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HYBRID EVOLUTIONARY SOLUTIONS IN MODERN MACHINE LINGUISTICS IN COMPLEX ENVIRONMENTS

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Abstract. This paper reveals the essence and significance of hybrid evolutionary technologies in modern machine linguistics in the conditions of a complex, uncertain and dynamic language environment. It is substantiated that the combination of evolutionary algorithms, neural network models, statistical methods, linguistic rules and formalized knowledge allows to increase the adaptability, stability, accuracy and interpretability of natural language processing systems. The advantages of such solutions in the tasks of machine translation, text classification, entity extraction, semantic analysis, generalization and dialogic interaction are determined. It is shown that hybrid evolutionary approaches are a promising basis for creating intelligent language systems of a new generation, capable of functioning effectively in conditions of noise, data heterogeneity, limited markup and contextual variability.

Keywords: hybrid evolutionary technologies, machine linguistics, natural language processing, evolutionary algorithms, adaptability, interpretability, semantic analysis, machine translation, intelligent language systems

Introduction.

Modern machine linguistics is developing under conditions of rapid complication of both language systems themselves and the environment of application of intelligent technologies of text and speech analysis [1]. The increase in the volume of unstructured data, the multilingual nature of the digital space, the presence of noise, incomplete or distorted data corpora [2], the need to process specialized terminology, dialect and sociolect varieties of language, as well as the increase in requirements for accuracy, adaptability and interpretability of models determine the search for new methodological approaches. In such circumstances, hybrid evolutionary technologies that combine methods of evolutionary computing, machine learning, neural network modeling, statistical data analysis and formalized knowledge [3] acquire special scientific and applied significance.

The relevance of this topic is due to the fact that traditional approaches to machine linguistics, based either exclusively on rigidly specified rules, or only on

statistical and neural network models, are far from always able to provide the necessary stability in complex operating conditions [4]. Complex conditions in this research context should be understood as situations of high uncertainty , limited labeled data, dynamic changes in language patterns, ambiguity, contextual variability, language mixing, as well as the presence of errors, noise, and incomplete input information. In such complex circumstances, technologies that are able not only to learn from data but also to evolutionary adapt their own structure , parameters, decision-making rules, and mechanisms for integrating heterogeneous methods become of particular importance.

Main Part.

Hybrid evolutionary technologies are a promising direction, as they make it possible to combine the advantages of different computational paradigms. Evolutionary algorithms provide the search for optimal or close to optimal solutions in complex spaces of features and architectures [5], neural network models - the ability to detect hidden patterns in large data sets, and linguistic rules and ontological structures - semantic validity, interpretability and controllability of results. Such a combination is especially significant for modern machine linguistics , where solving the problems of automatic translation, tonality analysis, named entity recognition, thematic classification, knowledge acquisition, dialogic interaction, summarization and discourse modeling requires taking into account not only statistical dependencies, but also the deep properties of language as a complex language.

The specificity of hybrid evolutionary technologies lies in their ability to function at the intersection of adaptability and formalization. Unlike exclusively deterministic linguistic models, they allow for decision variability, self-organization, and multi- stage optimization. Unlike pure “black boxes ” focused on maximizing metrics without explicitly taking into account the nature of language, such technologies can contain expert constraints, grammatical templates, semantic networks, logical dependencies, and other components of subject knowledge. This makes them especially popular in situations where not only high performance is required , but also resistance to non-standard input data, reduced sensitivity to noise,

and more reliable operation on poorly structured and heterogeneous information arrays.

The scientific interest in this issue is also due to the fact that modern machine linguistics is increasingly faced with tasks that go beyond the standard processing of general language texts . We are talking about working with legal, medical, technical, military, crisis, and other specialized corpora, where an interpretation error can lead to significant managerial, social, or technological consequences. In such conditions, not only the accuracy of models becomes important, but also their ability to quickly adapt, transfer knowledge, adjust to the specifics of a particular domain and operate stably when the context changes. It is hybrid evolutionary technologies that form the basis for solving such problems by combining intelligent search, self-adaptation and multi - level language analysis.

It should be emphasized that in the modern scientific literature a significant amount of research has been accumulated, devoted to both evolutionary algorithms and hybrid models of artificial intelligence in natural language processing tasks [6, 7]. However, as before, the issue of systematic understanding of their role in the complex conditions of functioning of machine-linguistic systems has not been sufficiently developed. The conceptual apparatus associated with the hybridization of technologies, criteria for the complexity of the language environment, methods of integrating symbolic and subsymbolic components, as well as mechanisms for assessing the adaptability, stability and quality of such solutions require further clarification [8], [9]. This necessitates the need for in - depth theoretical analysis and development of applied approaches to the design of hybrid evolutionary systems in machine linguistics. The purpose of the study is to substantiate the theoretical and methodological foundations of the application of hybrid evolutionary technologies in modern machine linguistics in complex conditions, as well as to identify their functional capabilities, limitations and prospects for further development. Achieving the set goal involves solving a number of interrelated tasks : clarifying the essence and features of hybrid evolutionary technologies; determining the specifics of their use in the main tasks of machine linguistics; characterizing the complex conditions of

functioning of modern language models; identifying the advantages of hybrid approaches in comparison with single-component solutions; and also determining the directions of increasing the adaptability, stability and interpretability of machine - linguistic systems.

