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SYSTEMATICAL OVERVIEW OF MODERN ONTOLOGY-BASED TOOLS TO ENSURE AUTOMATIZATION AND SYSTEMIZATION OF DATA IN SCIENCE

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Abstract. *This paper delves into the tools developed on the CIT Polyhedron platform, particularly in the context of scientific applications, with a comprehensive exploration of the consolidation and structuring of informational resources. Central to this is the use of ontological systems, where ontological engineering plays a pivotal role in creating structured knowledge systems that effectively represent and interact with various information resources. The paper particularly emphasizes narrative ontology, a unique methodology for organizing and assembling information across multiple disciplines, enhancing the richness and coherence of knowledge.*

A substantial portion of the study is dedicated to describing how to structure scientific studies using an IMRAD-based ontological structure. This innovative approach aims to facilitate the organization, retrieval, and comprehension of scientific data. The ontology is crafted to encapsulate the essence of scientific papers, covering objectives, methodologies, findings, and discussions. This systematization is especially crucial within a centralized, web-oriented educational framework, ensuring a seamless flow of knowledge and interoperability between different systems.

The paper also presents methods for representing and assessing information from scientific and educational organizations. This is achieved through a general ontology divided into several ontologies to address these organizations' various aspects and performance indicators. "Polyhedron Researcher", described in the paper, is a novel platform for systemizing scientific data. This platform is based on the Polyhedron model and focuses on adapting and optimizing the processes of scientific research and data management. It integrates cognitive services for information analysis and employs interactive documents for data representation. The platform is tailored to support researchers, aiding them in organizing their scientific activities and creating publications. This transdisciplinary approach supports various scientific and research activities and promotes efficient data management and knowledge dissemination in the scientific community.

Keywords: *Ontological engineering; narrative ontology; IMRAD structure; CIT platform "POLYHEDRON"; scientific data systemization; transdisciplinary methodology.*

1. INTRODUCTION

The automation of processes is increasingly ubiquitous and necessary in contemporary contexts. This trend encompasses the efficient collection and processing of data. Notably, Big Data mining and cognitive ontology technologies are gaining traction due to their effectiveness in facilitating decision-making processes (Stryzhak et al., 2021; Stryzhak, 2020). The significance of data in the realm of automation is manifold, playing a pivotal role in revolutionizing the practices of data scientists (De Bie et al., 2021) and enabling the automation of data analytical processes via semantic technologies (Bednar et al., 2022). Ontologies have proven to be a valuable tool in various domains, including text classifica-

tion (Malik & Jain, 2021), geospatial information (Claramunt, 2020), and oncology research (Silva et al., 2022). Ontologies enhance data interpretation, knowledge representation, and data sharing, and have been used to improve the efficiency of text classification by preserving semantic relationships (Malik & Jain, 2021). They offer a promising modeling alternative in geospatial information, although their potential and limitations need further evaluation (Claramunt, 2020). Research on using ontologies in the field of cancer investigation has also applied ontologies to manage and analyze complex data, enabling data accessibility, interoperability, and integration (Silva et al., 2022).

Weigand (2020) and Phillips (2020) both explore the application of ontologies in specific scientific domains, with Weigand focusing on information systems design and Phillips on radiation oncology (Phillips et al., 2020; Weigand et al., 2020). Phillips (2020) introduced ontologies in radiation oncology, emphasizing their role in standardizing vocabulary and facilitating computer reasoning (Phillips et al., 2020). Merrill (2019) delves into the relationship between philosophical ontology and applied ontology in science, advocating for a robust participation model (Merrill, 2011). Michie (2019) provides a practical guide for creating ontological definitions in scientific discourse, emphasizing the importance of clarity and specificity (Michie et al., 2019). These studies collectively highlight the role of ontologies in structuring and representing scientific knowledge and the need for a systematic approach to their development.

