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Bachelor's thesis

ROBOTIC TECHNOLOGY TERMINOLOGY
(BASED ON MODERN ENGLISH)

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АНОТАЦІЯ

Бакалаврська робота присвячена дослідженню термінології робототехніки, детальному аналізу її лінгвокогнітивних та лінгвокультурологічних аспектів, структурних, семантичних та функціональних характеристик. За допомогою системно-функціонального та описового методів виявлено функції мовних одиниць у текстах з робототехніки та технічної комунікації, а за допомогою методів стилістичного, композиційного та структурного аналізу – особливості текстів.

У праці простежується зародження і розвиток термінології як самостійної наукової дисципліни від початку 1900-х років, висвітлюючи роль віденської, радянської та празької термінологічних шкіл. Воно зосереджується на ключових поняттях і досліджує правила та закономірності формування, розвитку та функціонування термінів, використовуючи статистичні та аналітичні методи.

У роботі робототехнічні терміни поділено на загальнонаукові, міждисциплінарні та вузькоспеціалізовані. Розглянуто лексико-семантичні процеси синонімії, антонімії та метафоризації, проілюстровано їх закономірність у розвитку лексики, зокрема в термінології робототехніки.

Дослідження наголошує на стратегічному вдосконаленні термінології робототехніки за допомогою різних лінгвістичних підходів, включаючи морфологічні та синтаксичні прийоми, конверсію, метафоричне перенесення значень та запозичення термінів з інших галузей. Ця робота суттєво допомагає у вирішенні питань стандартизації, уніфікації та класифікації термінів, а також сприяє укладанню термінологічних словників і глосаріїв.

Ключові слова: термінологія робототехніки, термінологічна школа, терміносистема, терміни з робототехніки, лексико-семантичні ознаки, термінологічні словосполучення, класифікація термінів.

ABSTRACT

The bachelor thesis is dedicated to the study of robotics terminology, providing a detailed analysis of its linguistic-cognitive and linguistic-cultural aspects, and its structural, semantic, and functional characteristics. Employing system-functional and descriptive methods, it explores the function of linguistic units in robotics texts and technical communication, while stylistic, compositional, and structural analysis methods examine the texts' features.

The research traces the origin and growth of terminology as an independent scientific discipline back to the early 1900s, highlighting the roles of Vienna, Soviet, and Prague terminology schools. It focuses on key concepts and investigates the rules and regularities of term formation, development, and function, using statistical and analytical methods.

The study categorizes robotic terms into general scientific, interdisciplinary, and highly specialized groups. It delves into the lexical and semantic processes of synonymy, antonymy, and metaphorization, illustrating their natural occurrence in the development of vocabulary, particularly within robotics terminology.

The work emphasizes the strategic enhancement of robotic terminology through various linguistic approaches and involves morphological and syntactic techniques, conversion, metaphorical transfer of meanings, and incorporating terms from other fields. This study significantly aids in addressing issues of standardization, unification, and classification of terms, and contributes to the production of terminological dictionaries and glossaries.

Key words: robotics terminology, terminology school, terminology system, robotic terms, lexical and semantic attributes, terminological phrases, classification of terms.

Contents

INTRODUCTION

In modern linguistics, there is a growing interest in studying the peculiarities and patterns of formation and development of terminological systems in various fields of knowledge. Addressing the problem of linguistic processes that arise in the formation of terminologies allows researchers to raise and solve such important issues for terminology as identifying sources of formation, replenishment and development of terminologies, determining the future of terms borrowed from other terminologies, establishing the ratio of national and international terms in terminology, solving the problem of authorship and temporal correlation of the term's appearance, clarifying the role of extralinguistic factors in the formation of terminology, etc. This kind of research is especially relevant for the terminologies of the new fields of knowledge that have been formed recently, since the description of the terminology of any field is the most important stage in its development.

The above fully applies to the terminology of robotics, which is still in its infancy. The concept of using terms in the field of robotics emerged in the second half of the twentieth century. The term *robot* itself was coined by the science fiction writer Isaac Asimov in 1942 (the word *robot* appeared earlier, in Karel Čapek's play R.U.R., 1920) [25]. When the study of robotics terminology was conducted in 1979, the research material was based on terms discovered in the course of working with foreign-language journal articles, conference materials, monographs, manuals, reference books, etc. At that time, it was only possible to outline a list of terms that were frequently encountered in the professional literature on these problems, were likely terms from these fields, and could give a rough idea of how new terminology systems are formed.

In recent years, the interest in the problems of robotics has increased dramatically. There are many scientists researching in this field both in Ukraine and abroad: I. M. Kochan [13], O. V. Petrenko [21, 22, 23], A. V. Reva [25], B. I. Shunevych [25, 31, 32, 33, 34], H. Fluck [38], T. H. Savory [47], etc. The expansion of the use of robots, which have become increasingly used in advanced industrial production, agriculture, household services, healthcare, military, as well as in space, underwater and other extreme environments, has led to the emergence of an independent scientific field – the theory of robotics, which has combined the achievements of many fundamental fields of knowledge and engineering disciplines. In this regard, **the relevance** of the topic depends on the ever-increasing need:

- to systematize and unify terms in robotics – a relatively young, fast-paced, promising science;
- to create terminological databases.

The aim of the study is to research the current terminology within the field of Robotics in Modern English, to analyze the ways and sources of its formation and structural and semantic features of these terms in context.

To achieve this goal, we plan to accomplish **the following tasks**:

1) to study the theoretical works to define the terminological apparatus for the study of the terminology of the field of Robotics, to substantiate the methodology and principles of sampling of terminological units, the role of terminology;

2) to identify the ways of formation and origin, structural types and models of robotics terms, structural features of robotic technology terminology;

3) to investigate the lexical and semantic features of English within Robotics in a variety of texts;

4) to analyse the quantitative composition of the selected terms in the field of Robotics;

5) to explore the functioning of the terms of Robotics in professional texts of different genres (articles, conference materials, fiction prose, etc.).

The research material is represented by English-language journal articles (Journal of Intelligent & Robotic Systems; Neurocomputing; Industrial Robot: An International Journal; Robotics and Computer-Integrated Manufacturing; Computers in Cardiology; Journal of Marine Science and Engineering; International Journal of Mechanical and Production Engineering Research and

Development; International Journal of Control; International Journal of Online Engineering; Journal of Chromatographic Science; Control Systems Magazine, etc.) [70, 72, 73, 76–78, 81, 86, 95, 98, 100, 102, 103, 105, 115, etc.], conference materials [20, 21, 33, 71, 74, 75, 80, 82, 83, 93, 104, 111], dissertations [23], monographs [5, 34], manuals [4, 11, 24, 37], dictionaries abstracts [54–69], etc. The language data includes up to 45 scientific studies, articles and news articles in latest robotic advancements, enriched with robotic technology terminology. We analysed the structure, lexical-, semantic characteristics of about 600 terms, and ways of their formation.

The object of the research is the robotics terminology in Modern English.

The subject the research is the lexical, structural and etymological peculiarities of the terms within the field of Robotics, which are sampled from technology articles, scientific texts in robotic technology, and fiction.

The following research methods were used in the analysis: system-functional method to study the functioning of linguistic units in texts of scientific and technical communication; descriptive method to explain the peculiarities of the functioning of contradiction in language and speech; method of stylistic, compositional and structural analysis to explore the stylistic, compositional and structural features of the analyzed texts.

The theoretical value of the study is lies in the specific contribution to further investigation of current trends in term formation in the field of robotics terminology; determining the specifics of the development and functioning of robotics terms in English.

The practical value of the received results is important as they can be used in the courses of general linguistics; in creating a dictionary of terminological vocabulary of the sublanguage of robotics; creating and maintaining banks of terms in this field of science and technology. Some chapters can be used in special courses on term theory and specialized dictionaries.

The research opens several avenues for further study, including the potential for developing a comprehensive multilingual dictionary of robotic terms, exploring the impact of robotic terminology on other technical fields, investigation into the sociolinguistic aspects of term adoption and diffusion among non-specialist audiences.

1. ROBOTIC TECHNOLOGY TERMINOLOGY IN LINGUISTIC RESEARCH

1.1 Terminology: basic metalanguage, schools, principles of research

Terminology as a special group of vocabulary and a term for a special kind of words has been the subject of scientific discussions and research for several decades. It plays an integral role in science and technology development. The successful development of any science or industry is invariably accompanied by the emergence of new terms that express scientific and technical concepts. In a time of rapid development of science and technology, terminology plays an increasing role, so research aimed at comprehensive study, development, unification, universalization, streamlining and improvement in terminology in various fields of science and technology is important.

The period of origin and formation of terminology as a separate science dates back to the beginning of the XX century. According to A. Haiutin [30], this concept was first introduced in 1786, and in 1801 it appeared in English and French with the meaning of "description of a certain concept".

Terminology is one of the most intensively developing branches of linguistics. Modern linguistics conducts research both in terms of solving theoretical problems of terminology and applied aspects.

