FlexSim** environment is an effective way to explore and analyze different solutions to a single problem.

IV. SUBSTANTIATION OF BASIC STAGES OF RESEARCH, ANALYSIS OF STATISTICS AND VISUALIZATION OF SIMULATION DATA IN FLEXSIM ENVIRONMENT.

The analysis shows that in the study of processes using simulation of technological processes in the **FlexSim** system, there are five main stages of the study [8, 9] on (Fig. 8).

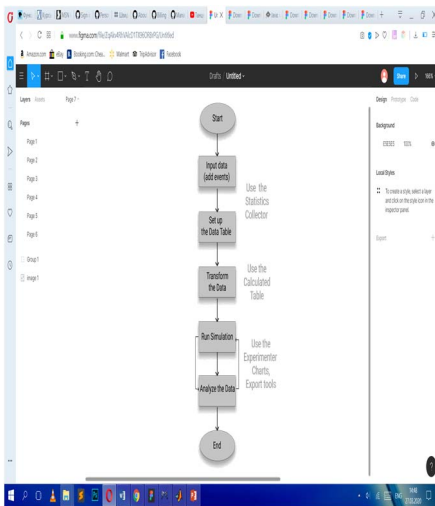


Fig. 8. An algorithm for entering and processing data in the **FlexSim** system

The first step is to set objects, enter data, create events, and build relations between objects. We use **Statistic Collector** to view standard statistics for each object. The standard statistics overview for a 3D object in real time is as follows:

3D model - 3D object - Quick Properties - Expand button.

In particular, we use the processing of these types of data using the **Statistic Collector** option. These options are contained in the **Statistic** group tab, which automatically expands when the simulation process starts. In Fig. Fig. 9 presents statistics of the **Queue1** object of the simulation model of the process of sorting products with the involvement of operators, which is shown in Fig.8.

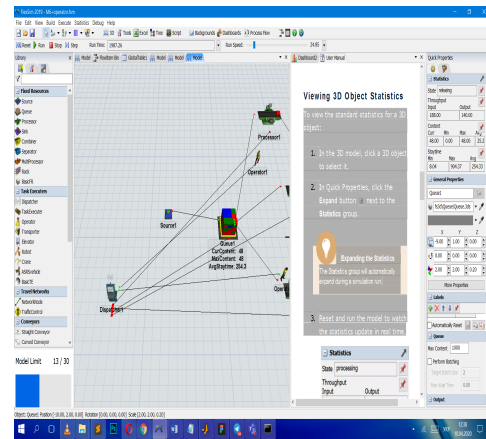


Fig. 9. Overview of object statistics when starting the simulation process

The next step in the **FlexSim** data processing algorithm is **Transform the Data**. We use **Calculated Table** to work with the data. **Calculated Table** can transform data obtained from **Statistics collector** in many ways: filtering, comparing, using advanced calculations, and more.

Once the simulation process is started, it is possible to analyze the data using **Dashboard** and **Use the Experimenters Charts**. For example, we analyze the dependence of the content of objects at a given station on time by creating a **Dashboard (Statistic - Content - Pin to Dashboard - Content vs Time)** (Fig. 10).

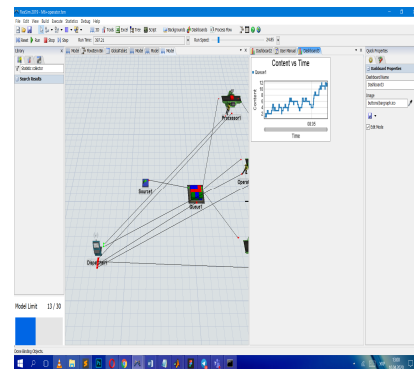


Fig. 10. Graph showing the dependence of the content of objects in a certain time interval

We see that in a certain interval of time (8 seconds) the number of units (4 pieces) that passed through this station was obtained.

V. SUBSTANTIATION OF TECHNOLOGICAL PROCESS FOR THE FOOD INDUSTRY (FOOD INDUSTRY) ON THE EXAMPLE OF THE JUICE BOTTLING PROBLEM. CREATION OF A SIMULATION MODEL OF THE PROBLEM BY MEANS OF FLEXSIM.

Consider the technological stage of production and bottling of juice (Fig. 11). The main production sites for the production of juice are the preparation of raw materials, dosage - mixed section, bottling and finished goods accounting. An important stage is water treatment. The water is purified and softened. The recovery of concentrated juices is that, with the help of special equipment, the moisture is recovered, that is, the prepared water is added. The next stage is the preparation of the container: the receipt of the container on the bottle washer, then on the labeling machine, dosing and filling machine, a special sealing machine. A visual

inspection machine is also required in order to notice a defective product [4].

