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INFORMATION TECHNOLOGY FOR QUALITY EVALUATION OF PUBLISHING AND PRINTING PROCESSES

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The article investigates the problem of predictive evaluation of the quality of publishing and printing processes. The relevance of developing information technology is substantiated. This technology is designed to account for the complex structure of technological interrelations, the influence of diverse factors, and the multicriteria nature of decision-making. A scientific basis is formulated for modeling the qualitative characteristics of printing processes by applying logical-mathematical and semantic tools. A multilevel information technology is developed. It includes the stages of domain analysis, function modeling, formal representation of input data, synthesis of factor models, optimization of models, design of alternative implementations of the examined publishing and printing process, construction of fuzzy inference models, and calculation of an integrated quality index. Each stage involves the construction of a functional model based on the IDEF0 methodology. A set of quality factors is identified. These factors are modeled using logical and semantic means. A hierarchical model with weight coefficients is constructed. Process implementation alternatives are selected according to Pareto optimality principles. The final stage involves the synthesis of a fuzzy inference model, the formation of a knowledge base, and the calculation of the predicted quality level.

The generalized model of information technology is presented as a structural-functional diagram. The proposed technology is adaptable to any publishing and printing process. It ensures a complete evaluation cycle — from data collection to the generation of conclusions in numerical form. This technology serves as a universal tool for quality prediction and informed decision-making in a multifactor environment.

Keywords: *semantic network, mathematical modeling of hierarchies, multicriteria optimization, optimal alternative, fuzzy logic, quality evaluation, information technology, publishing and printing process, printing industry.*

Problem Statement. Timely quality control plays an important role in modern printing production. Certain defects that arise during the manufacturing of printed products are not always detected immediately. They become noticeable only after all production stages are completed. This leads to unnecessary consumption of materials, time, and resources.

Information technology for predictive quality evaluation of publishing and printing processes refers to a set of tools, methods, and techniques that allow the quality level of products to be anticipated before production is completed. The application of such technology makes it possible to detect potential deviations from established parameters at early production stages.

Analysis of Recent Research and Publications. Publications address the development of an information technology for monitoring the quality of additive manufacturing based on deep neural networks [1], the evaluation of print quality parameters using automated image analysis with FSIMc and iCID metrics [2], the implementation of non-contact optical defect detection in 3D printing processes [3], the application of digital models and Industry 4.0 technologies for predictive quality assessment of manufacturing processes [4], the construction of expert systems for production data analysis [5], and the formalization of knowledge for decision-making systems in a technological environment [6], among others. However, the issue of developing a comprehensive information technology for predictive quality assessment of publishing and printing processes, which considers the semantic structure of factors, fuzzy models, and multifactor analysis, remains insufficiently explored.

Purpose of the Article. The purpose of the study is to develop an information technology for predictive quality assessment of publishing and printing processes.

Results and Discussion. The proposed information technology comprises several key stages based on advanced scientific methods and information processing tools. These include domain analysis, functional modelling, formal representation of input data, factor modelling, model optimisation, design of alternative process implementation options, construction of fuzzy inference models, and computation of an integral quality index.

At the first stage, the analysed publishing and printing process is decomposed into its constituent elements, operational sequence, and functional components. The process is treated as an integrated system.

The second stage involves the development of a functional model of the subject domain. A hierarchical structure of functions is constructed, including a context diagram and decomposition diagrams. The modelling is based on the IDEF0 methodology, which enables a structured visualisation of the logic and interrelations among process stages.

Next, expert evaluation is applied to identify the key factors affecting process quality. These factors are theoretically interpreted, and models are constructed to capture inter-factor relationships. Semantic networks are synthesised to visualise the structure of influences and dependencies. Predicate logic is used to formalise these connections. A feature space is defined, serving as the input for further logical and mathematical processing. Special attention is given to the semantic characteristics of the factors: their roles, weights in relation to specific printing operations, and possibilities for aggregation and combination. Factors are prioritised through ranking, taking into account the number of influence and dependency links and their respective weight coefficients. Hierarchical trees are built to determine the degree of influence each factor has on the quality of the

publishing and printing process. The resulting data is visualised using graphical models that reflect factor prioritisation.