The following problems deserve special attention of linguists: **systematicity of terms** (Kyiak [11], I.M. Kochan [13], D.S. Lotte [16], etc.), **the functioning of terms in texts and language** (R. Fluck [38], Korutets Ilke [42] etc.), **unification, ordering and universalization of terminology systems**, **lexicography**, **historical conditions of formation and development of terminology** (I.M. Kochan [13], T.I. Panko [18], T.N. Savory [47]), **interaction of terminology with common vocabulary** (A.V. Kryzhanivska [14]), **problems of translation of terms from one language into another** (B.I. Shunenvych [31, 33]) and other problems.

Only recently have we started to perceive terminology as an independent science, but it was different for a long time. In particular, the terminology was considered as:

- “a systematized, verbally expressed set of concepts of a particular science” (Kovalyk) [12];
- “as "part of the vocabulary of the modern literary language, emphasizing the functionality of terminology” (Haugen) [40]
- “1) vocabulary section covering terms from various fields of science, technology, art, social life; 2) a set of terms of some branch of science, technology, art, etc. or all terms of a given language” (The Ukrainian Encyclopedia) [58];
- “a set of terms of some branch of science, technology, art or of all the terms of the given language” (The Ukrainian Language Dictionary) [57];
- “a set of terms expressing historically formed concepts of a certain sphere of human knowledge or activity” (Kyiak) [11, p. 7].

T. R. Kyyak rightly distinguishes terminology as an arbitrary collection of terminological units and a term system as their systematically ordered combination [11]. A good reason for such a distinction is that a significant number of terms arise spontaneously and are not included in the terminological hierarchy as its organic component. The rest of the definitions, which can also be considered acceptable, do not have significant differences.

There are a lot of inventions in science and technology, phenomena caused by globalization, and other extralinguistic factors that influence the formation of new terminological units.

The review of recent works shows that there is a large number of definitions of a term in the linguistic literature with varying degrees of expression of its characteristic features. In this regard, it is necessary to focus on the analysis of the following concepts: "**terminology**", "**term**", "**terminology system**".

The word "terminology" has many meanings and is understood as: **a)** science of proper use of terms [61]; **b)** special words or expressions used in relation to a particular subject or activity [61]; **c)** the terms or system of terms used in a specific science, art, etc. [60].

We believe that scientific terminology should not be a simple set of words, but also a system of words or phrases connected in a certain way with each other. This is probably one of the main differences between terminology in the sense of a set of terms that name scientific concepts of various fields of knowledge, and scientific terminology.

In modern linguistics, according to Panko, terminology is not just a set of special words [18, p. 32], but a system of multi-level relations (Korutets) [42, p. 204], a set of terms of a certain field of knowledge, which is the basis for the study of functional, practical and theoretical aspects of terminology (Haugen) [40, p. 14].

The theoretical task of terminology is to establish the regularities of formation of concepts, definitions and terms and their use in various aspects. **The applied task of terminology** is to develop rational structures of subdivisions, terms and indices, and to establish their optimal connections. As for the terminology of robotics as a system of terms, it is currently in the process of formation, moving from the collecting and generalizing of concepts to their analysis and identifying of their inherent regularities.

Terminology is born and evolves on the basis of a particular national language. The creator of terms, as well as the bearer of special vocabulary, are the speakers of this particular national language. But the conditions for the birth of terms are quite different from the conditions for the birth of a common word. It is the conceptual apparatus as well as the patterns and processes of development of the sciences in which terms are used that determine the meaning of terms.

The need for the formation of new terminology arises at a certain stage of society's development, provided that the language system is developed. It should be noted that the formation of new terms is a complex process that can take place over centuries. An example of this is the development of linguistic terminology, which was created gradually with the knowledge of the phonetic and grammatical structure of the language. Greek and Latin became the basis for the development of linguistic terminology.

The foundations of terminology as a science were laid by the Austrian scholar Eugen Wüster and Russian terminologist Dmitrii Lotte [2], who published the first terminological works in 1930. The existence of a separate science of terms is no longer in dispute, and moreover, independent areas and schools are developing within it. However, the recognition of terminology as an independent scientific discipline has not yet resulted in the creation of a generalized theoretical works with a clear statement and solution of problems related to the necessary attributes of a scientific discipline. The reasons for this state of affairs are the distinctly interdisciplinary nature of this field of knowledge, as well as the fact that the pace of development of applied fields of terminology is ahead of its own.

Numerous experts became terminologists, including Antoine-Laurent Lavoisier (1746–1794), Eduard Paasch (1853–1904), Sergej Alekseevič Čaplygin (1892–1942), Ernest K. Dresen (1892–1937), Dmitrij Semënovič Lotte (1898–1950), John Edwin Holmstrom (1898–1878), Eduard Wüster (1898–1877), and others [51, 16].

The Vienna (Austrian), Soviet, and Czech (Prague) schools of terminology are the traditional schools that arose from the research conducted by these specialists. Maria Teresa Cabré [44] claims that these schools used the following three strategies:

- The first approach views terminology as an independent, multidisciplinary subject serving scientific and technical fields.
- The second approach centers on philosophy, which is mainly concerned with the arrangement of knowledge and the logical categorization of concept systems.
- The third approach centers on linguistics and regards terminology as a part of a language's lexicon, with special languages functioning as subsystems of general language.

The **Vienna or Austrian School** was born thanks to the work of Eugene Wüster [51] who in 1931 presented his thesis on the international standardization of technical language with emphasis on electrical engineering, at the Technical

University of Berlin. His thesis served as the foundation for the General Theory of Terminology, whose tenets and methods — univocity, synchronic approach, onomasiological approach, and term standardization — gave rise to the Vienna School as it exists today.

The foundation of the Czech, or Prague, School is based on functional linguistics. "The Prague School is the most 'linguistics-centered' school," according to M.T. Cabré [45], and it was established on the theories of literary and cultural language. It concentrated on language and terminological standardization and was almost entirely focused on the structural and functional description of special languages, where terminology plays a significant role.

The three schools maintained close contact and collaborated, and we owe them the foundation of today's terminology. The new theories and approaches have updated and expanded on traditional theory to account for not only new technologies, but also new cultural and communicative requirements.

Up until recently, terminology was usually perceived as a branch of lexicology, the main tasks of which were to establish the structure of terms in specific fields, to organize and unify terms, and to create terms for new fields; nowadays, most experts [4, 5, 17] consider terminology as an independent science of terms. An obvious difficulty in establishing the scientific status of terminology is that "in the process of research and development, so many specific features and peculiarities inherent only in terminology have been revealed; techniques and methods have become so separated from purely linguistic ones, and the object of terminology – the term (terminology) – is so multifaceted and comprehensive that it has prompted the vast majority of terminologists to conclude that the science of terms is complex" [6].

Terminology as a science studies the rules and regularities of the formation, development and functioning of terms in a particular field of human activity. This science uses **statistical and analytical** research methods.

The statistical method (SM), which defines "what is common?", is to determine the presence of a linguistic reality without regard to its correctness. The most important components of this method are the descriptive and the observational methods. The statistical method is traditionally used to study both oral speech and written sources, recording the practice of using a particular language/speech unit. A significant disadvantage of this method is that it does not provide for a critical assessment of the available results and the translation of the amount of information acquired into qualitatively new knowledge.

The analytical method (AM), which determines "what is correct?", allows to find out the scientific validity and expediency of a particular linguistic unit (including lexemes and, in particular, a term) or a rule, and includes methods of comparative, semantic, conceptual, logical-conceptual, historical-etymological, component analysis, induction and deduction, taxonomization, formalization, idealization, grammatical analogy, priority functioning, acoustic invariants, etc.

The use of both methods as equal components of a holistic approach in linguistic research helps to eliminate the typical shortcomings of the use of individual linguistic methods, in particular the imperfection of the initial theoretical positions and the generalization of one part of the whole and thus provides an opportunity to obtain the most balanced scientific generalization of the quantitative and qualitative characteristics of the linguistic phenomenon. In addition, the completeness of the scientific approach requires the application of the components of statistical and analytical methods in an integrated manner. On this basis, the problem of synonymy in terminology, the patterns of replenishment of terminology systems with new lexemes, the concept of a successful term, the semantic load of individual morphemes, the acoustic characteristics of speech sounds, and a number of spelling problems were investigated.

It should be noted that we have to differentiate SM from the method of statistical analysis [19], which includes elements of AM and therefore is a combination of both methods. For example, statistical analysis can be used to quantify how often a term is used under given conditions compared to other terms that mean the same concept.

Thus, SM identifies common (used), but not necessarily correct, language phenomena or forms. Instead, AM helps to identify correct, but not always habitual phenomena/forms, as well as to outline the process of formation or the existence of certain trends or laws.