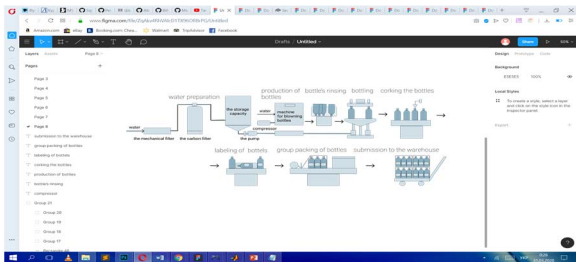


Fig. 11. Scheme of technological process of production and bottling of juice

The process of packing juices is to optimize the entire supply route, taking into account the interests of the manufacturer and the end consumer. Therefore, it is important to calculate the main steps and analyze them. For analysis, we considered the problem of constructing a simulation model of the operation of the juice bottling line. An empty bottle is sent to the line every second, sent to one of three sinks, each of which processes it in 3 ... 5 seconds. The bottles are then fed to a dispensing machine that spends 2 seconds filling each bottle. After that, two packing machines seal the bottles and stick labels. In this case, 10% of bottles are discarded. and optimize the simulation model of the shop [6, 7, 9].

FlexSim environment was used to create a simulation model of this technological process (Fig. 12).

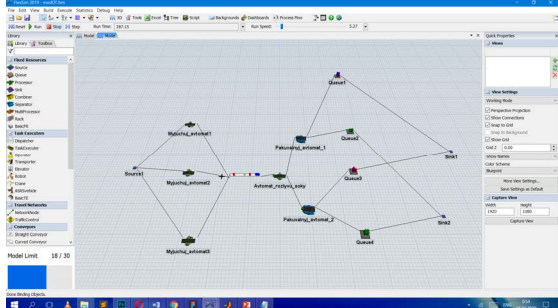


Fig. 12. Construction of a simulation model of the operation of the juice bottling line

From the **Source1** source, imitation models of bottles for three **Myjuchuj_avtomat1**, **Myjuchuj_avtomat2**, **Myjuchuj_avtomat3** washing machines are included every second, among which there are defective ones (Fig. 13).

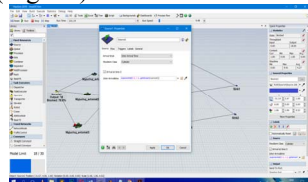


Fig. 13. **Source1** properties to output objects to a line

Assigning three objects to the simulation model of the problem is as follows:

Source1 - Triggers - OnCreation - SetItemType and Color - ItemType - duniform (1,3, getstream (current)) in Fig. 14.

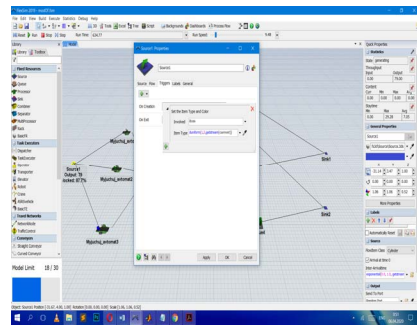


Fig. 14. The way to specify three types of objects

For the demonstration of defective objects is indicated in green in Fig. 12.

By the condition of defective bottles of 10%, so we denote this number of objects at the input, and set the other two types 45% and 45% equally to fulfill the initial condition (Fig. 15): **Source1 - Triggers - OnCreation - SetItemType and Color - Data - Set ItemType by Percentage**.

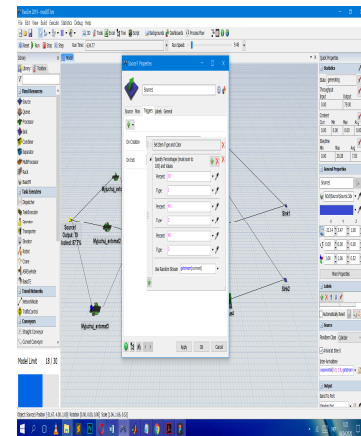


Fig. 15. Specifying object types

From the three washers, the bottles are fed to the conveyor, from where they move to the dispenser (**Processor 1**). After that, they arrive at two **Pakuvalnyj_avtomat_1** packing machines, **Pakuvalnyj_avtomat_2**, which seal the bottles and fit the labels. At this stage, the bottles are discarded. To model this stage, we selected a **Separator** object from the **FlexSim 2019** library, named **Pakuvalnyj_avtomat_1** and **Pakuvalnyj_avtomat_2** for both stations, and added the following properties for the sort operation (Fig. 16):

Packing_Automat_1 (Packing_Automat_2) - Separator - Split - Split / Unpack Quantity - By Percentage; Use Random Stream - getstream (current).

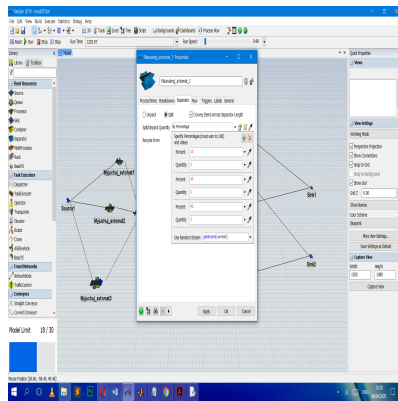


Fig. 16. Bottle rejection data entry

Queue 2 and **Queue 4** queues select discarded products that go to **Slink2** (recycle). **Queue1** and **Queue 3** turn into warehouse products (**Slink1**).

Using statistical analysis, it is possible to observe the frequency of receipt of defective bottles at the **Queue2** and **Queue4** station for a given period of time in seconds (Fig. 17).