Model optimisation is conducted using the pairwise comparison method and multi-criteria optimisation. Principal eigenvectors of comparison matrices are computed, the resulting values are normalised relative to unity, and consistency is verified. These optimised models refine the assessment of each factor's impact on process quality, ultimately producing a hierarchical structure with numeric weights assigned to each factor [7, 8].

Alternative implementations of the analysed process are then generated. Each alternative is considered within a decision space constrained by efficiency criteria. Pareto-optimal factor sets are taken into account in calculating multi-criteria evaluations. The most effective alternatives are selected based on the highest utility function values. Additionally, the method of fuzzy preference relations is applied to incorporate uncertainty in indicator values [6, 7].

The next stage entails the construction of a fuzzy inference system. Linguistic variables are defined, term sets and value spaces are generated, and multilevel dependency models are synthesised to capture relationships between terms and quality indicators. This modelling framework reflects the algorithm by which process quality is formed.

The final stage involves computing integral quality indices using the centre-of-gravity method. A knowledge base is developed to describe the logic for achieving a target quality level. Fuzzy IF–THEN rules are formulated, fuzzy logic equations are constructed, and defuzzification is carried out. Membership functions are used to convert linguistic terms into quantitative values [8].

The structural and functional model of the proposed information technology is shown in Fig. 1.

Thus, the developed information technology is applied for predictive evaluation of the quality of any publishing and printing process, which makes it a universal tool for decision-making in a multifactor environment.

Conclusions. An information technology for predictive evaluation of the quality of publishing and printing processes is developed. It consists in identifying key influencing factors, constructing a semantic network of factors, ranking the factors to determine priority levels, developing a factor weight model based on the established rankings, optimizing the weight model to refine the weight coefficients, determining the optimal implementation variant among several designed publishing and printing processes, constructing a fuzzy knowledge system, and calculating the predicted quality indicator of the studied process.

The integration of all components into a single information technology increases the accuracy and validity of evaluation, forming a decision-support tool for publishing and printing processes.

Future research is expected to focus on the development of a fuzzy system for predictive quality evaluation and its testing in real production environments.