Based on statistical and analytical methods, it becomes possible to formulate objective features of a "successful term," to conduct a comprehensive and reasonable classification and ordering of synonyms inherent in each developed terminology system, to develop reasonable recommendations for spelling and use of a particular linguistic reality, and to study the acoustic features of speech sounds and highlight their invariant characteristics, which allows, in particular, to unify the principles of graphic representation of foreign and borrowed words. In this way, terminology as a science actually combines the methodology and approaches of the exact sciences and the humanities, which allows for a much deeper and more objective study of language material.

1.2. Term features and its functional nature as a linguistic unit

It is commonly accepted in linguistics that the central semiotic unit of terminology is a term. However, despite the existence of a large number of terminological studies, there is no unambiguous interpretation of this unit today.

Obviously, it is not possible to provide a comprehensive review of all definitions of a term, so we will limit ourselves to the most important ones. Thus, in its historical development, the concept of *"term"* has been interpreted as:

- "a word that is the name of a clearly defined concept" [57];
- "a word or phrase of a special (scientific, technical, etc.) language that is created, obtained or borrowed for the precise expression of special concepts and designation of special subjects" [62];
- "a word or phrase that expresses a special concept of a certain field of science, technology, art, social life, etc." [58];
- "a specially cultivated word invented artificially or taken from the natural language" [2].

The above definitions cannot be considered successful. Firstly, in the respective definitions, it should be taken into account that the Latin *terminus* is not the etymon of the word "*term*", as it comes from the Greek τέρμα *'end, limit'* [58]. Secondly, the term "*special*" is not entirely correct, since terms are classified as commonly used (*distance, water, star, fire, light*), general scientific *(analysis, analogy, category, synthesis)*, interdisciplinary *(weight, electricity, osmosis, proton)*, sectoral *(boson, gluon, quark)*, slang *(DM – direct message)*, etc. [56, 67].

All scholars agree that the ontological feature of a term is its **conceptuality**, i.e., its correlation with a certain concept in the system of concepts of a professional field of knowledge (science, technology, politics, culture, etc.). In this regard, the conceptual paradigmaticity of a term is the basis of any logical definition or any working definition of this linguistic sign, and it is also the basis for establishing the characteristic features of the latter [5, 7, 14, 15 etc.].

The conceptual correlation of a term is directly related to its specific feature of **systematicity**. The idea that a term should be considered not as a separate sign, but as a constituent of a certain system was first substantiated and highlighted in the works of D.S. Lotte, who noted that "each term has a well-defined place in a certain terminological system, which depends on the place of the corresponding concept in this system of concepts" [16, p. 14].

It should be noted that, in addition to systematicity and conceptuality, which actually determine the semantic nature of a term, there is another stating feature of the latter – it is the presence of an **accurate definition**. In this case, the definition is understood as "the written or verbal content of the termed concept" [23]. The definition is intended to condense the information about the scientific concept concentrated in the term and to act as a regulator of semantic relations in terminology, acting as a means of conceptual consolidation of the term, which implies that the term of a certain terminology must necessarily be defined through another generic term of the same terminology.

Another defining feature of a term is its informative nature, or rather, its **dichotomy** (its intellectuality) [14, 22]. This means that the difference between a term and a non-term lies not so much in the linguistic sphere as in the sphere of intellect, and is primarily due to the amount of professionally relevant information encoded in a linguistic sign and the degree of processing of the concept by the thinking of an individual who carries professional knowledge, in which the concept has the right to be correlated with a scientific definition: the more this information is available, the more grounds a terminologist has to grant the word the status of a term.

In an effort to theoretically comprehend the essence of a term as a linguistic unit, terminologists [6, 19, 20, 31] note that in addition to the above constitutive features, the term must meet additional requirements, namely **a) unambiguity** (in a certain terminology system, each scientific concept should correspond to one term, and only one meaning should be attributed to each term); **b) accuracy** (in terms of internal form, the term should be correctly oriented and should reveal only the essential features of the concept); **c) independence and indifference to the context**; **d) conventionality** (purposeful nature of the term creation); **e) brevity** (the length of the term should facilitate easy memorization of the sign, and therefore its widespread use); **f) absence of synonyms and homonyms** (the terminology should be completely isomorphic with the system of terms and the system of concepts); **g) stylistic neutrality** (the term should be devoid of emotional and expressive coloration); **h) derivativity** (the term should be characterized by derivative potential, i.e. be convenient for the formation of new terminological nominations) and others.

So, summarizing and clarifying the above definitions, we can give the following definition: **term** *(from the Greek τέρμα 'end, limit')* is a word or phrase that denotes a certain concept in a certain field of human activity: science, technology, culture, sports, art, etc. [3] This understanding of a term has been entrenched in traditional linguistics, which considers a term as "a word or phrase denoting a concept in a particular field of science, technology, etc." [58]. Such a definition is generally accepted, but as a result of further development of the author's terminological concept, an improved version of the definition just given has emerged, namely: **term (from the Greek τέρμα 'end, limit') is a word or phrase that is an organic (systemic or non-systemic) element of the terminological register and denotes a certain concept in a particular field of human activity** [2]**.**

In an effort to theoretically comprehend the functional structure of a term, V.M. Leichyk provides the following list of functions of the latter: **nominative**, **signifying**, **communicative** (informational), **pragmatic**, **heuristic** and **instrumental**. The first consists in fixing special knowledge, i.e. naming concepts, categories, signs of concepts and relations between objects in the professional fields of human knowledge, without which scientific cognition and professional activity are impossible in the latter. The signifying function, which is directly related to the first one, is revealed in the way the objects of nomination are designated. The communicative function is the transfer of professional knowledge and the exchange of professional information. The pragmatic function is designed to ensure the effectiveness of professional communication by choosing the right guidelines for influencing the recipient. V.M. Leichyk considers the heuristic and instrumental functions as specific functions of the term, the first one is the function of discovering new knowledge, and the second one characterizes the term as a tool of cognition [15, P. 90-91].

A term has a number of features. A term differs from an ordinary word as it has a very specific meaning and logically identifies the features necessary and sufficient to express the characteristics of a given concept, on the basis of which a classification of concepts is built. V. M. Leichyk [15] specifies that terms appear as such in the special vocabulary of a language (vocabulary for special purposes), and not in the vocabulary of a natural language as a whole. Thus, it is the sphere of application of a term that is special, not necessarily the term lexeme itself. With the help of terms, the results of cognition are fixed in a material form, and at the same time, "a term is the unity of an element of the external side – the level of "lexis"– which is defined from the internal side-with the element of "logos," that is, the concept of the conceptual field of a scientific or technical discipline. A lexeme as a unit of the "external side" of a term, i.e. as a unit of the "lexicon" level, has both a plan of expression and a plan of content". In the framework of cognitive terminology, a term is understood as a component of a dynamic model of language that dialectically combines a stable sign system with its constant rethinking [2, 15].

G. Othman [43, p. 15], considering the conceptual specificity of a term, divides all terms into scientific terms, which denote theoretical concepts of sciences, and technical terms, which denote instruments, artifacts, experiments, observations, measures.

Scientific terms can also be **classified by origin** – into specific and borrowed; by the degree of motivation – into "correct" and "false"; by the degree of definition – into prototerms, terminoids, and preterms; by functional and stylistic limitations – into normative and non-normative, or into terms and professionalisms, because unlike terms, professionalisms are not widely used. Also, there are still no universally recognized grounds for distinguishing between terms and nomens, although a significant number of terminologists are inclined to believe that the former denote concepts, while the latter denote single objects [2, 20, 29, 33].

1.3 Terms within English word-formation

Exploring term formation involves naming the concepts needed by a specific language community to enhance cognitive processes and communication. This activity is a deliberate human action that stands out from typical word formation processes due to its heightened awareness of existing patterns and models, as well as its social duty to enhance communication and knowledge sharing.

Term formation involves creating new combinations of phonemes or graphemes, similar to word formation. It is quite uncommon, though. Typically, term formation is based on pre-existing lexical elements that are combined in specific ways, which can be explained and then utilized as templates for future formation processes. It is important to differentiate between simple terms made up of one lexical element and complex terms made up of two or more lexical elements, regardless of their graphemic connection and combinability. Using advanced vocabulary, terms can be compounds, derivatives with affixes, simple combinations, or phrases with articles and prepositions. It is challenging to differentiate between complex terms and free-formed phrases based on linguistic criteria. For instance, distinguishing between terms like *low-calorie diet* and *low-level radioactive solid waste*, and phrases like *low resistance level* or *low error rate* is not straightforward.

Term formation typically takes place in specific settings such as research laboratories, design offices, workshops, or any other situation where individuals require novel ways of expression. Term formation methods vary based on the subject area, the individuals involved, and the stimulus for term creation.

Distinguishing between **primary** and **secondary term formation** is crucial as these processes are driven by distinct motivations and influences. There is a fundamental distinction between these two scenarios: in primary term formation, there is no direct linguistic precedent, although there may be varying degrees of strict rules for creating suitable terms. When forming secondary terms, there is typically a previous term that serves as a basis with its own underlying rationale. One option can be impromptu, while the other is shaped by specific parameters and can be carefully planned and constructed.