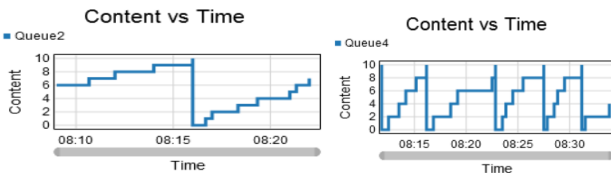


Fig. 17. Graphs showing the number of defective bottles (units) arriving at the station in the allotted time

VI. CONCLUSIONS

The result of the development of a structural model of the study of relations between different parameters of technological processes of industry is presented. The steps of data study necessary for simulation in **FlexSim 2019**. The following advantages of using this environment for specific tasks, such as the food industry, are demonstrated:

1) a simulation model of the juice bottling process allows to obtain information on various aspects of the technological process depending on the input factors;

2) the simulation model allows to investigate and analyze the process in cases where analytical calculations and mathematical programming fail;

3) it is much easier to develop an imitation model than an analytical one, since the process of creating an imitation model is step-by-step and modular;

4) the structure of the simulation model naturally reproduces the structure of the process for which the model is built;

5) a significant advantage of simulation modeling in the process of solving the proposed type of problems is the ability to explore the model in time and create an animation of its behavior, which allows you to quickly find errors.

FlexSim simulation simulation also allows you to meet the challenges of other types of industry: mechanical engineering, electricity, chemical, transportation and transportation logistics etc.

REFERENCES

- [1] Ye. Nong, Data Mining. Theories, Algorithms, and Examples, CRC Press, 2014.
- [2] P. Giudici and S. Figini, Applied Data Mining for Business and Industry, Wiley, 2009.
- [3] Shu Ing Tay, Lee Te Chuan, AH Nor Aziati, Ahmad Nur Aizat Ahmad, "An Overview of Industry 4.0: Definition, Components and Government Initiatives", Journal of Advanced Research in Dynamic and Control Systems, 10 (14), 2018, pp. 1379 - 1387.
- [4] J. Mager, ILO Encyclopaedia of Occupational Health and Safety. Fourth Edition. Chapter 67, The Food Industry, Geneva, International Labor Office, 1998.
- [5] J. Holt, S.A. Perry and M. Brownsword, Model - Based Requirements Engineering, Institution of Engineering and Technology, London, United Kington, 2012.
- [6] O.Gumen, S.Ljaskovska and A. Ujma, "Forming the optimal parameters complex for the production process by means of FlexSim" Zeszyty Naukowe Politechniki Czestochowskiej ISSN No. 25, 2019, pp. 55-60.
- [7] E. Forcael, M. Gonzalez, J. Soto, F. Ramis and C. Rodriguez, "Simplified Scheduling of a Building Construction Process Using Discrete Event Simulation", 16th LACCEI International Multi-Conference for Engineering, Education and Technology: "Innovation in Education and Inclusion", Lima, pp. 1-11, 19-21 July 2018. DOI: 10.18687 / LACCEI2018.1.1.194.
- [1] S. Liaskovska, "Data processing of technological processes in mechanical engineering", Scientific Bulletin of the Tavria Agrotechnological State University, Melitopol: TSATU, Is. 9, vol.1, 2019. [URL: <http://oj.tsatu.edu.ua/index.php/visnik>. DOI: 10.31388 / 2220-8674-2019-1ISSN 2220-8674.9]

Informational Graphic Technologies for Fire Safety Level Determination in Special Purpose Buildings

Yevgen Martyn
Department of Project Management,
Information Technologies and
Telecommunications
Lviv State University of Life Safety
Lviv, Ukraine
evmartyn@gmail.com

Olga Smotr
Department of Project Management,
Information Technologies and
Telecommunications
Lviv State University of Life Safety
Lviv, Ukraine
olgasmotr@gmail.com

Nazarii Burak
Department of Project Management,
Information Technologies and
Telecommunications
Lviv State University of Life Safety
Lviv, Ukraine
nazar.burak@ukr.net

Oleksandr Prydatko
Department of Project Management,
Information Technologies and
Telecommunications
Lviv State University of Life Safety
Lviv, Ukraine
o_prydatko@ukr.net

Igor Malets
Department of Project Management,
Information Technologies and
Telecommunications
Lviv State University of Life Safety
Lviv, Ukraine
igor.malets@gmail.com

Abstract — The article deals with the problem of public awareness about existing special purpose buildings such as protective buildings and shelters that can be used to protect against emergencies. The status update on the problem is considered. During research were analyzed recent scientific papers in the field of modern information technologies integration into civil protection system. The necessity of using modern informational graphic technologies for fire safety level determination in such type of shelters was substantiated. The features of actual data visualization with the involvement of mathematical transformations and methods of visual information graphing are investigated. Based on the offered methods of visualization graphics information has been developed software emulator “Fireware Emulator”. It can be used for fire safety level determination in buildings of such type.

Keywords— informational graphic technologies, software emulator, shelter, civil protection, room plan.

