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FORMATION OF THE CONCEPT OF CONDITIONAL NOOSPHERIC INTELLIGENCE USING ONTOLOGICAL AND GEOINFORMATION MODELING

ФОРМУВАННЯ КОНЦЕПЦІЇ УМОВНО-НООСФЕРНОГО ІНТЕЛЕКТУ З ЗАСТОСУВАННЯМ ОНТОЛОГІЧНОГО ТА ГЕОІНФОРМАЦІЙНОГО МОДЕЛЮВАННЯ

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Summary. Current scientific research demonstrates a tendency to use artificial intelligence for solving tasks in various fields of human activity. For example, tasks are addressed in geodesy for the automation of office processing of spatial data, in geographic information systems for the creation of vector models using machine learning, and in land management for the development of more automated systems of interaction with people.

However, certain interdisciplinary tasks, whose solutions require unconventional approaches, must be addressed at a higher level of information generalization. The highest level of generalization is essential for solving problems in legislative bodies, where laws are formulated that apply to all activities within the country.

The above considerations lead to the idea of creating a special intelligent system whose knowledge base would include a model of conditionally noospheric intelligence.

The term conditionally noospheric intelligence is introduced here because V. I. Vernadsky, in his doctrine of the noosphere, argued that all humanity on planet Earth influences its biosphere and that a collective mind, which he referred to as a «geological force» is necessary for the evolutionary transformation of the biosphere into the noosphere. Unfortunately, the impact of humanity on the Earth's biosphere is currently insufficiently studied. Nevertheless, the authors of this work attempt to develop an approach that would allow higher-quality interaction among specialists who are geographically distant and lack direct connections.

The purpose of this research is to provide a scientific rationale for the formation of the concept of conditionally noospheric intelligence using ontological and geographic information modeling to utilize the qualification potential of academic and teaching staff. Applying certain limitations and assumptions, the study examines the system's ability to systematically form groups of experts from among the intellectual elite, experts in their respective fields, to solve practical tasks and contemporary problems, with mathematical justification and representing scientific potential through a quantitative model constructed using geographic information technologies. Additionally, in this work, the intellectual elite refers to academic and teaching staff of higher educational institutions who have the appropriate specialization and a high qualification potential in their field of knowledge. Such a model may operate using artificial intelligence and information technologies but is not limited to them.

The study employs methods of system and functional analysis, as well as formal representations from set theory and utility theory, with the application of ontological and geographic information modeling.

As a result of the research, the term conditionally noospheric intelligence was introduced. For the first time, a conceptual representation of conditionally noospheric intelligence has been formulated. A core of conditionally noospheric intelligence has also been developed in the form of a mathematical model. Examples of potential applications of conditionally noospheric intelligence are presented using geographic information systems and illustrated within the field of geodesy.

Keywords: conditionally noospheric intelligence, artificial intelligence, analysis, ontological modeling, geographic information systems, geodesy and land management.

Introduction. The current stage of scientific and technological progress is characterized by intensified research in the field of artificial intelligence. Information technologies based on knowledge models are being developed. There is a clear trend toward the rapid growth of information; its volume and capacity are increasing dramatically, which, according to some scholars, may lead in the near future to an information singularity. In this context, Grid and Smart technologies – so-called «smart» technologies – are actively evolving, for example, smart watches, smart homes, smart cities, and so forth.

The authors of works [1–2] attempted to develop a concept for building a smart university. Higher education institutions are of particular interest to researchers because it is within them that the intellectual potential of the state is formed and concentrated. Works [3, 4] consider the idea of creating a cadastre of the state's intellectual resources, based on the already developed Land Cadastre – that is, the idea of establishing a Cadastre Information Processing Center (CIPC). One of the main functions of this center is to collect and standardize into a unified format various types of information received from different sources. In addition, this information must be classified and its properties identified: relevance, reliability, accuracy, and so on.