Primary term formation refers to the terminology development process that occurs in conjunction with the establishment of concepts due to advancements in science and technology or modifications within a linguistic community. As a result, it is predominantly monolingual. A designation may be regarded as definitive or provisional. In the latter case, it might be accompanied by a stipulative or temporary definition until a definitive name is accepted (as in the scientific naming of plants, which requires approval from an international committee).

Secondary term formation occurs in two distinct contexts and involves the creation of a new term for an existing concept:

- in the event when a designation is subsequently modified due to a monolingual revision of terminology, such as when a standards document is being produced.
- in the course of term creation, which facilitates the transfer of technological and scientific knowledge from one linguistic community to another.

There are three distinct approaches to term formation:

- the use of existing resources
- the modification of existing resources
- the creation of new linguistic entities

a) The Use of Existing Resources.

This method often involves expanding the definition of a term to encompass a new idea. For example, words like *robot* or *computer* now encompass a broader range of objects than originally intended. Everyday words can be used to represent broader concepts without specifying them. Specifically focusing on different body parts such as *fingers, hands*, and *arms* for mobility, and *legs* and *feet* for stability. Comparison can be seen as a way to help establish a concept by making it easier to understand. One way to overtly express simile is by using qualifying expressions like -*style, -like,* or -*type*. One way to utilize existing resources is by taking advantage of the multiple meanings of common language terms (such as "*shell of the house*" or "*river bed*").

b) The Modification of Existing Resources

One common way to introduce new concepts is by altering existing terms through derivation or affixation (*e.g. hydrodynamic*), compounding *(e.g. rock floor*), creating phrasal terms *(e.g. general purpose computer)*, conversion *(e.g. supply* as both a noun and a verb), and compression *(e.g. TNT)*.

The method of **determination** as a word formation device likely has its roots in syntagmatic determination. It is possible to see a development from a longer phrase such as "*a post that is built to support a beam*", where the relative clause specifies *post* by its function, or *"girders cast prior to construction*". As a result, there are typically multiple grammatical options for providing more specific details, with one option usually being the shortest and most commonly used.

c) The creation of new linguistic entities

Creating new terms is necessary when there are no existing words to describe novel concepts. Various methods are used to create new words, each involving different processes. Neologisms fall into two categories: they are either completely **new creations** or **borrowed from other languages**.

English scientific vocabulary mostly comes from Greek and Latin, and was later adapted into English. English has a history of borrowing words from Greek, Latin, and French. It can be difficult to determine if a word came into English through French or directly from the classical languages.

Another type of new word is the calque or loan translation, in which a term from one language is translated element by element into the receiving language. This practice is common in extensive terminology transfer, whether it's from translating product and service literature or textbooks (*online – en linea (Spanish*)) [45].

Developing countries' languages are influenced by word formation patterns of other languages, which can expand their means of expression. Various means may emerge based on the linguistic distance between the exporting and importing language, common elements between the languages, and traditions of contact between them, influencing a preference for techniques of term formation.

Conclusion Chapter 1

1) Specialized and common vocabulary are interrelated. The very process of forming terminology on the basis of common vocabulary and the use of terms to form words of general use is permanent due to the fact that the boundary between special (terminological) and common vocabulary is very unstable and has a functional rather than historical nature, so their distinction causes objective difficulties.

2) The terminology of robotics as a system of terms is currently in its infancy. Its research objectives are: collection and fixation of terms and means of their formation, identification of their inherent regularities, establishment of their functional characteristics, etc.

3) The central semiotic unit of terminology is a term. The constitutive features of a term include conceptual correlation, systematicity, availability of a scientific definition, and informativeness; additional features include unambiguity, precision, independence from context, conventionality, brevity, absence of synonyms and homonyms, stylistic neutrality, and derivativity. The concept of a term requires both definition and distinction from other concepts, .

4) Terms in robotics have all the features of common vocabulary: they can be multivalent, enter into synonymous and antonymic relations.

5) By a term in robotics we mean a word or phrase that means a concept related to the field of robotics and included in the relevant system of robotics concepts, limited to a special field of use, fixed in robotics and, as a rule, regulated by a definition.

2. CHARACTERISTIC FEATURES OF ROBOTIC TERMINOLOGY IN MODERN ENGLISH

2.1. Research of the Robotics Terminology System

Despite the fact that robotics terminology has been developing for a long time, it is still in the process of formation and has attracted the attention of lexicographers and linguists. Its research in different languages is carried out in the following areas: 1) compiling dictionaries; 2) theoretical studies; 3) applied research.

The first works on the study of these terms are related to their fixation in indexes and dictionaries of various sizes. In 1982, the first German-English-Russian dictionary on robotics was compiled in the GDR by the authors of the Department of Foreign Languages of the Higher Technical School (Zwickau) together with robotics specialists "Fachwortschatzsammlung Handhabe und Industrierobotertechnik: Deutsch-Englisch-Russisch" [54]. This is a small dictionary (about 500 lexical items). The dictionary contains lists of terms in the respective languages with their serial numbers, which can be used to find their equivalents in other dictionaries.

A five-language dictionary on this topic was compiled by a team of robotics specialists and teachers of the Department of Foreign Languages of the Higher Technical School in Zwickau (GDR) and Košice (Czech Republic) in 1985, "Fachwortschatzsammlung Industrierobotertechnik: Deutsch-Englisch-Französisch-Slowakisch-Russisch" [63]. The volume of the dictionary is about 960 terms. All terms are numbered. At the end of the dictionary there are graphic images: 1) coordinate systems of robot movement; 2) gripper designs; 3) robot arms; 4) robot diagrams with corresponding symbols and explanations. According to the authors, the dictionary was created on the basis of conference papers and other scientific and technical literature on robotics.

In 1987, the GDR published a four-language English-German-French-Russian dictionary on robotics with a volume of 7,000 lexical items "Robotertechnik: English-Deutsch-Franzosisch-Russisch" (G.-D. Junge [66]).

The lexicographic works on this topic also include three lists of English neologisms (1986-1987) developed by B.I. Shunevych and M.P. Tykhomyrova and "Methodological developments and educational tasks for reading texts on robotics in English" [23]. The list contains about 2000 of the most frequent single-component terms (with a frequency of at least 3) and 185 multi-component terms (with a frequency of at least 10). Overall it includes about 7 thousand lexical items [31].

Along with the lexicographic works on robotics, the terms of this field of science and technology are being standardized. For example, in the USSR, in 1983, standards for 28 basic terms and their definitions in robotics were approved and adopted in 1985. International standards organizations have approved 152 terms for basic concepts in robotics [23]. Each term has a short definition.

In parallel with the fixation and standardization of terms in robotics, terminological studies of this terminology system are being conducted, the results of which are presented in articles, reports at various conferences and seminars in the following areas:

1) the principles of compiling a frequency dictionary of terms and the availability of the rank lists of robotics terms created on the basis of different samples;

2) studying the possibilities of using frequency dictionaries on robotics as a basis for a dictionary in the system of automated processing of English texts on this topic, in particular, in the system of automatic indexing and abstracting. Thus, a frequency dictionary was introduced into the machine's memory and used to determine the saturation of terms in different parts of the texts of three genres of scientific and technical literature on robotics, as well as to determine the distance between the occurrence of terms in the text;

3) analysis of the creation of terms of a certain terminology;

4) study of synonymy in certain terminology;

5) establishing the origin of key terms in robotics;

6) correlation of the peculiarities of term formation in English and Russian, German and Ukrainian [23].

Such a variety of theoretical issues covered in the literature indicates that the study of robotics terminology systems is increasingly moving from the field of term fixation to the field of term analysis.

Applied studies of the robotics terminology system include articles and reports that address the problems of selecting the lexical minimum at different stages of training future robotics specialists. The most frequent vocabulary (basic vocabulary) was used to create textbooks for students of the relevant specialty of full-time and part-time education [31; 54].

2.2. Lexical and semantic characteristics

The most relevant area of terminological research devoted to determining the specifics of a term as a special type of linguistic unit is the study of its main lexical and semantic features. According to the traditional view, Strachenko [28], the nature of the term is determined by the specifics of professional and scientific communication.

The term **"semantics"** (from the Greek *Semantikos* - denoting) has several meanings. Its main meanings include: 1) the semantic side of language units; 2) a linguistic discipline that studies the plan of language content as a whole; 3) a section of semiotics that studies sign systems as a means of expressing meaning; 4) analysis of the relationship between language units and the world (concepts and objects of reality), as well as the totality of such relationships. The essence of this relation is that language units (words, phrases, sentences) denote objects, qualities (or properties), actions and relations that occur in the real world [23].

Lexical and semantic groups of words are groups of full-sense words, each of which is distinctive lexically, semantically and in terms of stylistic functions. The semantics of words covers the names of objects, processes, phenomena, relations between them, realities and fantasies, dreams, etc. It is inherent in all meaningful words.