I. INTRODUCTION

The current integration state of modern information technologies to human life environment initiate appearance of new natural threats which can be serious risks to its normal and safety life. Military conflicts and the risks to use mass destruction weapon forced us to make protective purpose buildings - safety places such as housing units and shelters where peoples could stay and live during emergency situation.

Based on the daily facts of human life process both society and its individual members, we observe a progressive tendency towards increasing potential threats to humanity. The amount of the increasing anthropogenic and natural character risks is proportional to the number of tasks to be undertaken to ensure the safety of human life. Among these problems we could highlight the problems of peoples safe staying in protective purpose buildings: housing units and shelters.

The process of necessary building choosing is based on own human's preferences, its geographic location, type of

emergency situation and other additional factors. But the most important among them is security (Fig.1). First, in such protective building, user should to determine the state of fire safety, the possibility of safe evacuation from the rooms and the comfortableness level of staying. After it, on the basis of visualized data about protective building, human should to analyze the possible deterioration causes of the situation in the shelter and to identify ways to better its planning. All upgrades must be produced by taking into account the position of ensuring proper level of fire safety.

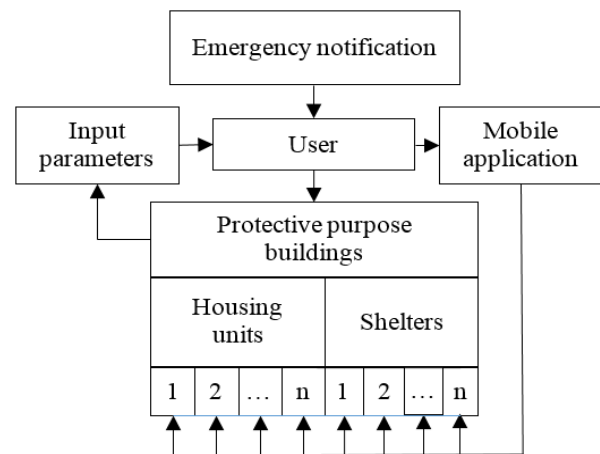


Fig. 1. Flowchart of necessary protective purpose buildings choosing process

If emergency situation will appear and it will be necessary to use protective building or air raid shelter, user should know in advance all important data, including comfortableness level and safety stay in it.

The main requirements that applies to protective buildings and shelters are regulated by the relevant state documents and the Civil Protection Code of Ukraine. These documents specify the external and internal parameters of the protective buildings. External includes geographical location and distance from neighboring homes, and internal includes

buildings configuration and planning of elements for safe staying users indoors. However, it is also important for users to have actual information about such buildings.

II. PROBLEM STATEMENT

Review of recent international research shows numbers of existing developments in the fire safety field, particularly about uses of information technologies to improve human's life safety. The whole process of modeling protective environment in buildings for different purpose, including shelters has been describing in detail by scientists. In [1] were explored some aspects and approaches for creation of user-oriented mobile information technologies. This software is developing for individual use to help people in choosing suitable fire protective building where they could hide during emergency situation. According to [2], authors had analyzed fire safety requirements to information technology for implementation in selected commercial building. The main practical requirements to information technologies for fire safety providing in different types of buildings are highlighted and analyzed in [3, 4, 5].

Researches [6 - 10] refer to evaluation system of building fire emergency response capability maturity (FE-CMM) that based on the capability maturity model (CMM). Mostly they are considering to acceptable ways for emergency situations response. Authors declared that the proposed module could preliminarily realize the intelligent evaluation of building fire emergency response capability. Also, it able to improve the practice and intelligence of the fire emergency response capability evaluation, especially in smart cities. Studies [10-12] analyze the main features of developing, improvement and uses of modern information technologies in the field of civil protection, particularly during implementation of safety-oriented emergency response projects.

However, there are still little number of studies that related to software development for protective buildings safety evaluation, as well as for situation comparing capability in different buildings during best option choosing process. Today, there are also not enough information about qualitative evaluation of information technology impact to decision making process of choosing particular building type.

Current state regulatory documents determine all requirements to protective structures, buildings and shelters arrangement, particularly, from the point of safe stay in them. But, due to requirements universality and generality, shelters are objectively limited in ability of getting attention to each ones. The reason of it – lack of a real possibility to create completely safe building for a long stay. As a result, people must make choice of protective building and carry out its arrangement by themselves. This will be possible only if the following conditions will meet:

- the choice of each protective building or shelter is based both on its level of comfortableness and fire protection;
- all possible ways of getting to the protective building or shelter are analyzed depending on humans' location during an emergency;
- information technologies are used as a helping tool to make choice of protective building;

- preliminary prediction is made to determine unforeseen occasions appearance possibility during humans' stay in shelter;
- it is possible to make own additions to the contingency plan.

Therefore, according to previously outlined problems, developing of graphic information technology for fire safety evaluation of protective purpose buildings is one of the most important and urgent task in nowadays moving world.