Rimkus (2020) discussed the use of ontologies in a scientific conference, covering topics such as human and biorobots, ethics of technology, and the ontology of instrumentality (Rimkus, 2020). Fathalla (2020) proposed the Science Knowledge Graph Ontologies (SKGO) for structuring scholarly information, with a focus on modeling research findings in various fields of modern science (Fathalla et al., 2020). Ontologies A range of studies have explored the use of ontologies in scientific activities. Dovhyi (2020) and Globa (2020) developed an ontological model for scientific institutions, focusing on performance evaluation (Dovhyi et al., 2020; Globa et al., 2020). Therefore, it highlighted the potential of ontologies in enhancing the organization and exploration of scientific work.

One of the most developed approaches is the CIT Polyhedron. It uses ontologies and has cognitive tools such as Audit or Ranking. It was previously used to structure scientific data (Shapovalov, 2023; Stryzhak, 2014; Stryzhak et al., 2014; Velichko et al., 2017). However, it was not systematically analyzed using those tools in science in general.

Therefore, **this paper aims** to identify and describe tools developed by CIT Polyhedron and propose a systematic analysis of them. To achieve **this objective**, the following research question is investigated: What science-related tools have already been developed on CIT Polyhedron?

2. METHODOLOGY

The methodology of this paper revolves around a comprehensive analysis and integration of existing knowledge and applications of the cognitive IT platform “Polyhedron” in systemizing scientific data. This approach is not about developing a new method but rather about summarizing and integrating established experiences in using “ Polyhedron “ to organize and analyze scientific information effectively. We proved systematical analysis of current approaches using Polyhedron to systemize scientific data:

- **Literature Review and Case Study Analysis:** The research began with a thorough literature review focusing on existing uses of “ Polyhedron “ in various scientific contexts. This was supplemented with case studies illustrating the platform’s practical applications in different research settings.
- **Ontological Framework Analysis:** A significant portion of the methodology involved analyzing the ontological structures used in “ Polyhedron “. This included a detailed examination of how these structures enable the organization, representation, and assessment of scientific data.
- **Evaluation of Narrative Ontology and IMRAD Structure:** The paper delves into the

narrative ontology and the IMRAD (Introduction, Methods, Results, and Discussion) format's role in structuring scientific studies within " Polyhedron". This involved evaluating how these formats aid in systematizing and comprehending scientific literature.

- **Assessment of Data Management and Interoperability:** The methodology also entailed assessing the challenges and solutions related to metadata standardization and data entry, focusing on the platform's ability to enhance data interoperability and utility.
- **Application of Cognitive Services:** The research explored the integration of cognitive services within " Polyhedron ", examining how these services facilitate the analysis of scientific and technical information.
- **Transdisciplinary Approach Evaluation:** Lastly, the study evaluated the platform's effectiveness in supporting a transdisciplinary approach, encompassing various scientific and research activities, and promoting efficient data management and knowledge dissemination.

Through this structured methodology, the paper aims to provide an in-depth understanding of how " Polyhedron " can be effectively utilized in scientific research, emphasizing its role in organizing, processing, and presenting scientific data in a coherent and accessible manner.

3. RESULTS AND DISCUSSION

The advancement of science is increasingly relies on ontology-based tools, which provide a structured framework for integrating and managing vast amounts of data. These tools facilitate consolidating informational resources, allowing for more cohesive and interconnected knowledge systems. Ontologies are especially valuable in representing scientific studies, offering a standardized methodology to encapsulate complex research findings in an accessible format. Moreover, they play a crucial role in organizing scientific and higher educational statistical information, ensuring that data is not only comprehensible but also usable across various academic and research platforms. One of the standout implementations of such ontological frameworks is the CIT "Polyhedron-researcher", which epitomizes the synergy between cutting-edge computational technologies and the rigorous demands of scientific inquiry. By harmonizing data from disparate sources, ontology-based tools are instrumental in enhancing the efficiency and effectiveness of scientific research and education. Considering this, ontologies could be used to systemize science, and one of the most promising instruments is CIT Polyhedron. Ontology-based tools developed in CIT Polyhedron in science are shown in Figure 1.