The most complete and compact lexical and semantic essence of full-meaning words can be traced in such phenomena as polysemy, homonymy, paronymy, synonymy, antonymy of lexemes, etc. The stylistic and functional potential of these layers of the lexicon is not equally vast, but communicatively distinctive and important. Most of all, it concerns polysemy and synonymy according to the Ukrainian language manual [56].

There are two conceptual approaches to describing a term and a system of terms: **normative** (prescriptive) and **functional** (descriptive). The proponents of the normative approach view a term as a unique lexical unit and a system of terms as a unique sign system, wherein common language features like homonymy, polysemy (metaphor, metonymy), synonymy, and antonymy are undesired and not considered inherent.

The supporters of the **functional approach** consider the system of terms as an independent subsystem within the general literary language, which is characterized by all lexical and semantic processes of the general literary language. Since the terminosystem has some freedom and independence in terms of lexical development, the lexical and semantic processes that take place in it differ from similar phenomena in the general literary language. "The difference is that these processes do not affect the characteristic lexical and semantic features of terminology. They take place within the limits that do not violate the semantic definition of the term" [23].

Thus, in the study of the English-language term and terminosystem, we adhere to the functional approach and believe that in the specific terminology of robotics, there are lexical and semantic processes between terms: polysemy, metaphor, metonymy, synonymy, antonymy, homonymy, and others. And this is quite obvious, because terminology is a functional type of the national language, and therefore cannot be isolated from the laws and processes of formation and development of the general lexical system of the language; it has the same lexical and semantic relations that characterize the lexicon in general, but with its own specific features and "within the limits that do not violate the semantic definition of the term" [28, p. 61].

In the analyzed terminology of robotics, there are such lexical and semantic processes characteristic for the lexicon in general:

1. Synonymy in terminology is a manifestation of a general linguistic pattern. The peculiarity of this phenomenon in terminology is that synonymous terms relate to the same concept and object. Therefore, there are absolute synonyms in terminology that are devoid of stylistic shades. However, synonymous terms differ in features, for example, structure, origin, and functioning. For example: *service robot – operating robot, functional value – utilitarian attributes.*

Service robots were mainly judged for its service and experience that has been provided to its customers rather than its capability as a machine itself.

Airstar is the world's first commercially operating robot, where any passenger can interact with Airstar using its touch screen [76].

2. Antonymy occupies a significant place in terminology, because any phenomenon, concept, or object is perceived more deeply and vividly when compared or contrasted. Antonyms are terminological units that do not denote just any opposite concepts, but necessarily correlative concepts, i.e., those that belong to the same range of phenomena of objective reality, united by content, based on opposition. Antonyms in the field of robotics enter into complementary, conversion and vector relations. For example: *robot hard**ware** – robot software; robot **exporter** – robot **importer**; **in**put – **out**put.*

One way to this end is the exploitation of the computer input-output devices to operate with industrial robotic equipment [113].

In addition, measured input and output signals concerning the specific hardware modules are shown, too – This connection between the reader and the map software describes, figuratively, the link between the reader and an indoor navigation system [93].

3. Metaphorization of terms is a manifestation of a general linguistic pattern, which consists in the transfer of meaning based on associations due to similarity of shape, color, place, behavior, and sound. Observations show that ambiguity develops in the same categories of word-terms as in the system of the general literary language. Source concepts are most often formed from somatisms, names of parts of the relief, natural phenomena, names of phenomena and processes related to human social life, names of geometric figures and other concepts. For example: *robot arm; intelligent robot.*

Through the camera mounted on the robot arm to collect images and image processing and target recognition, so as to control the robot arm to accurately grasp the target object.

The Methodology of Mechanical Arm can be divided into two parts: 3D Coordinate System Modeling and PID Algorithm [90].

Thus, synonymy, antonymy, and metaphorization are natural manifestations of the general laws of vocabulary development.

2.3. Structural classification of English terminological phrases

Scientific and technical terminology is an important layer of vocabulary that is actively developing and interacting with other terminology systems. It is an independent functional type of the general literary language. Terminology occupies an important place in the lexical system of the language, influencing its development and word formation processes. The terminology of robotics forms one of the layers of scientific and technical terminology. Analyzing this terminology, we pay special attention to its structural classification.

Among the terms of robotics, there are **general scientific, interdisciplinary, and highly specialized** ones. It is not easy to draw a clear distinction between different types of terms, because they are diffuse due to constant interaction and transience.

Scholars propose different structural classifications of terms. For example, T. R. Kyiak identifies eight types of terms [26]: 1) terms-root words; 2) derived terms;

3) terms-compound words; 4) terms-phrases; 5) terms-abbreviations; 6) letter conventions; 7) symbols-signs; 8) nomenclature. L. B. Tkacheva [23] divides the terms into: 1) simple; 2) complex; 3) terminological phrases with prepositional or prepositional-free combination of elements.

In the process of analyzing the terminological material of the field of robotics according to lexicographic sources, it was found that the terminology of this field, like most modern professional languages, consists of lexical units of two types: terms-words and terms-phrases.

From language to language, from genre to genre, from terminology to terminology, the ratio of parts of speech used to express terms changes. For example, technical terminology is dominated by nouns derived from verbs, musical terminology often uses prepositions, and professional and industrial terminology often uses verb terms [22]. In the following example you can see underlined terms from the field of robotic technology with terms derived from verbs in bold.

*Additionally, since the forward and backward **directions** of the sequence may reflect different sequence information, both directions are modeled here to extract sequence features, with each direction generating a dimension of d/2; the two **output** tensors are concatenated along the **model** dimension [95].*

Single-unit terms from the field of robotic technology are represented mainly by nouns (88,2%), second comes adjective (8,3%), rarely we can meet verbs (1,75%) or participles (1,75%) among all the terms. (see Table 1 and 4 in Appendix).

In the study, we distinguished three groups within all noun terms in English in the field of robotics: **simple** *(robot, actuate),* **derivative** *(execution, movement)*, and **compound** (or complex) **terms** *(breakpoint).*

Proprioception is subject to drift **(simple)** *and thus is not amenable to task-level autonomy* [80].

The vector-adjusting characteristic of a DSJ actuator **(derivative)** *can be realized by controlling the movement* **(derivative)** *of the adjustable slider.*

The intersection point of the vectoring-angle curve with the abscissa is denoted as breakpoint **(compound)** [78].

In the studied robotics terminology system, adjective terms are almost never used, since most of them are not independent and realize their terminological meaning only in the structure of compound terms or phrase terms. For example, the adjective *intelligent* is part of such a complex term as *"intelligent robot".*

The intelligent robot proposed in this paper is a wheeled robot combined with a mechanical arm, and the vision through the camera is used to accurately grasp the tar-get object [90].

In scientific and technical texts on robotics, adjectives narrow down the concepts conveyed by the noun: ***magnetic*** *tweezers.*

An extreme version of tip shaping is seen in magnetic tweezers, in which fine-tip cores are used for micro- or nanomanipulation in an optical microscope [70].

Verb terms are used in robotics terminology both independently *(robotize, activate)* and as part of phrases *(move and save).*

The ultimate goal is to design social robots that trigger attributions of intentionality with a high likelihood and activate social-cognitive areas in the human brain.

Similarly, a robot of human-like width and height would be able to move and operate in human environments better than a larger robot [114].

In our study, one-component terms can consist of a stem, a stem and affixes, two or more stems with or without affixes, written together or hyphenated. Among single-component word terms, we distinguish simple and derived words.

Simple terms are root terms that do not include affixes and serve as the basis for the formation of new terminological units. In scientific and technical texts, they are represented by simple root terms such as *drift, arm*, etc.

However, proprioception is subject to drift and thus is not amenable to task-level autonomy [80].

Single-component terms of robotics include: a) neologisms, e.g: *robot, sensor, manipulator*; b) terms formed by metaphorical transfer of meaning from words denoting parts of body, e.g. *arm, body, hand, leg etc*; c) general technical terms that have acquired a new meaning in the analyzed terminosystem, e.g: die *axis – 1. axis; 2. axis sensor, axis of mobility, degree of mobility in robotics*; d) general technical terms used in this terminology system to denote parts of a robot, for example: *base – the base of the robot, which is located in its lower part*.

While the robot's arm joints are not fully equivalent to the legs, they do contain additional encoder sensors that directly sense the joint angle with lower sample noise.

We use a Schmitt trigger with a threshold of 575 N to classify contact forces sensed by the robot's 3-axis foot force-torque sensors and detect whether either foot is in contact.

At the base of the locomotion algorithm, a gait transition detector infers the current stage of the walking motion and then decides which of the feet has stationary contact with the ground [80].

In addition to simple terms in the studied terminology, there are many **derivatives** formed by adding word-forming affixes (prefixes or suffixes, as well as conversion) to the root. For example: *robotics – (robot N + ics).* At the same time, derived nouns, like simple noun terms, make up the majority of all derived one-component special terms.

Bhattit and Rao applied the concept of reliability through which a statistical measure of manipulator performance can be made. Recently, Taguchi Methods were applied in robotics [87].