III. SUBSTANTIATION OF DATA VISUALIZATION METHODS USE IN PROTECTIVE BUILDINGS FIRE SAFETY EVALUATION PROCESS

In general, users informational content I about protective buildings or shelters include two components: visual (presence component) and virtual (technological component) object review. Some users can get necessary information directly by observing selected object without using any information technology (IT), while others can use special software. Bases on this and according to [10], informational content I could be determine by the following equation:

$$I = u + iv = (x + iy)^3 \quad (1)$$

where u , v – components of information content, respectively, without and with the use of information technology; x – presence component parameter that indicate the level of knowledge about object without using IT; y – technological component parameter that indicate the level of knowledge about object with using IT.

Parameter y also takes into account both the level x' of knowledge about the object (building) and the use of developed application f :

$$y = x' + f \quad (2)$$

In most cases, x' does not always equate to x , but for simplifying research, we accept that $x = x'$. According to this, (1) takes the following form:

$$I = u + iv = x((4x^2 + 6xf + 3f^2) + i(x^2 - 3f^2)) \quad (3)$$

The working range of variables x and f in information content I level determining process is in diapason between 0 and 1. Equation (3) determine information contents value I as a direct numerical dependence to the parameter x : for each level of information support f , the value of information content is equal to zero if $x = 0$. As a result, information content components u and v defines function of x and f . Thus, if we take these conditions into account, components values will determine like (4) and (5):

$$u = 4x^2 + 6xf + 3f^2 \quad (4)$$

$$v = x^3 - 3xf^2 \quad (5)$$

If user does not use software for help in choosing suitable shelter and condition (2) is fulfilled, the value of components u and v will determine (6) and (7):

$$u = 4x^3 \quad (6)$$

$$v=x^3 \quad (7)$$

Component v has value change restriction (8) of x and f . In our research we use only positive values that fits condition $x > 3f = a$ and belongs to zone A (Fig. 2).

$$v=x(x^2-3f^2)=x(x-\sqrt{3}f)(x+\sqrt{3}f) \quad (8)$$

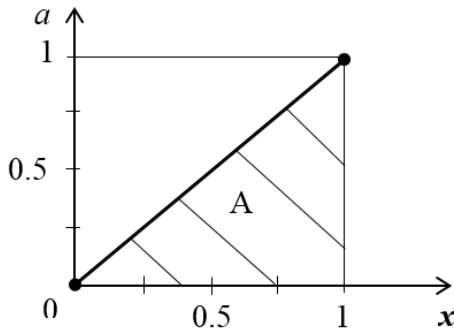


Fig. 2. Restriction zones of parameters

Now, let us determine the influence of parameters x and f to component u (4) values change. Even if x gets small values, such as $x = 0.1$, the values of component u increases extremely fast (Fig. 3 a). This proves the efficiency of using information technologies f .

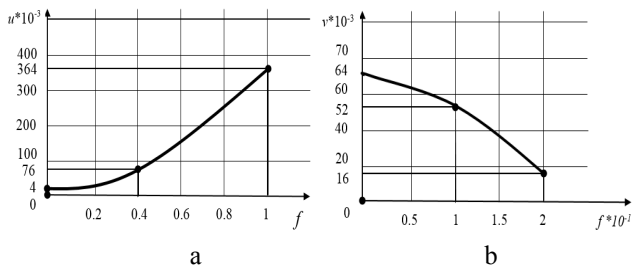


Fig. 3. Dynamics of components u (a) and v (b) values change

The information contents' component v is determined by the amount of knowledge set ($x' = x$) about buildings fire safety state according to which IT is used for help. The main condition that applies to v it is $x' = x > \sqrt{3}f$ (Fig. 3 b).

IV. DEVELOPMENT PROCESS OF INFORMATION GRAPHIC TECHNOLOGY FOR PROTECTIVE PURPOSE BUILDINGS SAFETY LEVEL DETERMINING.

Information technologies and its use in the field of Civil Defense can solve problem of visualizing data about protective purpose buildings. Basically, proposed emulator will work with graphical parameters of the buildings, which are used during its floors plan creation. Also, there will be possibility add another data, such as temperature of the shelter environment, the presence of fire extinguishers, etc. (Fig. 4).

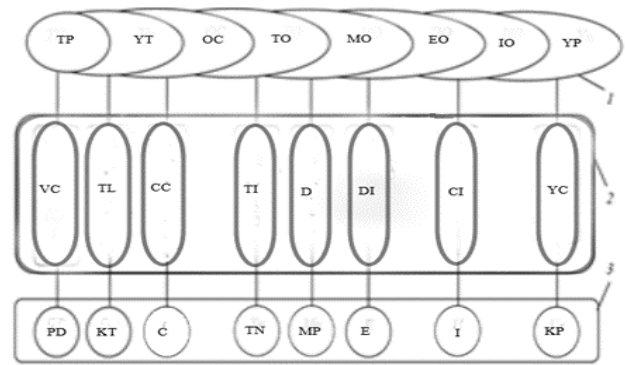


Fig. 4. Information model of data visualization process about protective purpose buildings with use of emulator

where 1 – emulator software operation block: TP - the technological process of emulator creation; YT - control units; OC - provision by programmers; TO - the level of equipment provision; MO - material resources; EO - energy resources; IO - the financial value of technology; YP - software resources; 2 - functional parameters of providing data visualization processes: VC - emulator implementation environment; TL - involved information technologies to the emulator creation process ; CC - the level of performers provision; TI - the level of information provision; D - the level of GPS monitoring technologies involvement of ; DI - the level of easy getting to the building; CI - transport infrastructure near buildings location; YC - basic standards for program creation; 3 - visualization resources: PD - the output product of emulator ; KT - programmers team; C - the product of created program; TN - technical means; MP - material resources; E - energy resources; I - information resources; KP - IT project team.