3.1. Consolidation of informational recourses

Recent studies proposes an innovative approach to managing and integrating networked information resources, focusing on ontological systems (Stryzhak et al., 2023; Gonchar et al., 2021). Central to this methodology is ontological engineering, which involves creating a structured knowledge system through defined concepts, relationships, and axioms. This concept is designed to represent the semantic properties of information resources and facilitate effective interactions within and between them (Stryzhak et al., 2023; Gonchar et al., 2021).

A significant aspect of the approach is the emphasis on narrative ontology. The paper explores how narratives, as a unique type of ontology, can be utilized to organize and meaningfully assemble information across various disciplines. By interconnecting narratives through ontological systems, the approach seeks to enhance the richness and coherence of knowledge (Stryzhak et al., 2023; Gonchar et al., 2021).

The methodology also addresses the challenges of metadata standardization and data entry in digital archives, particularly in libraries and museums. The lack of standardization in these areas is identified as a major hurdle in effectively utilizing digital archives. The proposed solution aims to improve interoperability and standardization, thereby enhancing the utility of these information resources (Stryzhak et al., 2023; Gonchar et al., 2021).

The studies advocate for a transdisciplinary methodology for consolidating information re-

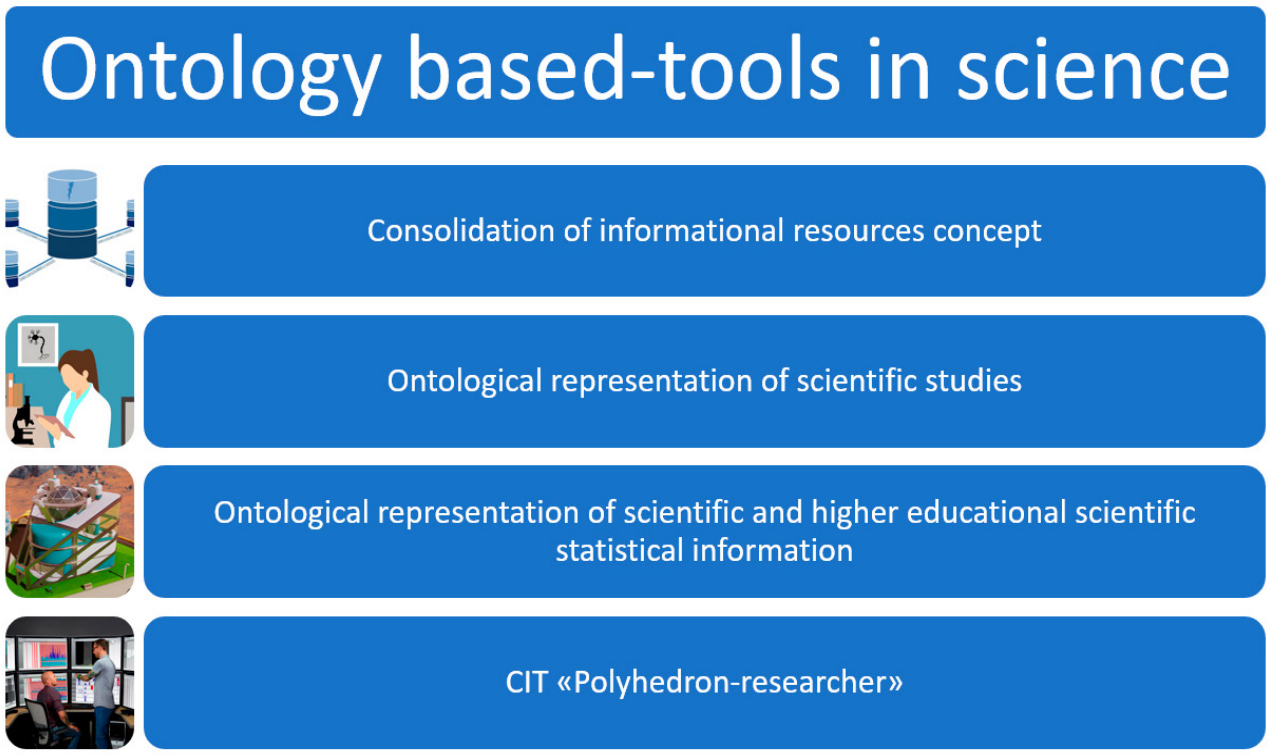

Fig. 1. Ontology-based tools in science

sources. By leveraging ontological systems and narrative structures, they aim to create a more organized, meaningful, and interoperable assembly of information. This approach not only fosters a deeper understanding of diverse knowledge domains but also enhances the practical utility of digital archives in academic and cultural institutions (O. Stryzhak et al., 2023; Gonchar et al., 2021).