Multi-word terms consist of several words and are the most common type of terms in the field of robotics. Such terms have received different names in the works of scientists. They are also called **term-phrases,** multi-word terms, multi-component term phrases, term complexes, term logical phrases, polysemous compound terms [26, 27]. We will use the name (following O. M. Ivashchyshyn

[8]) terminological phrases (TP). In the studied terminology, 462 TPs were found, which is 77% of the total number of terms.

TPs are multicomponent terms in which one component is a carrier of generic, generalizing and systematizing meaning, and the others express a specific name [26].

A term-word names a feature of a concept that enables communicators to assign this concept to a particular class and thus differentiate it from other classes of concepts. By adding attributive components to the term-word, which name additional features, we get a terminological phrase, which, due to additional features, is differentiated from other concepts of the same class. Thus, TPs are formed as a result of the complication of the syntactic construction, *program - control program, application program, etc.*

When the existence of initial program is specified by s3, a program written in S-expression is required.

Heineman and Kaiser have proposed a language called CORD enabling users to describe the behavior of the concurrency control program.

The concurrency control program suited to an application program is tried to be generated by using GP [111].

A terminological phrase is a phrase with certain properties of a term and properties of a phrase. The results of research on the phrase as a linguistic phenomenon are also typical for TP. Phrases are higher-level lexical units that include lower-level units – words. A TP is a phrase that is actualized in the knowledge system and becomes a terminological phrase.

As a term, such a phrase has the following qualifying features: a tendency to unambiguity (within the same terminology system), a clear definition, systematicity, stylistic neutrality and lack of expression, brevity, etc.

The main function of a TP is nominative, which gives a name to a certain concept. Changes in lexical character are manifested in the acquisition of a general character of the exact meaning in a certain field of use.

TP are characteristic for new branches of science and that convey more features of a special concept, and the degree of semantic motivation of the term also increases.

Terminological phrases are characterized by the ability to specify the meaning with the help of additional clarifying characteristics expressed by commonly used words.

A **terminological phrase** is a syntactic construction consisting of several components that are interconnected. Thus, TPs are formed in the process of syntactic term formation. The creation of complex nominations – terminological phrases – is also called the analytical method of term formation, or analytical derivation.

Using combinatorial methods of studying the lexicon, in particular modeling, it is possible to identify structural models of terms that indicate the part-of-speech affiliation and morphemic composition of the term's components, as well as the position of elements in the term.

Terminological phrases can be analyzed:

1. According to the type of structure or the number of structural components, terminological phrases (TP) are divided into:

a) simple TP, consisting of two words, one of which is the main word and the other is the dependent word;

b) complex TP, which include more than two components.

Thus, we distinguish between two-component and multicomponent TPs. Multicomponent TPs are formed by expanding and specifying the meanings of two-component terms. Attributive components specify the meaning of a TP. The attributive type of TP is characterized by a variety of structural models.

The analysis of the structural forms of terms has shown that TPs prevail in the field of research, as they express more complex concepts.

The task of our research is to distinguish models and variants of TP. For convenience, we have grouped the models into groups based on the components expressed by the same parts of speech.

2. According to the morphological feature of the main word (core) or the grammatical categories of the core component, we differentiate TPs into:

a) substantive TP with a core noun;

b) adjectival terminological phrases with a core adjective or participle;

c) verbal TP with a core verb.

3. According to the type of compatibility of components or syntactic features, we distinguish between:

a) prepositionless, or syndetic, TP connected by a control method *(conservative motion, control device), w*hich are the most common in this field;

The end effectors and joints always move in a specific route only which is called conservative motion.

An instrument that allows a person to have control over a robot or automated systems is called control device [72].

b) prepositional, or asyndetic, TPs, which include a preposition ***(****degrees of freedom, single point of control****)***. In the studied material, 102 prepositional terms were found.

The control should be carried out with the help of unified human-machine interfaces with many degrees of freedom, allowing high-quality control of various equipments.

The system of centralized management of a group of robots should be a single point of control, precluding the use of specialized remote controls, adapted to control different robots [98].

4. By the type of grammatical relation between the core and dependent components. A TP is a certain syntactic construction that consists of two or more words based on a subordinating grammatical relation: agreement, control or adjacency.

Two-component TPs are formed on the basis of a single grammatical relation.

Complex TPs are formed by different types of linkage in relation to the core word – on the basis of agreement and adjacency or control and adjacency *(Proportional plus Integral plus Derivative Controller).*

Mathematically, a proportional plus integral plus derivative controller will operate on some variation of the following equation (...) [108]

Prepositional, or syndetic, TPs are divided into **simple, complex and combined** according to the grammatical relation.

Simple syndetic TPs are characterized by one type of grammatical relation (*mainly control*) between the core and dependent component *(center of gravity).*

In the process of high-altitude operation, the robot's overall center of gravity is changed due to the extension of the lifting mechanism [82].

Complex syndetic TPs are formed with the help of different types of grammatical relation: agreement and adjacency or control and adjacency *(to maintain contact of...).*

The graph and snapshots indicate that the subtrack motions generated by the autonomous controller in the three-LIDAR system maintained a stable posture of Kenaf, maintained contact of Kenaf with the surface of the bump during traversal, and made Kenaf traverse the entire length of the bump [97].

Combined syndetic TPs are formed on the basis of links from different core words *(to control the Tool Changer by providing "Latch" and "Unlatch" signals* [59]*).*

There are prepositional and postpositional attributes. Positive attributes can be expressed by a noun, adjective, participle, gerund, adverb, and numeral. Positive attribute combinations are more concise constructions than the group of attributes in postposition, so this method is typical for robotics terminology (*active compliance, collision sensor).*

The force/torque data is used in active compliance during grasping and to retract the robot safely if forces exceed a user-defined threshold during operation.

The interface plate is bolted to a collision sensor that is primarily used as a compliance device [74].

The most productive structure among the models of English terminological phrases is the two-component TPs. The structure of such TPs is different. The most active are structural models of attributive nature. Two-component TPs contain a main component that names the main concept and a subordinate definition. The main component is mostly expressed by a noun.

2.4. Multicomponent terms in Robotics

There are three types of relations between the words of a multicomponent term, namely: **subordinating, predicative, and conjunctive.**

The relation can be:

a) **regressive**, i.e. the first word of the term combination is a clarification of the second word, which can be graphically represented by an arrow going from the second to the first word – *(1) assembly*⟵ *(2) system* – AN,

Robotic manufacturing and <u>*assembly systems*</u> *are widely used in several industries such as automotive, aerospace and consumer electronics [73].*

b) progressive, i.e. the second word of the term combination clarifies the first word, graphically indicated by an arrow, which goes from the first to the second word – *(1) system*⟶ *(2) performance* – NN,

Such a learning capability to improve <u>*system performance*</u> *forms an essential control strategy of the human being [100].*

c) **combined**, i.e. regressive-progressive, in which the first word of the terminological combination is a clarification of the second word [26], which can be graphically shown by an arrow going from the second to the first word (regressive relationship), and the fourth word clarifies the third (progressive relationship):

(1) compressed ⟵ *(2) air (3) supply* ⟶ *(4) source* – VedNNN.

This unit can be hooked to a ***compressed air supply source*** *and can be used as a Snap-on MOC or integrated with a compressor [97].*

Terms can be characterized by only subordinate relations between components with:

a) **chain structure**, for example, *(1) adaptive (2) rate (3) modem* – ANN, when the first word specifies the second, and the second – the third word.

The idea of an adaptive rate modem has received more and more attention in recent years due to the growing demand of transmitting high data rates over a mobile channel [83].

b) bush structure, for example, *(1) robotic (2) assembly (3) system* – AAdvN, where the first and second words are definitions for the third word separately.

Robotic assembly systems are widely used in industry to improve the production task [73].

c) **multi-level hierarchical structure**, for example, *(1) social (2) brain (3) area* – ANN, where the first word complements the second word, and together the first and second words complement the third word.

We suggest that this issue should be addressed in social robotics by incorporating neuroscientific methods in the engineering design cycle, with the goal of designing robots that activate social brain areas in a similar manner as human interaction partners do [114].

We selected 462 multicomponent terms in robotics for analysis.

The field under study is characterized by substantive TPs, where 359 two-component TPs were found, which is 77,7 % of the total number of multicomponent TPs. Such a model is formed by adding an additional component (mainly an adjective or a noun) to the core component (noun). Thus, I. Kochan notes: "The role of the main component is played by the noun. It is the base or derivational base. The dependent component is an adjective or participle. It is called an onomasiological feature or adjunct, whose role is to clarify or specify the base." [13]

The group of two-component TPs is dominated by word combinations formed by the structural type N + N – a substantive TP with an attributive relation, where the main component N (standing mainly at the end of the combination) can be extended by a group of prepositional attributive nouns. It has been found that several TPs of the N + N model lack the grammatical and morphological design of an attributive prepositional noun (*control device, computer vision*). This means that the first component has the syntactic properties of a noun and is perceived as a word form of a noun, but acts as a definition for the second component – the signified. That is why it is not easy to understand the grammatical relations between the components of such a TP [26]. The words *control* or *computer* are nouns, although in these TPs they act as attributes.