Information graphic technology is designed as an emulator program “Fireware Emulator”. For its development were chosen Java. “Fireware Emulator” allows users to evaluate protective buildings or shelters safety level.

Java is an object oriented language which gives a clear structure to programs. There are some major advantages of this language. Java is straightforward to use, write, compile, debug, and learn than alternative programming languages. Object oriented programming is associated with concepts like class, object, inheritance, etc. which allows you to create modular programs and reusable code. Java code runs on any machine that doesn't need any special software to be installed. Those advantages are essential in developing secure, powerful device or computer system that gives you possibility for quick use of the right class and method. Software emulator “Fireware Emulator” was developed using IntelliJ IDEA 2019.1 Community Edition.

A flowchart of proposed software development stages was designed to facilitate the process of its programming (Fig. 5). The emulator has friendly user interface, is quite reliable and provides high speed of safety evaluate algorithm calculation.

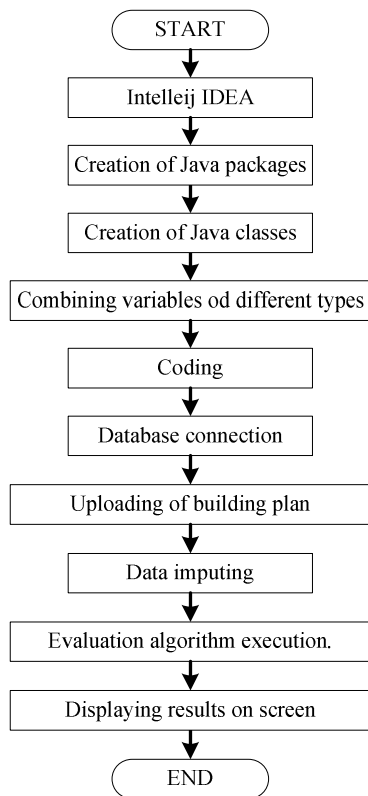


Fig. 5. The flowchart of the "Fireware Emulator" development process

Designed information graphic technology as an emulator program allows users evaluate the security level of shelters independently. The software supports different types of protective buildings and their plans. An algorithm for the process of choosing a safe building is presented in Fig. 6.

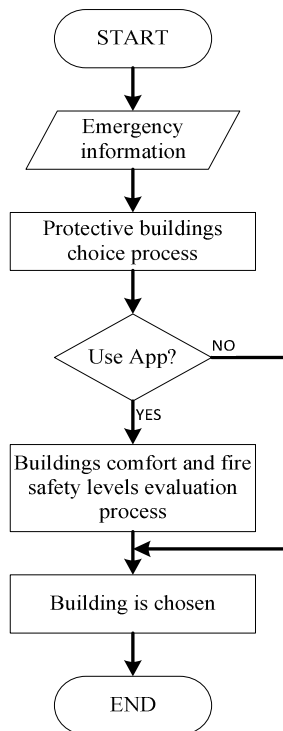


Fig. 6. The flowchart of protective building choosing process

User obtain actual information about buildings fire safety level and can check its reliability and evaluate his own

protection in emergencies. This is possible by integrating buildings plan into emulator's database.

When buildings or shelters plans are importing into software database, the following parameters must be specified: inner temperature, height and width of the room, a wall material, the number of persons who may present at the same time. Lighting and air filtration settings are also available. Based on all this data, the program makes analyze and outputs the result of security level evaluation.

Software adaptation to the real conditions of the shelters and protective buildings is provided by changes of their plans. They are made based on additional perimeter measurements. Emulator "Fireware Emulator" stores visualized data of plan in its database, that makes them acceptable for changes up to different conditions.

The emulator interface for the school building is shown in Figure 7.

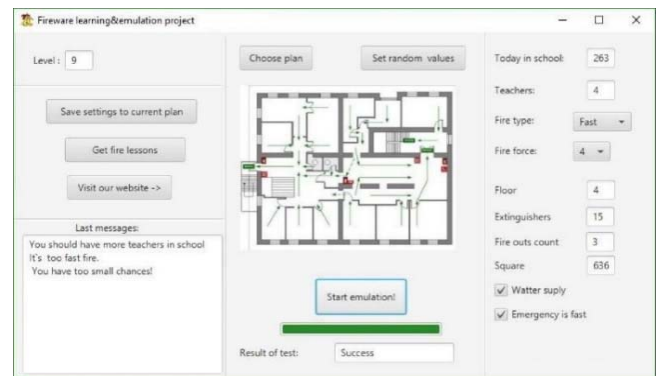


Fig. 7. Initial parameters values setting in software "Fireware Emulator"

Input parameters: two hundred sixty-three students and four teachers will be staying in building at the same time and each of them had passed a fire safety courses; there are four floors, three emergency exits and fifteen fire extinguishers; all-day water supply.