In this regard, the task of processing large volumes of data and developing corresponding decision-making solutions arises. It is important to note that it is proposed to solve specific tasks based on information that has different levels of generalization. For example, agricultural tasks of specific territorial communities may be solved with a high degree of detail and with reference to a specific geographic area. Environmental

tasks and problems must be addressed at a higher level of information generalization, as they cover large geographic regions and include data on enterprises that pollute the environment. Finally, the highest level of generalization is necessary for solving tasks within legislative bodies, where laws are formed whose effects extend across all activities within the country.

The above considerations suggest the possibility of creating a special intelligent system whose knowledge base would contain a model of conditionally noospheric intelligence.

The term «conditionally noospheric intelligence» is introduced here because V. I. Vernadsky, in his doctrine of the noosphere, argued that all humankind of planet Earth influences its biosphere, and that a collective mind («geological force» according to Vernadsky) is required for the evolutionary transformation of the biosphere into the noosphere. Unfortunately, it is currently impossible to account for the influence of all humankind on Earth's biosphere. Therefore, this work introduces certain constraints and assumptions: namely, conditionally noospheric intelligence (CNI) is understood as the system's ability to form expert groups composed of the intellectual elite – specialists in their respective fields – for solving practical contemporary tasks and problems.

Furthermore, the term intellectual elite refers to the academic and teaching staff of higher education institutions who possess the appropriate specialization and a high level of qualification in their domain of expertise.

Materials and Methods. The methodological basis of the study is a scientific approach to analyzing the research problems through the application of systematic and functional analysis, formal representations of set theory and utility theory, as well as ontological and geoinformation modeling.

The aim of the study is the scientific substantiation of the conceptual principles for creating quasi-noospheric intelligence using ontological and geoinformation modeling.

Main Results. We propose a conceptual model for the formation of conditionally noospheric intelligence, shown in Figure 1. Here, carriers of natural intelligence (NI) are academic and teaching staff (ATS), who, in the course of their professional activity, may progress from assistant (early-career lecturer) to professor, potentially assuming positions such as department head, dean, or rector. This process (T) is commonly referred to as career growth. A distinguishing feature of this process is that at different stages of professional activity $T=\{t_1^r, t_2^r, t_3^r, t_4^r\}$ an ATS member acquires the necessary knowledge and competencies and thereby develops and enhances their natural intelligence.

urthermore, in studying human intellectual activity, Howard Gardner [5] identified and substantiated nine components of natural intelligence, which he termed the components of multiple intelligence.

To strengthen the semantic content of Gardner's components, instead of the term «component», we will use the term vector, which indicates the directionality of a person's intellectual activity.

Thus, we denote $\overrightarrow{\rho_1}, \overrightarrow{\rho_2}, \overrightarrow{\rho_3}, \ldots, \overrightarrow{\rho_8}, \overrightarrow{\rho_9},$ де ρ_1 – naturalistic vector; $\overrightarrow{\rho_2}$ – musical vector; $\overrightarrow{\rho_3}$ – logical-mathematical vector; $\overrightarrow{\rho_4}$ – linguistic-verbal vector; $\overrightarrow{\rho_5}$ – existential vector; $\overrightarrow{\rho_6}$ – interpersonal vector, $\overrightarrow{\rho_7}$ – intrapersonal vector; $\overrightarrow{\rho_8}$ – bodily-kinesthetic vector; $\overrightarrow{\rho_9}$ – visual-spatial vector. Formally, we identify natural intelligence (NI) with multiple intelligence $\Upsilon=\{\overrightarrow{\rho_i}\}, i=\overline{1,9}$.

Such a decomposition and classification of the natural intelligence of ATS allow a formal description of the properties characteristic of a particular carrier of natural intelligence, as well as revealing the directionality of intellectual activity within a specific specialty.

There exist various approaches to evaluating intellectual activity, particularly those oriented toward assessing the results of intellectual activity. This refers to quantitative indicators such as the Hirsch citation

index (h-index). Unfortunately, existing methods and tests have a number of limitations that do not allow for quantitative assessment of collective intelligence.