The object of the study is modern machine linguistics technologies oriented towards automated natural language processing . The subject of the study is the theoretical, methodological and applied aspects of the development and application of hybrid evolutionary technologies in conditions of complexity, uncertainty and variability of the language environment.

The methodological basis of the study is formed by a systems approach, methods of comparative analysis, elements of evolutionary modeling, concepts of artificial hybrid intelligence, as well as principles of structural-functional study of language and computing systems. The use of such methodological tools allows us to consider hybrid evolutionary technologies not as a set of disparate algorithms, but as a holistic architectural and intellectual paradigm aimed at improving the quality of solving linguistic problems in conditions of multidimensional complexity.

The practical significance of the topic lies in the fact that the results of the analysis can be used in the creation of intelligent automatic translation systems, chatbots, search and analytical platforms, semantic monitoring systems, specialized text processing tools and other solutions that require a combination of accuracy, adaptability and stability. In addition, the study of hybrid evolutionary technologies creates the prerequisites for improving the algorithmic foundations of modern machine linguistics and the formation of more reliable, flexible and intellectually rich models of language processing. Thus, the study of hybrid evolutionary technologies in modern machine linguistics in complex conditions is a timely and scientifically significant direction that meets the current demands of the digital society, the development of artificial intelligence and the deepening of interdisciplinary research at the interface of linguistics, computer science and intelligence.

Conclusions.

As a result of the desk research by the author of this topic, the author concludes

that this direction is one of the most promising in the development of modern natural language processing systems. Its significance is determined not only by technological novelty , but also by the ability to meet the challenges associated with the complication of the language environment, the growth of data heterogeneity, the need to take into account the context, ambiguity, domain specificity and high dynamics of language changes. It has been established that hybrid evolutionary technologies are formed as a result of the integration of several computational and cognitive approaches , among which evolutionary algorithms, neural network models, statistical methods, expert rules and formalized linguistic knowledge play a key role. Their combination allows overcoming the limitations of single-component systems. In particular, if purely symbolic models often turn out to be insufficiently flexible in the conditions of variability of natural language, and exclusively neural network solutions can be characterized by weak interpretability and dependence on the volume of qualitative data, then hybrid evolutionary systems are able to compensate for these shortcomings due to adaptive tuning of architecture, parameters and logic. It is substantiated that in complex conditions of functioning of machine-linguistic systems , which include noisy data, limited markup, language heterogeneity, code-whitening, terminological saturation, context instability and variability of subject areas, it is the hybrid evolutionary approach that provides a higher level of stability and adaptability. Its advantage is the ability to effectively search for optimal solutions in multidimensional parameter spaces, select significant features, combine different levels of language representation and adapt to changes in the environment without completely rebuilding the entire model.

The analysis revealed that the use of hybrid evolutionary technologies is particularly effective in the tasks of machine translation, automatic text classification, entity extraction, semantic analysis, summarization, question-answer systems, intelligent search and dialog interfaces. In these areas, the value of not only high prediction accuracy, but also the ability of the model to take into account linguistic constraints, structural connections, semantic dependencies and contextual variations is growing . Evolutionary mechanisms in the composition of hybrid systems allow for

the optimization of not only numerical parameters, but also the interaction schemes between components themselves, which opens up the possibility of forming more flexible and subject-sensitive architectures. An important result is the understanding that hybrid evolutionary technologies should be considered not simply as a technical tool, but as a methodological basis for a new stage in the development of machine linguistics. Their use reflects the transition from highly specialized algorithms to complex intelligent systems capable of combining learning, adaptation, comprehensibility and stability. This is especially important in conditions when machine linguistics is increasingly integrated into critical areas - public administration, medicine, security, education, law, scientific analytics and digital communications . At the same time, it has been established that the development of the direction is constrained by a number of factors. These include the high computational complexity of hybrid models, the difficulty of harmonizing different types of knowledge representation, the problem of assessing the interpretability of results, the shortage of high-quality specialized corpora, as well as the need to develop universal performance criteria for systems operating in non-standard and dynamic conditions. This means that the prospects for the implementation of hybrid evolutionary technologies are directly related to the improvement of architectural solutions, optimization methods, small data learning strategies and approaches to validating the quality of linguistic models.

Thus, the promising nature of hybrid evolutionary technologies lies in their ability to become the foundation for the creation of new generations of machine-linguistic systems, oriented to work in conditions of uncertainty and complexity. They provide a deeper integration of statistical, neural network and symbolic language processing, create the prerequisites for increasing the accuracy and reliability of solutions, and also expand the scope of application of machine linguistics in real practical tasks.

Thus, we can conclude that hybrid evolutionary technologies are not only a relevant but also a strategically significant direction of modern machine linguistics. Their development contributes to the formation of new types of intelligent systems

capable of effectively functioning in complex conditions, taking into account the multi - level nature of language and providing a qualitatively new level of automated processing of natural language information.

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