3.2. Structuring of scientific studies

One of the approaches that uses the consolidation approach (described before) presents a comprehensive approach to structuring educational and scientific data using IMRAD (Introduction, Methods, Results, and Discussion) as a basis for ontology. The study emphasizes the significance of systematizing scientific and educational research reports within a centralized, web-oriented educational framework. It specifically focuses on the integration of scientific studies with educational ontologies to enable a seamless flow of knowledge and interoperability between different systems (Shapovalov et al., 2021; Shapovalov & Shapovalov, 2021; Shapovalov, 2023; Shapovalov et al., 2022; Shapovalov & Shapovalov, 2023; Shapovalov, 2022).

The core of this approach involves creating and utilizing a detailed ontological structure that reflects the IMRAD format. This structure aims to facilitate the organization, retrieval, and comprehension of scientific data. The ontology is designed to capture the essence of scientific papers, including their objectives, methodologies, findings, and discussions, thus allowing for a more efficient and comprehensive understanding of scientific literature. This ontological system is intended to enhance the utility of scientific reports in educational contexts, making them more accessible and relevant for students and researchers. Example of a detailed ontological structure that reflects the IMRAD format for the Development a method for utilization of methane tank effluent research is shown in Figure 2 (Shapovalov et al., 2021; Shapovalov & Shapovalov, 2021; Shapovalov, 2023; Shapovalov et al., 2022; Shapovalov & Shapovalov, 2023; Shapovalov, 2022).

The study elaborates on the application of this approach using specific tools and case