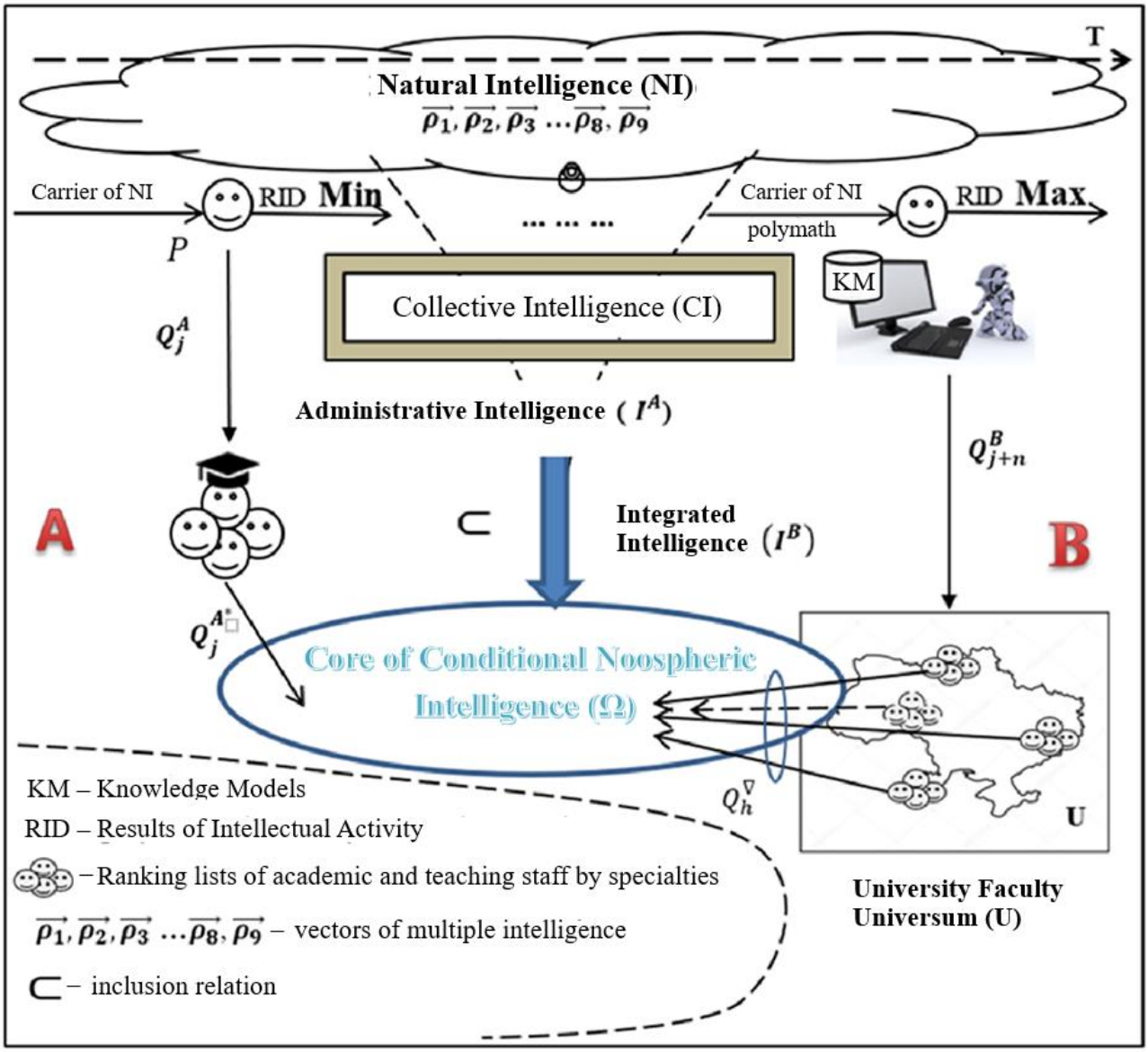

Figure 1 – Conceptual Model of the Formation of Quasi-Noospheric Intelligence
Рисунок 1 – Концептуальна модель формування умовно-ноосферного інтелекту

The model presented in Figure 1 consists of two branches, ***A*** and ***B***. Branch ***A*** represents collective intellectual activity within organizational structures of different systems. We call this type of activity administrative intelligence and denote it as (I^A). Here, private tasks in various subject domains are solved collectively using computational tools – for example, at a department meeting in an educational institution, a technical meeting at an enterprise, or a medical council determining a treatment strategy for a patient.