An instrument that allows a person to have control over a robot or automated systems is called a control device [72].

Substantive models with attributive relation are represented by the following models:

1. The N + N model resulted in 159 two-component TPs, which is 44,2 % of the total number of two-component TPs. This model is the most productive: *feature recognition, trajectory record, etc.*

Possible reasons for the experimental results are discussed, and future research directions, such as adaptive grid granularity and spatial key feature recognition, are explored [95].

This model includes a variant that contains a complex element expressed by a two-word composite: *strip-chart recorder, entity-relationship model, etc.*

Also, a Model Z830 Power and Event Controller was used to operate pneumatic devices by activating solenoid valves and to switch power to the vortex mixer, the HPLC pump, and a strip-chart recorder [103].

2. The A + N model is also widely used to create two-component substantive TP. During the analysis of the TP structure, 124 TPs (34,4 % of the total number of two-component TPs) were identified, formed by this model: *common factor, detectable failure, solid fault, etc.*

There are 3 fault cases: no fault, solid fault, and resistance fault [89].

3. The Ving + N model belongs to the productive models of TP formation. We found 34 substantive TP in the studied terminology (9,4 %): *swinging jaw, sliding joint, crushing jaw, etc.*

Blake type jaw crusher, primary crushers in the mineral industry; attains maximum amplitude at the bottom of the crushing jaws as the swinging jaw is hinged at the top of the frame [105].

4. The N + Ving model turned out to be unproductive for terminological phrases in the field of environmental protection, with 19 TPs formed (5,3%): *material handling, region labeling, etc.*

Pick and place robots are the most popular material handling systems; providing dependable solutions for production lines primarily [72].

5. The Ved + N model is not very productive, with only 18 TPs (5 %) were formed: *eliminated job, articulated joint, etc.*

The origins of articulated joint models for human character representations can be found in the study of kinematics of robotic manipulators [109].

6. The A+Ving model is used to form 4 TPs: *deep learning, magnetic steering, material handling, real-time monitoring,* etc.

Therefore, the main role of prediction learning in the adaptive learning case is in estimating the whole profile of (...) as well as the disturbance vector (...) [100].

See table 2 and 4 in Appendix.

When analyzing the means of organization of two-component terms (360), it was found that the main relation here is regressive: *automatic mode* – AN and only two terms have a progressive relation, for example: *system performance* – NA.

The analysis of the means of organizing three-component terms (63) showed that in approximately the same number of them, regressive relations are observed in bush and chain structures (for example, *horizontal hand velocity* – ANN, *point light source* – NNN). In a slightly smaller number of terms, regressive and progressive relations in hierarchical structures were found. For example, *general purpose processor* – ANN, *product of inertia* – NPrpN.

Examination of individual horizontal hand velocity and acceleration profiles also fail to reveal any inflection points [101].

We adopted the 2D/3D convertible display using pinhole array on an LC panel in the proposed integral imaging, the principle of which is based on point light source array [88].

Each tile contains a general-purpose processor, which is connected to its neighbors by a static router and a dynamic router [112].

In this research, disturbances in a product of inertia measurement system (POI-MS) are investigated theoretically and experimentally [79].

The majority of four-component terms have a hierarchical structure with regressive and regressive-progressive relations between words (ex. *first generation industrial robot* – NumNAN, *passive degree of freedom* – ANPrpN), and the minority has a bush and chain structure with a regressive relation (ex. *algorithmic robot control syste*m – ANNN, *compressed air supply source* – VedNNN).

Experts agree that these marked that China mastered the manufacturing techniques of the first generation industrial robot and new robot industry was born in China [115].

Thus, Inversion and eversion is assumed as passive degree of freedom [104].

The Algorithmic Robot Control System gives the possibilities to achieve a flexible and operative robot control in supervisory and automatic modes in real time [99].

The air supply to the VGJs was provided from compressed air supply source [110].

For more details on multi-component terms models see Table 3 and 4 in Appendix.

In terms of numbers, two-component TPs rank first among multicomponent terminological phrases. The most productive structural model of two-component terminological phrases is N + N, with the help of which 159 TPs were created. The A + N model is inferior to the above N + N model, which indicates the advantage of using a noun in this terminology as a definition.

Finding out and correctly understanding the relations between the words of a multicomponent term is especially important for translating professional literature into another language.

2.5. Formation of Robotic Technology terminology

The terminology system of robotics terminology is currently developing very actively and is being replenished with new lexical items. Based on the research material of robotics technology articles, dictionaries and manuals (for more details look for lexicography and language data in references), we would like to point out the ways of forming new lexical units.

In the linguistic literature, according to Bohdan Shunevych [33], there are four ways of forming new words, including terms: semantic, morphological, syntactic, and borrowing. All of the above-mentioned methods have been identified in the creation of robotics terms:

1. the use of commonly used words in a terminological sense, for example, *learning – e-learning, deep learning, machine learning etc.;*

Deep learning is one of the modern approaches that could automate this process in order to achieve effective smart e-learning.

Arthur Samuel in 1959 defined machine learning as “the field of study that gives computers the ability to learn without being explicitly programmed”[75].

2. conversion, for example, *move*, *v* – *move*, *n*;

The next level of sophistication, into which most of the robots fall, allows adjustment of both the minimum and maximum positions of all moves.

...the robot's gripper can move in a straight or curved path for the entire length of the program [86].

3. metaphorical transfer of the word meaning, for example, *blue-collar – blue-collar robot*;

He envisages third generation minirobots which may revolutionize the blue-collar robot industry toward the end of the decade. 4. formation of terms by word compounding, for example, *autooperator, workstation [86];*

5. a syntactic way of forming terms, for example, *autonomous navigation*; *superior navigation.*

Furthermore, this system could lead to a basis for supporting superior navigation systems, as well as representing an autonomous navigation system, itself [93].

6. abbreviation, e.g., *QA*; modem *(**mo**dulator-**dem**odulator)*;

The idea of an adaptive rate modem has received more and more attention in recent years due to the growing demand of transmitting high data rates over a mobile channel.

The quasi-analytic (QA) simulation technique used in this paper is a combination of simulation and analysis [83].

7. borrowing terms from other fields of science and technology, for example, *memory* or from other languages, for example, *robot* – from the Czech word robota, *manipulator* – from the French word manipulateur.

Much effort has been contributed to robotics, and different types of robot manipulators have thus been developed and investigated, such as serial manipulators consist of redundant manipulators and mobile manipulators, parallel manipulators, and cable-driven manipulators [85].

Formation by the suffix method

The English linguistic terminology is dominated by nouns [1]. Noun terms are represented mainly by the following models (where: V – verb, N – noun, A – adjective):

– V + -er або V + -or: *grip – gripp**er,** transist – transist**or**.*

An amplifier circuit was developed using an organic thin-film transistor (OTFT) to achieve high sensitivity [97].

– V + -ing: *detect – detect**ing**.*

The results demonstrate the feasibility of producing a robotic gripper that includes a high-sensitivity electronic skin system for detecting slippage events *[97].*

*– V + -(a)tion: dissipate – dissipa**tion**.*

Widely different and often conflicting heat dissipation results have been reported, particularly as a function of the nanoparticle concentration [77]

*– A + -(i)ty: diverse – divers**ity.***

To check the feasibility of our model, we next benchmark it against a diversity of experimental results reported in the literature [77].

*– N, Adj + -ism: magnet – magnet**ism**.*

The suffixes *-or, -er, -e* indicate an active or passive participle: *manipulat**or**, engine**er.***

Some materials used for micro- or nanorobotics that are ferromagnetic at large sizes exhibit a special class of magnetic response known as superparamagnetism when at submicrometer size [70].

The suffix *-ing* denotes a process: *reduc**ing**;*

That is, by reducing the standard deviation of positional variations 3 by one-half, we can improve the failure probability more than four times [87].

The suffix *-ation* means a process or its result*: automat**ion.***

Taguchi Methods are employed to improve the accuracy of the Cartesian workspace in manufacturing automation by selecting the location which yields higher accuracy, subject to the spatial considerations and boundary conditions of the manufacturing process [87].

The suffixes *-ing, -tion, -ition, -ation* have proved to be productive in the formation of linguistic terms. The rest are less productive.

Terminology is also inherent in some verbs and is ensured by functioning in certain contexts, although the names of actions are not registered in linguistic dictionaries. For example*: to integrate*.

If we integrate the effect of each point along the length of the conductor, we arrive at the magnetic field at Pb [70].

The analyzed units revealed the presence of suffixes of different semantics.