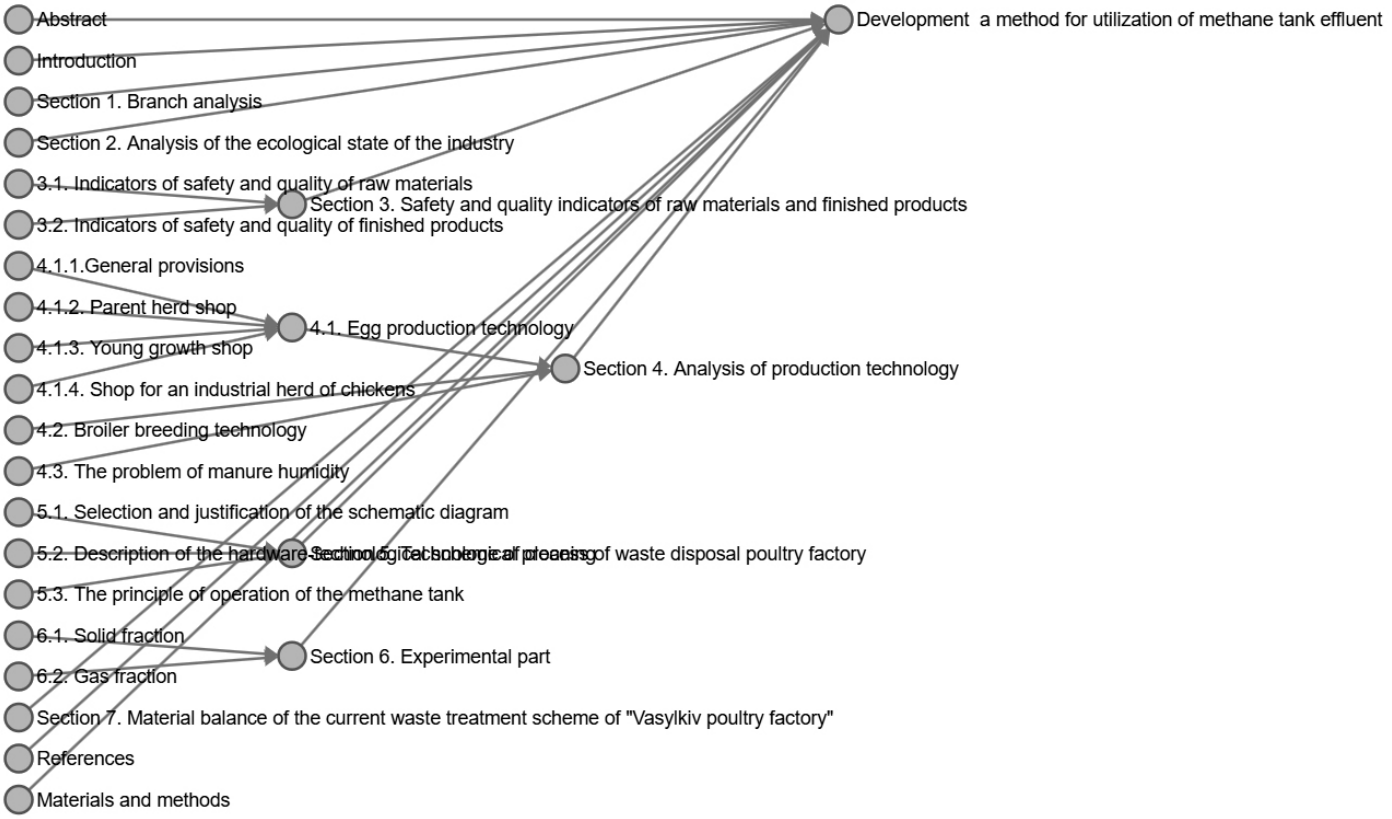

Fig. 2. Detailed ontological structure that reflects the IMRAD format research (Shapovalov et al., 2021; Shapovalov & Shapovalov, 2021; Shapovalov, 2023; Shapovalov et al., 2022; Shapovalov & Shapovalov, 2023; Shapovalov, 2022)

studies, demonstrating how the proposed system can effectively organize and process scientific data. The methodology also includes the use of ranking and auditing tools for evaluating scientific data based on various criteria, such as economic prospects and hypothesis testing. This approach not only simplifies the handling of complex scientific information but also bridges the gap between educational and scientific data, promoting a more integrated and holistic educational environment (Shapovalov et al., 2021; Shapovalov & Shapovalov, 2021; Shapovalov, 2023; Shapovalov et al., 2022; Shapovalov & Shapovalov, 2023; Shapovalov, 2022).

3.3. Repotting of institutions activities

The paper presents a method for representing and assessing information from scientific and educational organizations, emphasizing ontological modeling. This approach structures and organizes data, focusing on assessing organizational quality. The general ontology, divided into several ontologies, addresses various aspects and performance indicators of these organizations. This comprehensive system is applied through the cognitive IT platform “Polyhedron,” facilitating the development and population of the ontology. It enables a detailed evaluation of institutional performance, considering internal functions and external assessments by organizations and ministries. The paper thoroughly outlines the elements and interconnected components of the ontological system evaluation (Dovhyi et al., 2020; Globa et al., 2020). The Taxonomic view of reporting institution activities in an ontological system is shown in Figure 3.