Branch ***B*** reflects the essence of group intellectual activity focused on working with knowledge models (***KM***), that is, with artificial intelligence. Such collective intelligence is referred to as integrated or hybrid intelligence and is denoted I^B.

We highlight an important component in the formation of the core of conditionally noospheric intelligence, denoted (**Ω**). This collective intelligence is not formed by all ATS in Ukrainian higher education institutions, but only by those who rank highest within their respective specialties. To explain this, let us characterize the relationships and connections that may arise during the formation of CNI. o achieve this, we reformat Figure 1 and abstract from minor details. In Figure 2, we highlight the time axis ***T***, which reflects temporal relations in the process of forming CNI. These relations include learning, knowledge accumulation, and competence formation in ATS, characterized by their qualification potential.

Let us denote Q_j^A – the relation «to be useful for solving specific (local) tasks» within a given collective (e.g., performing program guarantor functions within a department); $Q_j^{A^*}$ – a set of relations forming morphism cones within **Ω** for solving complex tasks in various subject domains; Q_{j+n}^B – «to be useful for solving weakly structured, multicriteria complex tasks» within a group of experts forming integrated intelligence; $Q_h^{B\nabla}$ – a set of relations forming morphism cones within **Ω** for solving complex tasks in various subject domains.

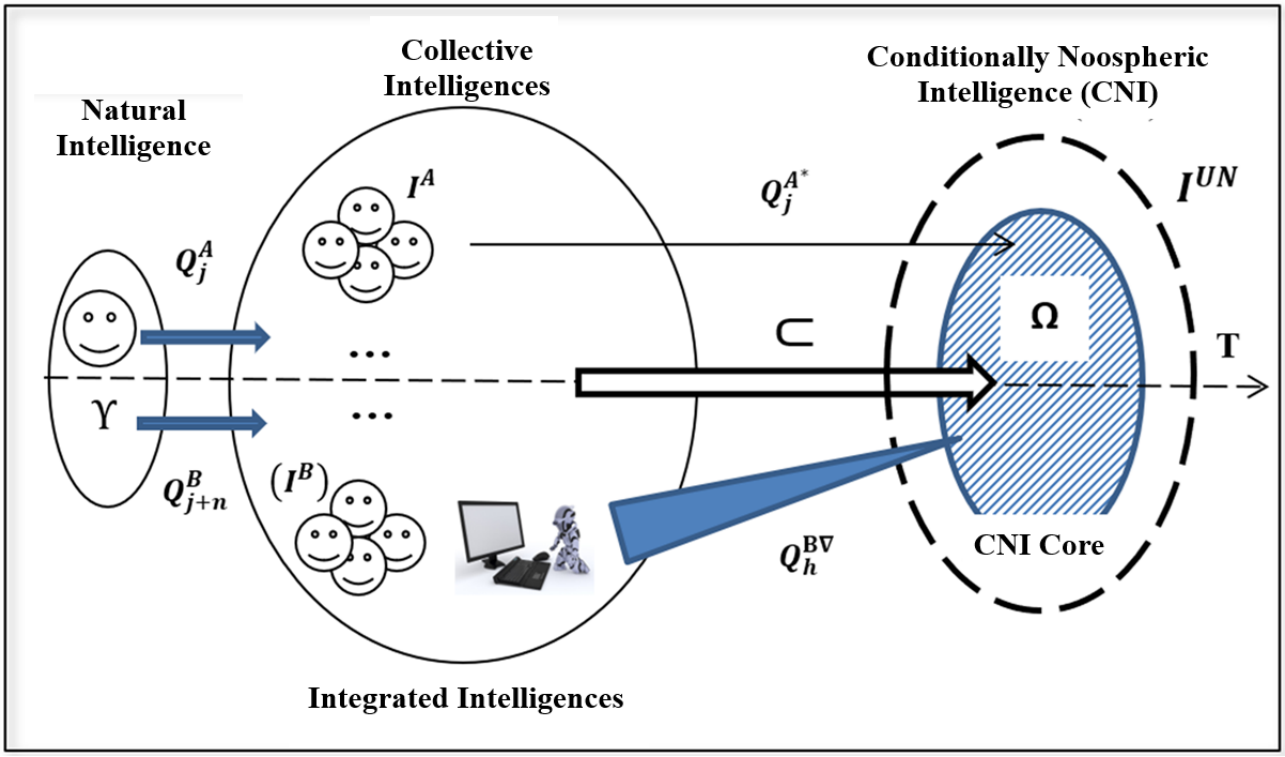

Figure 2 – Illustration of the Relationships Between the Elements of Conditionally Noospheric Intelligence
Рисунок 2 – Ілюстрація відносин між елементами умовно-ноосферного інтелекту

Abstracting from specific details of forming the CNI core, we express it analytically as:

$$M(I^{UN}) = (P(\Upsilon), I^A, I^B \overbrace{Q_j^{A^*}, Q_h^{B\nabla}}^{signature}, \subset, T).$$

Graphical and analytical interpretation of the CNI formation process allows us to conclude that the CNI core is formed for a specific task or problem. This implies that the foundation of the entire process is the qualification potential of carriers of natural intelligence, represented by the diversity of multiple intelligence $\Upsilon=\{\vec{\rho_i}\}$.

CNI represents a conceptual model of an intellectual environment encompassing human, social, cultural, natural, and technotronic components, based on the experience of leading specialists in specific domains of knowledge. If developed as a real model of interaction and application of knowledge, it possesses a higher level of generalization than traditional artificial intelligence, whose features have been considered in [6–8]. Such a model may function using AI and information technologies but is not reducible to them..

