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## SYNERGY OF HYBRID INTELLIGENT TECHNOLOGIES IN INNOVATIVE MACHINE LINGUISTICS IN TIMES OF CRISIS

**Krasniuk S.O.**

senior lecturer

ORCID: 0000-0002-5987-8681

Kyiv National University of Technologies and Design,  
Mala Shyianovska Street 2, Kyiv, Ukraine

**Abstract.** This article analyzes the use of hybrid intelligent technologies in modern machine linguistics in the face of uncertainty and crisis-driven information processes. It is noted that traditional neural network and formal linguistic approaches, despite their high effectiveness, demonstrate limited resilience when working with incomplete, heterogeneous, and dynamic text data. Therefore, the need for hybrid architectures combining artificial intelligence, big data analysis, and formalized knowledge is substantiated. It is shown that the synergistic effect arising from the integration of heterogeneous intelligent components facilitates a more accurate interpretation of content and context, and also improves the adaptability and reliability of NLP systems. The paper formulates key scientific and practical recommendations for implementing hybrid solutions in text analysis and decision support tasks. It concludes that hybrid intelligent technologies hold promise as a key area for the development of machine linguistics in an unstable information environment.

**Keywords:** hybrid intelligent technologies; machine linguistics; NLP; synergistic effect; artificial intelligence; big data; crisis conditions; uncertainty.

### Introduction.

Modern machine linguistics is being formed in conditions that are difficult to call stable or predictable [1]. Rapidly changing social and economic processes, global and local crisis phenomena [2-4], as well as the constant complication of the information environment significantly affect the nature of semi-structured and unstructured Big Data [5], on the methods and technologies of their processing, analysis and analytics [6], [7]. In such difficult circumstances, it becomes obvious that universal and "once and for all" effective universal solutions in the field of automatic processing, analysis and analytics of large corpora of all types of data (in particular for R&D in the field of philology) practically do not exist [8, 9]. It should be noted that traditional approaches to machine linguistics, which have developed relatively autonomously for a long time, demonstrate both strengths and quite noticeable limitations. Statistical and neural network models provide high performance and training on large data sets, but are often sensitive to the quality of

the input information and are poorly interpretable. At the same time, formal and linguistically oriented methods allow for a more transparent description of language structures, but are often inferior in flexibility and scalability. In conditions of uncertainty, these shortcomings become especially noticeable.

That is why in recent years, scientific research has increasingly turned to the idea of intelligent hybrid technologies, which involve combining different techniques, modes [10] and methods/algorithms of both Data Science [11] and AI [12]. Such solutions are not reduced to a mechanical combination of algorithms. We are talking about an attempt to build more complex architectures in which neural network models, symbolic representations, probabilistic estimates and elements of expert knowledge complement others [13] depending on the context of the task.

Of particular interest in this regard is the synergy effect that arises when various intellectual components are used together [14]. In practice, it manifests itself not only in increasing the accuracy of text processing, but also in a more stable reduction of the system when working with incomplete, noisy or contradictory data [15]. In uncertain, especially in crisis situations, when information flows are characterized by high dynamism and heterogeneity, it is precisely these, the above-mentioned properties that acquire decisive importance [16].

Further, consider that modern information linguistics is increasingly used in applied areas related to crises and uncertainty - from the analysis of media discourse and monitoring of public sentiment to supporting management decisions and ensuring security. In these conditions, the need is growing not only for effective, but also for adaptive, explained linguistic systems. Hybrid intellectual technologies in this context are considered one of the most realistic ways to achieve such a balance.

Thus, addressing the problem of the synergy effect of using intelligent hybrid technologies in machine linguistics is due to both theoretical and practical factors. The analysis of this effect allows us to take a fresh look at the principles of building a linguistic system and assess their potential in an unstable and uncertain information environment.

## **Main Part.**

Below, a set of scientific and practical recommendations will be presented for the maximum optimal use (and, hence, the maximum synergy effect) of hybrid intelligent technologies in innovative machine linguistics in modern contexts.

### *1. Methodological and theoretical proposals:*

1.1. Formation of a hybrid concept of machine linguistics. It is advisable to move from the use of isolated approaches (purely neural network or exclusively symbolic) to complex hybrid models that integrate: deep learning architectures (Transformer, large language models); formalized knowledge (ontological structures, linguistic rules); probabilistic, heuristic, and fuzzy inference methods. Such integration enhances the interpretability, reliability, and adaptability of linguistic systems in the face of data instability and uncertainty.

1.2. Incorporation of cognitive-linguistic approaches into AI systems. Systematic incorporation of principles from cognitive linguistics, pragmatics, discourse theory, and speech interaction into the structure of hybrid intelligent models is recommended, allowing for a deeper semantic representation and contextual understanding of textual information.

1.3. Synergistic integration of data and expert knowledge. The development of mechanisms for integrating data arrays and formalized knowledge is promising, whereby language models are trained not only on Big Data corpora but also enriched with expert rules and domain-specific ontologies, which is especially relevant in situations of fragmented or distorted data.