3.4. Polyhedron researcher

The paper by Prykhodnyuk et al., “The Use of Information and Analytical Platforms in the Organization of Scientific and Research Activities on an Adaptive Basis,” introduces the “Polyhedron Researcher” as a novel platform for systemizing scientific data. The core of this

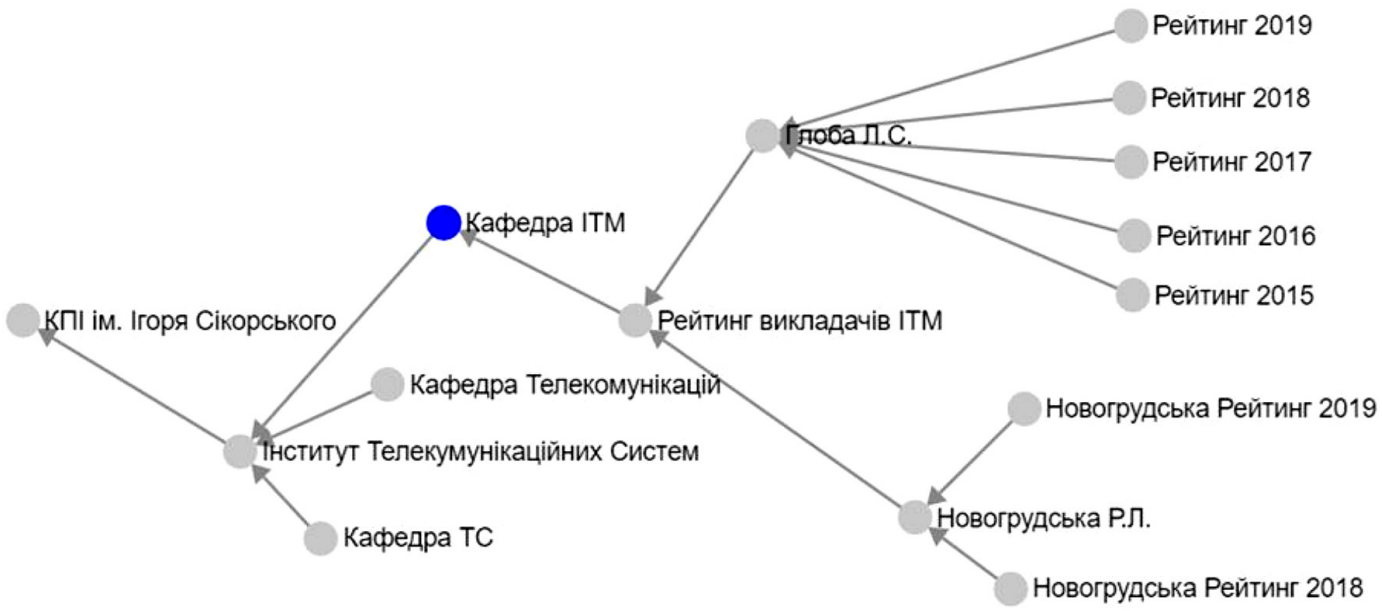

Fig. 3. Taxonomic view of reporting institution activities in ontological system evaluation (Dovhyi et al., 2020; Globa et al., 2020)

approach is the creation of a comprehensive, ontology-driven system designed to enhance the organization, analysis, and representation of scientific research (Prykhodnyuk, Gorborukov, & Franchuk, 2023; Prykhodniuk, Gorborukov, Shapovalov, et al., 2023).

This system, based on the Polyhedron model, focuses on adapting and optimizing the processes of scientific research and data management. It integrates cognitive services for information analysis and interactive documents for representation. The platform is tailored to support the work of researchers, particularly at the National Center "Junior Academy of Sciences of Ukraine" (JANU), and other scientific institutions of the National Academy of Sciences of Ukraine (NASU) (Prykhodnyuk, Gorborukov, & Franchuk, 2023; Prykhodniuk, Gorborukov, Shapovalov, et al., 2023). A general view of the Polyhedron researcher interface is shown in Figure 4.

Key features of this approach include:

- Ontology-Driven Data Management: The system leverages ontology-based methodologies to provide a structured and efficient way of handling scientific information.
- Cognitive Services Integration: The use of advanced cognitive services facilitates the analysis of scientific and technical information.
- Interactive Document Representation: The platform presents analyzed data using interactive documents, enhancing the accessibility and comprehension of complex scientific findings.
- Research Support and Organization: It aids researchers in organizing their scientific activities, especially in creating publications based on their research findings.