Developed software is open for updates. There is an opportunity to quickly add plans of buildings, functionality, providing reliability, accessibility and multiplatform. A high level of protection against unauthorized changes to the code was used.

V. USES OF DEVELOPED SOFTWARE IN FIRE SAFETY EVALUATION PROCESS

Next stage of research is analyzing correctness of the software algorithms. There were 4 practical experiments conducted using different input parameters, protective building plans and squares.

Experiment 1. Input parameters used in experiment: storage temperature - 21 °C, height - 2.45 m, width - 4.35 m, wall material - metal construction, number of persons - 5. The result of emulation (Fig. 8) demonstrates that such protective building complies to all standards and regulations and is completely safe to stay in an emergency.

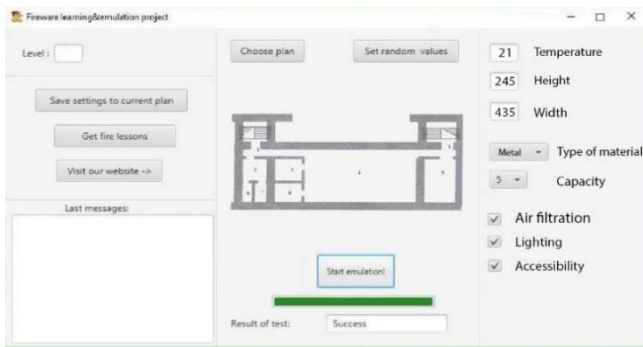


Fig. 8. Experiment 1: result of “Fireware Emulator” running with input parameters

The program provides a large number of parameter combinations. The algorithm selects the most optimal by analysing of given data [10]. In case of inconsistency, the program produces a negative result.

Experiment 2. Were used parameters which did not complies to standards or regulatory documents. Due to input parameters this shelter is uncomfortable for staying and the result of fire safety evaluation is negative (Fig. 9).

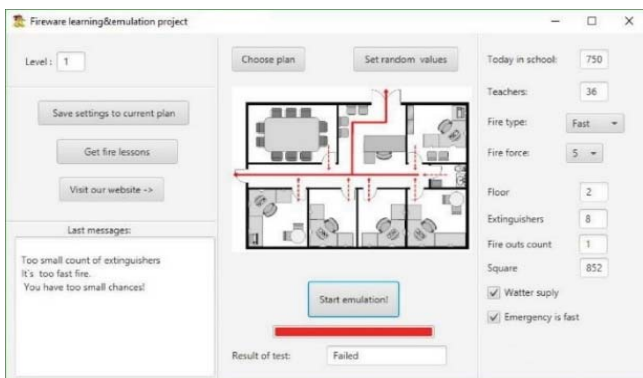


Fig. 9. Experiment 2: the result of buildings fire safety evaluation with many people inside

This is because there is no ability to avoid the danger: the building has a large square and only one spare exit, the number of people is too big, the fire ignites quickly and there are only eight fire extinguishers.

Experiment 3. A shelter with small square were analysed. Also there were a low wall height and inside temperature (8 ° C), the number of staying persons - 6. According to the normative documents, such protective building is not suitable for a comfortable staying despite positive level of fire safety evaluation. The result of the program demonstrates a similar conclusion (Fig. 10).

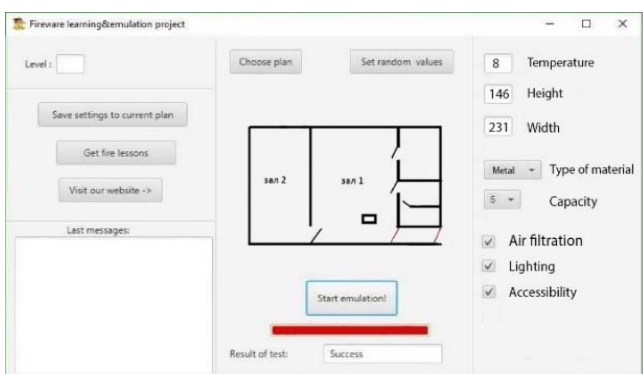


Fig. 10. Experiment 3: negative result of shelter staying comfortability

Experiment 4. In developed software “Fireware Emulator” is predicted a graphic information window for displaying problems which must be solved to increase both fire safety and comfortability levels. In Fig. 11. is presented the result of evaluation process, according to the input parameters. In information window is displayed text message with recommendations.

Analyses of input conditions and received recommendations (Fig. 11) shows that the algorithm of message output is correct. The inside temperature of 4 degrees above zero storage does not correspond to the norm, the height - 1.68 m and the width - 4.61 m. In this experiment, there is lighting, but no air filtration. All this conditions are dangerous and not comfortable for staying of 52 people in shelter.