In examining the peculiarities of knowledge-based models in geographic information systems and related fields [9–13], the idea emerged to reflect the scientific potential of Ukraine, which can become the foundation for implementing CNI. This mathematical model establishes the basic principle for determining quantitative effectiveness of ATS, enabling more detailed ranking models for selecting researchers to address specific tasks within academic disciplines and university research domains. For example, Figure 3 presents a quantitative model of higher education institutions (HEIs) in Ukraine by region, based on GIS data derived from [14–15]..

Figure 3 – Model of the number of Higher Education Institutions (HEIs) by regions of Ukraine
Рисунок 3 – Модель кількості ЗВО по областям України

Using this model, which characterizes only the quantitative scientific development of Ukrainian regions, it becomes possible to enrich it qualitatively by calculating parameters of individual CNI components and linking them to HEI-related data.

These data are current and closely aligned with reality based on the conducted experiment and open sources of the Ministry of Education and Science of Ukraine. They demonstrate changes in HEI scientific performance depending on ATS composition. However, fuller and more reliable modeling requires a larger dataset, using not an averaged experimental indicator but relevant data for individual ATS.

Conditionally noospheric intelligence is a tool for integrating knowledge and professional experience across fields, forming an aggregated intellectual field. This field enables well-founded recommendations for solving complex cross-disciplinary tasks. The system takes into account factors that individual ATS members may overlook, especially in cases beyond classical solutions.

For example, in geodesy and land management, CNI can provide a much broader context for evaluating data – from legal aspects of land administration to ecological, social, and technical interdependencies that influence spatial measurements, their interpretation, and the use of non-standard geodetic technologies. This enables specialists to obtain not only results but interdisciplinary recommendations derived from the collective experience of experts from multiple scientific fields.

Overall, the development and implementation of CNI will ensure a qualitatively new level of decision-making across various domains of human activity.

Conclusions. This study formulates conceptual principles for the formation of conditionally noospheric intelligence as the next stage in the evolution of humanity's information space.