### *2. Practice-oriented recommendations for implementation:*

2 1. Creating crisis-resilient NLP platforms. To improve the operational stability of machine-language systems, it is advisable to: use ensemble and hybrid architectures; implement dynamic adaptation and retraining mechanisms; and employ tools for identifying semantic anomalies, manipulative narratives, and disinformation.

2.2. Development of multilingual and intercultural hybrid solutions. It is recommended to focus on creating models capable of effectively processing multilingual, low-resource, and regionally specific languages, which contributes to

strengthening information resilience and expanding the inclusiveness of digital communications.

2.3. Ensuring transparency and explainability of analysis results. The implementation of Explainable AI approaches in hybrid linguistic systems is of significant practical importance, as it allows for: interpreting the obtained results; minimizing the risk of erroneous conclusions; and increasing the level of trust among users and institutional regulators.

### *3. Organizational and management recommendations:*

3.1. Application of hybrid NLP technologies in public and corporate governance. The active use of hybrid intelligent solutions is recommended in the following areas: public and crisis communications analysis; information space monitoring; automated processing of regulatory and legal documents; and knowledge and intellectual resource management for organizations.

3.2. Interdisciplinary training of next-generation personnel. The development of educational programs that integrate knowledge from the following fields is warranted: computational and applied linguistics; artificial intelligence and data analysis; applied mathematics; and the humanities. This will enable the development of specialists capable of designing, implementing, and critically evaluating hybrid intelligent systems.

### *4. Promising areas for further research:*

4.1. Formalization of synergistic effect indicators. A promising area is the development of quantitative and qualitative criteria for assessing the contribution of neural, symbolic, and probabilistic components to the overall performance of hybrid machine-linguistic models.

4.2. Analysis of the ethical and sociocultural implications of implementation. The need to study the impact of hybrid intelligent technologies on: the formation and transformation of public discourse [17]; information and cognitive security; the preservation of linguistic and cultural diversity in the context of global crises is becoming more pressing.

## **Conclusions.**

The results of the study allow us to conclude that intelligent hybrid technologies are gradually becoming an integral part of modern machine linguistics. In conditions of crisis and uncertainty, it is precisely such approaches that demonstrate the greatest stability and practicality, since they are based not on one dominant method, but on their combination.

The analysis showed that the synergy effect when using hybrid technologies is manifested in various aspects of natural language processing. First of all, this concerns improving the quality of interpretation of content and context data, especially when working with heterogeneous or limited ones. In addition, combined models are less subject to degradation when external conditions change, which distinguishes them from more “rigid” monolithic solutions.

It is important to note that the synergistic effect is not automatic. Its formation depends on the system architecture, the nature of the integration methods and the specifics of a particular task. Nevertheless, with correct tuning, hybrid linguistic systems are able to compensate for the weaknesses of individual components and provide a more balanced result. In the context of crisis information environments, this becomes especially important.

From a theoretical point of view, the conclusions obtained confirm the expediency of abandoning highly specialized models in favor of more flexible and adaptive solutions. The interaction of neural network, symbolic and probabilistic approaches expands the methodological framework of machine linguistics and creates a basis for further interdisciplinary research. From a practical point of view, hybrid technologies open up additional opportunities for analyzing large text arrays, monitoring dynamic information flows and supporting decision-making under conditions of uncertainty.

In general, it can be stated that the synergy effect from the use of intelligent hybrid technologies plays an important role in increasing the efficiency of modern linguistic systems. The prospects for further research in this direction are associated with a more detailed study of the mechanisms of interaction of intelligent

components, the development of applied criteria for assessing synergy and the testing of hybrid models in real crisis scenarios, where the requirements for reliability and adaptability are particularly high.

#### References:

1. Goncharenko S. Intelligent technologies for modern sociolinguistics / S. Goncharenko // Science: Development and Factors its Influence : Proceedings of the 6th International Scientific and Practical Conference (October 6-8, 2025; Amsterdam, Netherlands). - Amsterdam: Scientific Collection «InterConf», 2025. - P. 61-64.

2. Ostapenko T., Onopriienko D., Hrashchenko I., Palyvoda O., Krasniuk S., Danilova E. (2022) Research of impact of nanoeconomics on the national economic system development. *Innovative development of national economies: collective monograph*. – Kharkiv: PC TECHNOLOGY CENTER, 2022. – pp. 46-70.

3. S. Illiashenko, O. Bilovodska, T. Tsalko, O. Tomchuk, S. Nevmerzhytska, N. Buhas (2022). Opportunities, threats and risks of implementation the innovative business management technologies in the post-pandemic period COVID-19. *WSEAS Transactions on Business and Economics*. – 2022. – Volume 19. – pp. 1215-1229. <https://doi.org/10.37394/23207.2022.19.107>

4. Tsalko T. R., Nevmerzhytska S.M. (2023) Risk assessment in innovative activity. *Actual problems in economics, finance and management: materials of the International Scientific and Practical Conference*. East European Center for Scientific Research (Odesa, 25 october 2023). Research Europe, 2023. pp. 92-94 <https://researcheurope.org/product/book-31/> [in Ukrainian].