The POLYHEDRON Researcher is designed to be a transdisciplinary platform, that supports various scientific and research activities, and promots efficient data management and knowledge dissemination in the scientific community.

4. CONCLUSIONS

The conclusion of this paper underscores the effectiveness of the CIT Polyhedron platform in systemizing scientific data through various innovative approaches. Consolidating informational resources using ontological systems, particularly narrative ontology, has proven to be instrumental in organizing and interpreting data across multiple disciplines. The structured knowledge system created through ontological engineering addresses key challenges in metadata standardization and enhances the practical utility of digital archives. Incorporating an IMRAD-based

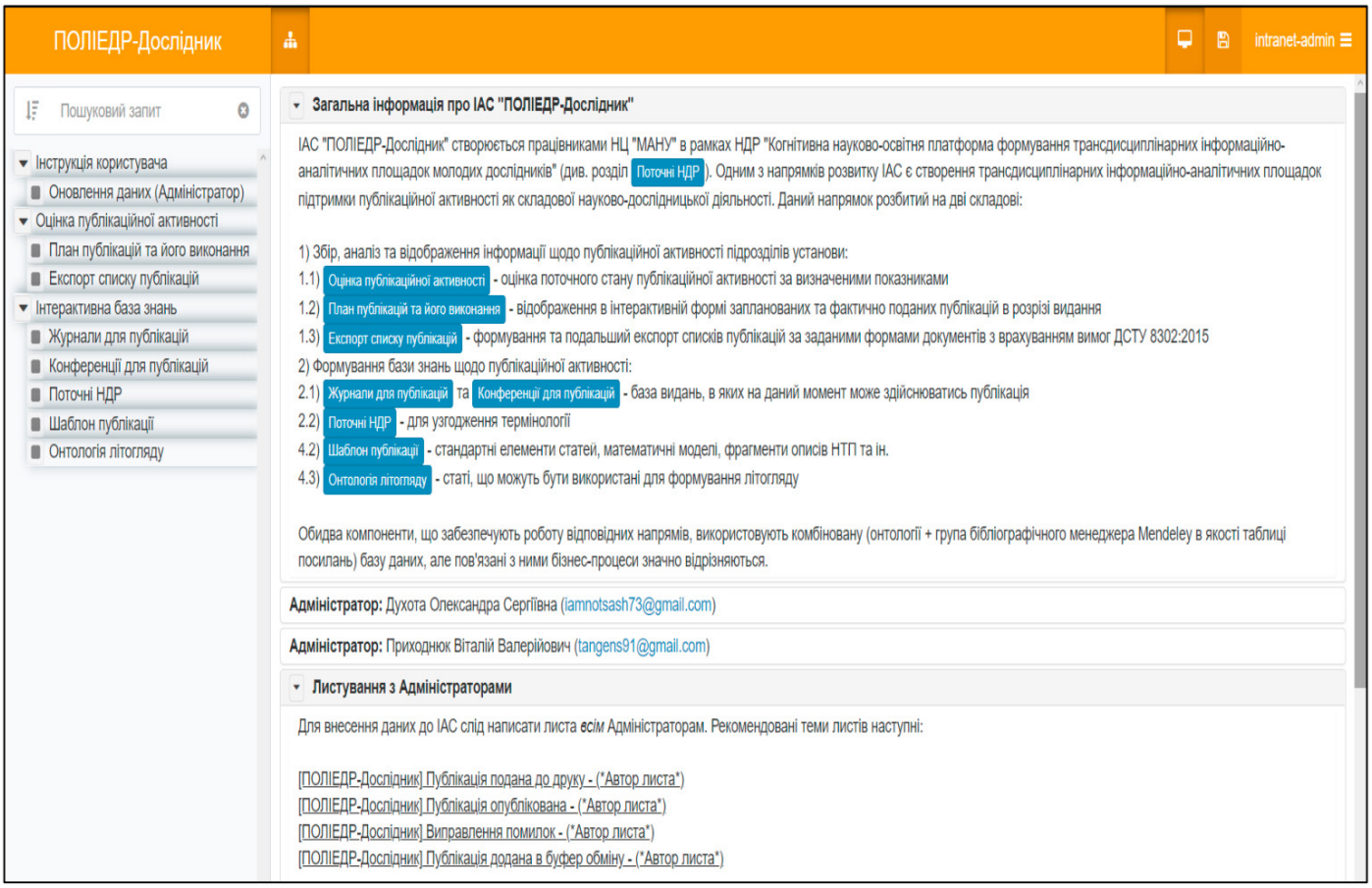

Fig. 4. General view of Polyhedron researcher interface Prykhodnyuk, Gorborukov, & Franchuk, 2023; Prykhodniuk, Gorborukov, Shapovalov, et al., 2023)

ontological structure further facilitates the organization and comprehension of scientific data, bridging the gap between educational and scientific information. The methodology's focus on assessing the quality of scientific and educational organizations through a comprehensive ontological system highlights the platform's capability in detailed performance evaluation. The introduction of "Polyhedron Researcher" marks a significant advancement in ontology-driven data management, integrating cognitive services and interactive document representation for research support. This multifaceted approach not only simplifies the handling of complex scientific information but also fosters a more integrated, holistic educational environment, promoting efficient knowledge management and dissemination in the scientific community.

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СИСТЕМАТИЧНИЙ ОГЛЯД СУЧАСНИХ ІНСТРУМЕНТІВ НА ОСНОВІ ОНТОЛОГІЙ ДЛЯ АВТОМАТИЗАЦІЇ ПРОЦЕСІВ ТА СИСТЕМАТИЗАЦІЇ ДАНИХ В НАУЦІ