For the first time, the term «conditionally noospheric intelligence» has been introduced, based on the works of V. I. Vernadsky.

For the first time, conceptual principles for the formation of CNI using ontological and geoinformation modeling have been developed, relying on the knowledge and experience of ATS.

For the first time, ontological models of the functioning of conditionally noospheric intelligence have been constructed.

Examples of information support for CNI and its potential applications in geodesy and land management have been presented.

Overall, the results of this study constitute a development that, in contrast to existing research in artificial intelligence, proposes a concept that anticipates modern technological understanding, while AI methods and tools can facilitate the implementation of the complex structures of CNI..

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ФОРМУВАННЯ КОНЦЕПЦІЇ УМОВНО-НООСФЕРНОГО ІНТЕЛЕКТУ З ЗАСТОСУВАННЯМ ОНТОЛОГІЧНОГО ТА ГЕОІНФОРМАЦІЙНОГО МОДЕЛЮВАННЯ

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Анотація. В існуючих наукових дослідженнях спостерігається тенденція використання штучного інтелекту для вирішення задач в різних галузях діяльності людини. Так, наприклад, вирішуються задачі й в сфері геодезії для автоматизації камеральної обробки просторових даних, в геоінформаційних системах для формування векторних моделей за допомогою машинного навчання, в землеустрої для формування більш автоматизованих систем взаємодії з людьми.

Але певні міждисциплінарні задачі, вирішення яких потребує нестандартних підходів мають вирішуватися на більш високому рівні узагальнення інформації. Найвищий рівень узагальнення є необхідним для вирішення задач у законодавчих органах влади, де формуються закони, дія яких поширюються на всю діяльність всередині країни.

Вищесказане призводить до думки про можливість створення спеціальної інтелектуальної системи, база знань якої містила б модель умовно-ноосферного інтелекту.

Термін «умовно-ноосферний інтелект» тут запроваджено тому, що В. І. Вернадський у своєму вченні про ноосферу стверджував, що все людство планети Земля впливає на її біосферу і необхідний колективний розум («геологічна сила» за Вернадським) для еволюційного перетворення біосфери на ноосферу. На жаль, врахувати вплив людства на біосферу Землі нині недостатньо вивчено, але автори даної роботи намагаються сформувати певний підхід, який дозволить більш якісну взаємодію спеціалістів на великій відстані між ними та при відсутності між ними прямих зв'язків.

Метою цього дослідження є наукове обґрунтування формування концепції умовно-ноосферного інтелекту з застосуванням онтологічного та геоінформаційного моделювання для використання кваліфікаційного потенціалу науково-педагогічних працівників. застосовуючи обмеження та припущення, а саме розглянути його здатність системно формувати групи експертів із числа інтелектуальної еліти, експертів у своїх галузях, для вирішення практичних завдань та проблем сучасності, з застосуванням математичного обґрунтування та відображуючи науковий потенціал кількісною моделлю сформованою за допомогою геоінформаційних технологій. Крім того, в цій роботі під інтелектуальною елітою розуміються науково-педагогічні працівники вищих навчальних закладів,

які мають відповідну спеціальність і високий кваліфікаційний потенціал у своїй галузі знань. Подібна модель може функціонувати, використовуючи засоби штучного інтелекту та інформаційних технологій, але не зводиться до них.

В роботі використовували методи системного, функціонального аналізу, а також формальні уявлення теорії множин і теорії корисності з застосуванням онтологічного та геоінформаційного моделювання.

В результаті дослідження виведено термін «умовно ноосферний-інтелект». Вперше сформовано концептуальне представлення умовно ноосферного-інтелекту. Також, розроблено ядро умовно-ноосферного інтелекту у вигляді математичної моделі. Представлені приклади можливого застосування Умовно-ноосферного інтелекту за допомогою ГІС та на прикладі геодезії.

Ключові слова: умовно-ноосферний інтелект, штучний інтелект, аналіз, онтологічне моделювання, геоінформаційні системи, геодезія та землеустрій.

Перелік посилань

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