5. M. Krasnyuk, T. Motsyuk, S. Krasniuk (2021) Relevanz des wahlfaches «Wissensdetektion in unstrukturierten daten» bei der ausbildung von mastern der technischen und humanitären fachrichtungen. Education and science of today: intersectoral issues and development of sciences : *collection of scientific papers “ΑΙΓΟΣ”* with proceedings of the I International scientific and practical conference, Cambridge, United Kingdom, March 19, 2021. Vol. 3. Cambridge-Vinnytsia : P.C. Publishing House & European Scientific Platform, 2021. pp. 66–67.

6. Goncharenko S. Big semi-structured data & deep ANN in computational linguistics / S. Goncharenko // *Science and Global Challenges in the Modern World : Proceedings of the 2nd International Scientific Conference (Leicester, United Kingdom, 5 October 2025)*. - Lulu Press, Inc., 2025. - P. 133-136.

7. Goncharenko S. BIG Data in modern literary studies / S. Goncharenko // *Science: Development and Factors its Influence : Proceedings of the 6th International Scientific and Practical Conference (October 6-8, 2025; Amsterdam, Netherlands)*. - Amsterdam: Scientific Collection «InterConf», 2025. - P. 82-85.

8. Goncharenko S. Innovative R&D management during instability and multi-crisis / S. Goncharenko // *Trends, Issues, and Challenges in Modern Science : Proceedings of the 2nd International Scientific Conference (Cambridge, United Kingdom, 5 September 2025)*. - Lulu Press, Inc., 2025. - P. 29-32.

9. Goncharenko S. Intelligent information technologies for innovative management of advanced philology projects / S. Goncharenko // *Innovations and New Directions in Scientific Research : Proceedings of the 2nd International Scientific Conference (Manchester, United Kingdom, 20 September 2025)*. - Lulu Press, Inc., 2025. - P. 176-179.

10. Krasnyuk, M. T., & Krasniuk, S. O. (2020). Fraud detection in the business data as an important corporate anti-crisis method of audit. *Suchasni vyklyky i aktualni problemy nauky, osvity ta vyrobnytstva: mizhhaluzevi dysputy: materialy III mizhnarodnoi naukovo-praktychnoi internet-konferentsii – Modern challenges and current problems of science, education and production: interdisciplinary debates: materials of the III international scientific and practical internet conference (pp. 14-16)*. Kyiv.

11. Krasnyuk, M. (2014). Hibrydyzatsiia intelektualnykh metodiv analizu biznesovykh danykh (rezhym vyivlennia anomalii) yak skkladovyi instrument korporatyvnoho audytu [Hybridization of intelligent methods of business data analysis (anomaly detection mode) as a standard tool of corporate audit]. *Stan i perspektyvy rozvytku oblikovo-informatsiinoi systemy v Ukraini - Stan i perspektyvy rozvytku oblikovo-informatsiinoi systemy v Ukraini : materialy III Mizhnar. nauk.-*

*prakt. konf. [m. Ternopil, 10-11 zhovt. 2014 r.] - The state and prospects of the development of the accounting and information system in Ukraine: materials of the III International science and practice conf. [m. Ternopil, October 10-11. 2014].* TNEU, 2014. pp. 211-212 (in Ukrainian)

12. Naumenko, M., & Hrashchenko, I. (2024). Modern artificial intelligence in anti-crisis management of competitive enterprises and companies. *Grail of Science*, (42), 120–137. DOI: <https://doi.org/10.36074/grail-of-science.02.08.2024.015> [In Ukrainian].

13. Naumenko, M. (2024). Models of business knowledge in artificial intelligence systems for an effective competitive enterprise. *International scientific journal "Internauka". Series: "Economic Sciences"*. № 6. DOI: <https://doi.org/10.25313/2520-2294-2024-6-10010> [In Ukrainian].

14. Derbentsev, V. D., Serdiuk, O. A., Soloviov, V. M., & Sharapov, O. D. (2010). *Synergistic and econophysical methods of studying dynamic and structural characteristics of economic systems*. Cherkasy: Brama-Ukraine. - 2010 [in Ukrainian].

15. Derbentsev, V. D., V. M. Soloviov, and O. V. Serdiuk (2005) Precursors of critical phenomena in complex economic systems. *Modeling of nonlinear dynamics of economic systems*. - Donetsk: DonNU, 1 (2005). pp. 5-13 [in Ukrainian].

16. Derbentsev, V. D., B. O. Tishkov, O. D. Sharapov (2013). Systematic methodology for studying the dynamics of the current information economy in the minds of increasing instability. *Modeling and information systems in economics*. – 2013. – Vol. 89. – pp. 47-62 [In Ukrainian].

17. Krasniuk, S., & Goncharenko, S. (2024). Ethics of using large language models in machine linguistics. *Лінгвістичні та методологічні аспекти викладання іноземних мов професійного спрямування* : матеріали V Міжнародної науково-практичної конференції, м. Київ, 28-29 березня 2024 року. – Київ : НАУ, 2024. – С. 43.

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