Анотація. *У статті досліджено інструменти, розроблені на платформі КІТ «Поліедр», зокрема в контексті наукових застосувань, із всебічним дослідженням консолідації та структурування інформаційних ресурсів. Центральним у цьому є використання онтологічних систем, де онтологічна інженерія відіграє ключову роль у створенні структурованих систем знань, які ефективно представляють різні інформаційні ресурси та взаємодіють із ними. Особливу увагу приділено наративній онтології, унікальній методології для організації та збору інформації в багатьох дисциплінах, яка збільшує багатство та узгодженість знань.*

Значна частина дослідження присвячена опису структурування наукових досліджень за допомогою онтологічної структури на основі IMRAD. Цей інноваційний підхід спрямований на полегшення організації, пошуку та розуміння наукових даних. Онтологія створена для інкапсуляції суті наукових робіт з охопленням цілей, методологій, висновків і дискусій. Ця систематизація особливо важлива в межах централізованої веборієнтованої освітньої структури, що забезпечує безперебійний потік знань і взаємодію між різними системами.

У статті також наведено методи представлення та оцінки інформації наукових та освітніх організацій. Це досягається за допомогою загальної онтології, розділеної на кілька онтологій для вирішення різних аспектів і показників ефективності цих організацій. «ПОЛІЕДР Дослідник», описаний у статті, є новою платформою для систематизації наукових даних. Ця платформа заснована на моделі «Поліедр» і фокусується на адаптації та оптимізації процесів наукових досліджень і управління даними. Вона інтегрує когнітивні служби для аналізу інформації та використовує інтерактивні документи для представлення даних. Платформа створена для підтримки дослідників, допомоги їм в організації наукової діяльності та створенні публікацій. Цей підхід є міждисциплінарним, підтримує різноманітні наукові та дослідницькі заходи та сприяє ефективному управлінню даними й поширенню знань у науковому співтоваристві. Ключові слова: онтологічна інженерія; наративна онтологія; структура IMRAD; KIT «Поліедр»; систематизація наукових даних; трансдисциплінарна методологія.

Ключові слова: *онтологічна інженерія; наративна онтологія; структура IMRAD; KIT «Поліедр»; систематизація наукових даних; трансдисциплінарна методологія.*

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