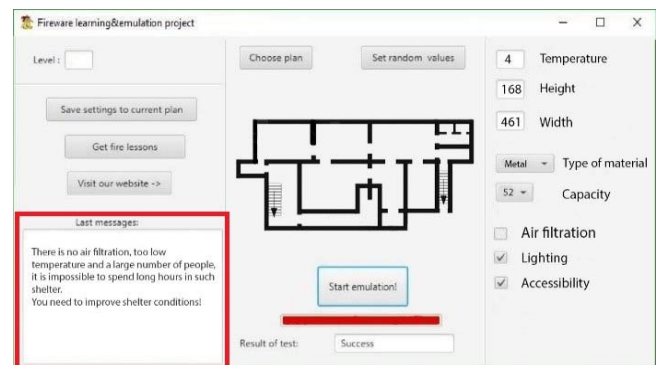


Fig. 11. The result of evaluation process with generated recommendations

The errors and deviations of the program are minimal, and their analysis indicates correctively of algorithms calculations.

VI. CONCLUSION

Current rates of science and technology development, integration of information technologies into everyday life of society, state of ecology and influence of anthropogenic factor on the environment lead to appearance of new emergencies. The ability to make the right decisions in such circumstances is a guarantee of safety human's life. That is why it is so important for human today to have as much as possible information about around environment.

Informational graphic technology was developed as an emulator program to help people in process of protective buildings fire safety level evaluation. The emulator program "Fireware Emulator" is a product of universal purpose. It helps to determine the level of person's security staying in protective purpose buildings. Developed software is designed for personal use. Performance of the program can be enhanced by the combination of prior knowledge about object and the information component comparing. Also were made mathematical substantiation of evaluation algorithms execution correctness.

Integration of the latest information technologies in the field of civil protection will provide to society an effective tool for analyzing and using data to explore possible ways of avoiding or protecting against emergencies.

REFERENCES

- [1] E. Martyn, S. Ljaskovska and N. Tarapata, "Emulator of analysis of bombshelters", Scientific bulletin of the Tavria agrotechnological state university, Melitopol: TSATU, Is. 9, vol.1, 2019. DOI: 10.31388/2220-8674-2019-1-62

- [2] M. Anjay and S. Anjuli, "Assessment of Exit Requirements for Fire Safety of Commercial Buildings, Kathmandu, Nepal", *International Journal of Emerging Technologies and Innovative Research*, vol.4, Issue 10, 2017, pp. 248-255. DOI: 10.1717/JETIR.17074
- [3] Building Department, Code of Practice for Fire Safety in Buildings, 2011, Available at: [www.bd.gov.hk/english/documents/code/fs_code2011.pdf].
- [4] OSHA, Available at: [https://www.osha.gov/OshDoc/data_General_Facts/emergency-exit-routes-factsheet.pdf].
- [5] G. Ma, S. Tan and S. Shang, "The Evaluation of Building Fire Emergency Response Capability Based on the CMM", *International Journal of Environmental Research and Public Health*, 16(11), 2019, 1962. DOI: 10.3390/ijerph16111962.
- [6] A. Rego, L. Garcia, S. Sendra and J. Lloret, "Software Defined Network-based control system for an efficient traffic management for emergency situations in smart cities", *Future Generation Computer Systems*, 88, 2018, pp. 243-253. DOI: 10.1016/j.future.2018.05.054
- [7] S. Granda and T. Ferreira, "Assessing Vulnerability and Fire Risk in Old Urban Areas: Application to the Historical Centre of Guimarães", *Fire Technology*, 55, 2019, pp. 105-127. DOI: 10.1007/s10694-018-0778-z.
- [8] N. Kwok, C. Bratiotis, M. Luu, N. Lauster, K. Kysow and S. Woody, "Examining the Role of Fire Prevention on Hoarding Response Teams: Vancouver Fire and Rescue Services as a Case Study", *Fire Technology*, 2017. DOI: 10.1007/s10694-017-0672-0.
- [9] J.C. Cheng, Y. Tan, Y. Song, Z. Mei, V.J. Gan and X. Wang, "Developing an evacuation evaluation model for offshore oil and gas platforms using BIM and agent-based model", *Autom. Constr.*, 89, 2018, pp. 214-224. DOI: 10.1016/j.autcon.2018.02.011.
- [10] R. Ratushnyi, P. Khmel, A. Tryhuba, E. Martyn and O. Prydatko, "Substantiating the effectiveness of projects for the construction of dual systems of fire suppression", *Eastern-European Journal of Enterprise Technologies*, 4, 2019, pp. 46-53. DOI: 10.15587/1729-4061.2019.175275.
- [11] O. Smotr, N. Burak, Yu. Borzov and S. Ljaskovska, "Implementation of Information Technologies in the organization of Forest Fire Suppression Process", in *Proceedings of the 2018 IEEE Second International Conference on Data Stream Mining & Processing (DSMP)*, Lviv, Ukraine, pp. 157-161, August 21-25, 2018. DOI: 10.1109/DSMP.2018.8478416
- [12] I. Malets, O. Prydatko, V. Popovych and A. Dominik, "Interactive Computer Simulators in Rescuer Training and Research of their Optimal Use Indicator", in *Proceedings of the 2018 IEEE Second International Conference on Data Stream Mining & Processing (DSMP)*, Lviv, Ukraine, pp. 558-562, August 21-25, 2018. DOI: 10.1109/DSMP.2018.8478486