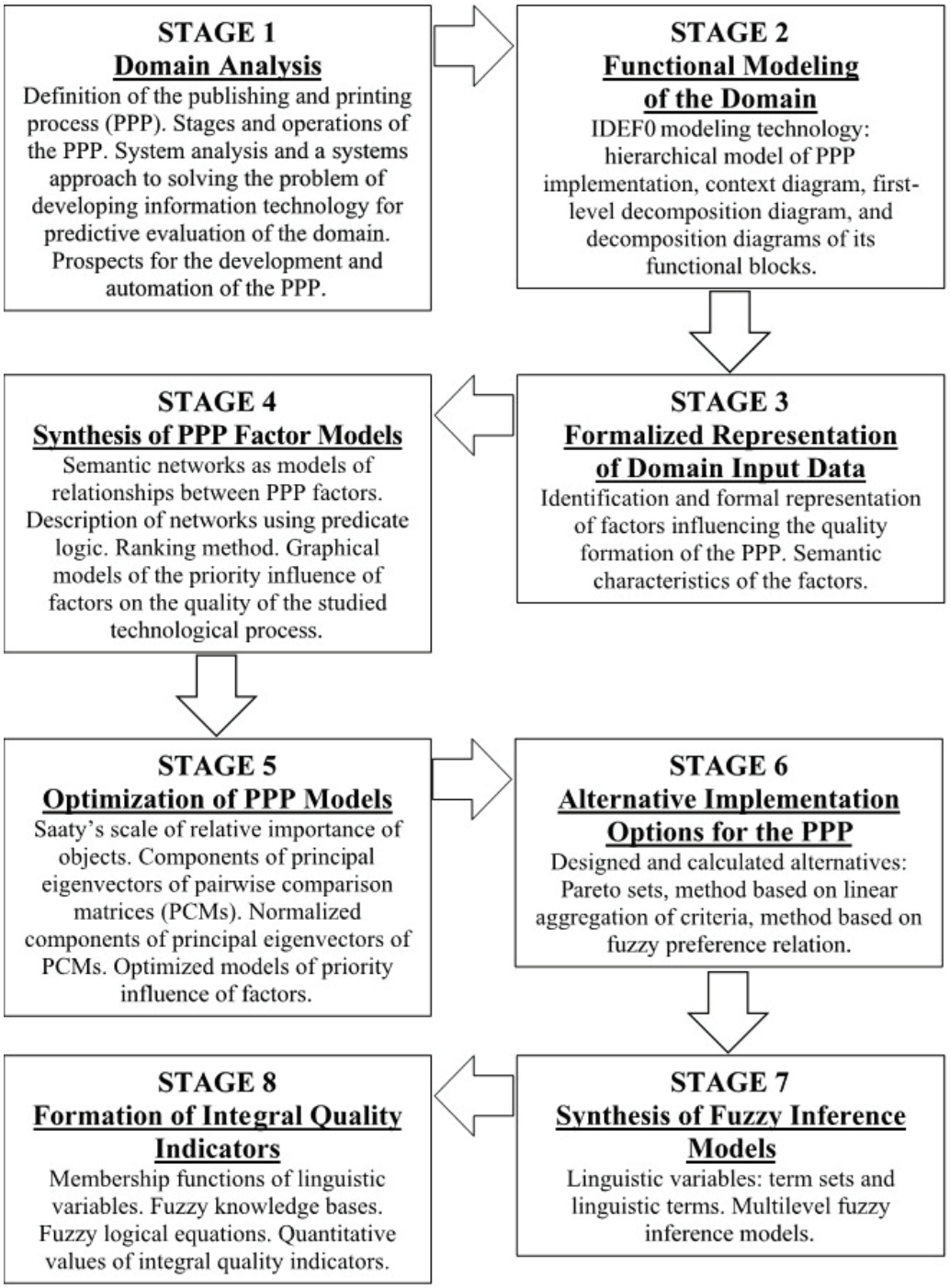

Fig. 1. Structural and Functional Model of the Information Technology for Predictive Evaluation of the Quality of Publishing and Printing Processes

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ІНФОРМАЦІЙНА ТЕХНОЛОГІЯ ОЦІНЮВАННЯ ЯКОСТІ ВИДАВНИЧО-ПОЛІГРАФІЧНИХ ПРОЦЕСІВ

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У статті досліджено проблему прогностичного оцінювання якості видавничо-поліграфічних процесів. Обґрунтовано доцільність створення інформаційної технології, здатної враховувати складну структуру технологічних зв'язків, вплив різнорідних факторів та багатокритеріальний характер прийняття рішень. Сформульовано наукову основу для моделювання якісних характеристик поліграфічних процесів із застосуванням логіко-математичних та семантичних засобів. Розроблено багаторівневу інформаційну технологію, що охоплює етапи аналізу предметної області, моделювання функцій, формалізованого подання вихідних даних, синтезування моделей факторів, оптимізації моделей, проєктування альтернативних варіантів реалізації досліджуваного видавничо-поліграфічного процесу, побудови моделей нечіткого логічного виведення, обчислення інтегрального показника якості. Суть виокремлених етапів полягає у побудові функціональної модель за методологією IDEF0, визначенні множини факторів якості, виконанні їх логіко-семантичного моделювання та побудові ієрархічної моделі з ваговими коефіцієнтами. Запропоновано вибір варіантів реалізації процесу на основі принципів Парето-оптимальності. Завершальним етапом є синтезування моделі нечіткого логічного виведення, формуванні бази знань і обчисленні прогнозованого рівня якості.

Узагальнююча модель інформаційної технології представлена у вигляді структурно-функціональної схеми. Запропоновану технологію можна адаптувати до будь-якого видавничо-поліграфічного процесу. Вона забезпечує повний цикл оцінювання — від збору даних до формування висновків у числовій формі. Технологія є універсальним інструментом для прогнозування якості та прийняття обґрунтованих рішень у багатофакторному середовищі.

Ключові слова: *семантична мережа, математичне моделювання ієрархій, багатокритеріальна оптимізація, оптимальна альтернатива, нечітка логіка, оцінювання якості, інформаційна технологія, видавничо-поліграфічний процес, поліграфія.*

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