Adjective terms do not refer to the phenomenon itself, but to its specific features and qualities. For example: *phonometric*;

Formation using the prefix method

This method is quite common; it modifies the stem to which the prefix is added. There are the following productive prefixes:

dis-, which has the meaning of reversal;

over- with the meaning of redundancy;

anti - with the meaning "opposite, reverse".

Prefixed noun terms are represented by the following models:

– dis- + N: *placement* – ***dis****placement*;

This arrangement allows the transformation of shaft rotation into nut linear displacement with less friction and high precision [106].

– over- + N: *shoot* – ***over****shoot;*

This research explores a monitoring method based on the automated extraction and the analysis of signal features such as steady value, overshoot, settling time, or presence of unexpected peaks [106].

– anti- + N: ***anti****backlash.*

Ball-screws with fitted antibacklash ball-nut model RM1605-C7 with 5-mm lead and Nema 34 stepper motors with 4.6-Nm holding torque were selected [106].

There are also units formed with the unproductive prefix *a-*, such as *anomaly*.

Unfortunately, most existing anomaly detection systems are neither suitable for the domain of robotic behavior nor flexible enough or even well generalizable [81].

Prefixed adjectival formations are represented by models:

– non- + Adj: ***non****-contact;*

Non-contact recording of cardiac electromagnetic fields with a microfabricated magnetometer is feasible in a shielded environment [91].

– pre- + Adj: ***pre****cession.*

Atomic magnetometers are based on the Larmor precession of atoms with nonzero angular momentum in a magnetic field [91].

Formation by conversion

This type of formation is the transition of a word from one part of speech to another. It is not common among linguistic terms. These are primarily the N -> V, V -> N models. For example: *probe –to probe.*

The magnitude and phase of the Larmor precession is read out with a second "probe" optical field [91].

Formation by composition

This method is also called syntactic-morphological. Its most common subtype is the model:

– N + N, for example: *base-form* (a type of compound word).

Genetic algorithms can be used in base-form and the computations can be done in 3D-working space without transformation into C-space [107].

The terms composites can be subordinate, whose components are interdependent (*image-flow*), and coordinative, both components of which are independent in structural and semantic terms. The latter are represented by a large number of adjectives, for example: *language-specific, articulatory-auditory [67];*

Formation by abbreviation

Term abbreviations are intended to express thoughts in a compact form. The following types of abbreviations have been identified among linguistic terms:

Terms-abbreviations: *CA – componental analysis; IP – internet protocol;*

Physical interaction with remote environments over IP networks, however, poses many technical challenges that are still outstanding, such as time delay, limited bandwidth, and unreliable transmission [92].

Truncated terms: *mid –middle (half-mid, mid-saggital); fin – final.*

The plane is defined as the mid-sagittal plane and it is obtained by locating it's intersection with each slice [81].

Combinations with a shortened component*: c-selection* - categorical selection; *s-selection* - structure selection;

As you know, robotics, as the main branch of science and technology, has emerged at the intersection of many sciences. For this reason, there are many terms of related sciences in the robotics terminology: automation, mechanics, mechatronics, cybernetics, and others. For example: *control system, software, vision, link, etc.*

...a low cost machine vision based quality control system [94].

The above-mentioned robotics terms – *blue-collar robot* (a robot that performs the functions of service personnel) or *white-collar robot* (a robot that performs the functions of management personnel) refer to **terms-definitions** that initially had no equivalents in other languages, and then scientists and practitioners find short equivalents or abbreviations because it is inconvenient to constantly use equivalents in the form of multi-component terms. Such terms are also found in other new terminology systems, for example, laser ***(l***ight ***a***mplification by ***s***timulated ***e***mission of ***r***adiation – quantum mechanical amplification or light generation).

Thus, the replenishment is carried out in different percentages by traditional means, for example, by using commonly used words in the terminological sense, including conversion, metaphorical transfer of the word meaning, morphological and syntactic methods, borrowing terms from other fields of science and technology, which are specific to each individual terminology system.

2.6. Robotic Neologisms in the fiction of Isaac Asimov

The "Literary Dictionary and Reference Book" states that a neologism is "a new word or expression, the appearance of which is conditioned by the needs of the time (scientific discoveries, changes in social relations, cultural development, etc.)" [54]. Usually, the authors of neologisms are writers themselves, while the newly created lexemes are author's neologisms that have not yet entered into widespread use, replacing old concepts or giving names to new ones [9]. It is not uncommon for neologisms to lose their author's status and become commonly used, widely used by society in everyday life or in certain fields of knowledge.

Fantasy literature has always been an integral part of human culture. Initially existing in people's imaginations only in the form of myths and legends, it has come a long way to becoming a full-fledged literary genre in the nineteenth century.

The concept of "fiction" is a collective term for several subgenres, among which one of the most famous is science fiction. Science fiction, as a kind of fantastic work, is focused "on the high achievements of scientific and technical thought. Along with fantastic elements, the work contains scientific hypotheses, technical imagination, and mental experimentation" [55, p. 461]. It gained popularity in the middle of the last century, and during its existence, writers working in the genre not only made a significant contribution to literature but also enriched the vocabulary of many languages, creating a whole layer of completely new vocabulary that gradually entered the general use or terminology of a particular field. Such units are nominated in philological science as "neologisms".

The role of author's nominations in science fiction is essential: they serve as names of newly created realities inherent only in a particular work of the writer, whose function is to help the reader immerse themselves in the world of the work. It also happens that the author's nomination becomes popular and used in the circle of science fiction writers, as happened with the once completely new, unknown concept of "robot," which came from the Czech language and became common knowledge thanks to the play R.U.R. by Karel Čapek. [25] The American science fiction writer Isaac Asimov gave new life to the neologism "robot," whose vision would form the basis of the modern understanding of the term. Over time, this concept evolved into an entire industry, "robotics," which determined the development of scientific and technological progress in the twenty-first century.

The work of Isaac Asimov, a representative of twentieth-century American literature, is written in the genre of science fiction, where each story has its own set of neologisms, most of which came into common use by the end of the twentieth century.

Isaac Asimov primarily wrote science fiction in the majority of his early works. He authored numerous pessimistic narratives regarding alien existence or intelligent robots. As previously mentioned, his fiction stood out due to its absence of unrealistic and evasive storylines, instead being grounded in the current state of modern science. In 1939, he commenced the composition of his initial narratives concerning robots. For instance, through his works "Robbie" (1939) and "Liar" (1941), he established himself as an expert in the realm of robotics [48]. Through these literary works, his concepts started spreading as precise rules governing the field of robotics. In certain instances, the robots depicted in Asimov's work exhibit a higher level of compassion and empathy compared to their human companions.

Isaac Asimov's works were significantly ahead of their time, and some of his inventions have become established in the technical field. Such neologisms include the concept of "positronic brains" and all concepts that are related to it in one way or another. According to the classification, it is a simple, syndetic (prepositionless) terminological phrase consisting of two components with regressive relation.

In that long-ago era when he had first come from the assembly line of United States Robots and Mechanical Men he was as much a robot in appearance as any that had ever existed, smoothly designed and magnificently functional: a sleek mechanical object, a positronic brain encased in a more-or-less humanoid-looking housing made from metal and plastic [84].

There are four more similar terminological phrases in the author's work: "positronic potential", "positronic field", "positronic bombardment", "positronic interplay" and "positronic robot". In the case of the last phrase, both components were neologisms at the time of the story series's release.

He hesitated a moment as though the concept of being a man was so alien to him that it would fit nowhere in his allotted positronic pathways.

Their positronic minds were more complex than the simple digital "minds" of non-positronic computers, which operated entirely in stark binary realms, mere patterns of on or off, yes or no, positive or negative, and that complexity could sometimes lead to moments of conflicting potential.

His coordination improved steadily. He moved swiftly toward full positronic interplay.

It was the positronic robot – the real robot, the authentic item – that Andrew was primarily concerned with [84].

In Isaac Asimov's robot stories, the focal point of interest for readers wasn't solely the robots themselves but rather the underlying theme of atomic power. By examining the terminology employed in "I, Robot," such as *"atomic"* and *"hyperatomic",* one can discern Asimov's deliberate linkage between robots and atomic energy throughout his narratives. Both terms are derivative single-component terms: *atom + ic; hyper + atom + ic.*

What about interstellar travel? It's only been about twenty years since the hyperatomic motor was invented and it's well known that it was a robotic invention [84].

Among underlined examples one can also see such neologisms as *interstellar travel*, which is a two-component TP with regressive relation (A ← N). That was another invention of Asimov which could be possible only thanks to atomic power.

Asimov describes the robot's energy source as a "tiny spark of atomic energy" in "Runaround":

He had unscrewed the chest plate of the nearest as he spoke, inserted the two-inch sphere that contained the tiny spark of atomic energy that was a robot's life [84].

In "Reason," Powell and Donovan utilize *"atomic flare"* tools to construct a robot.

It fitted snugly into the cavity in the skull of the robot on the table. Blue metal closed over it and was welded tightly by the tiny atomic flare [84].

That is another example of two-component substantive TP. The relation is regressive (A ← N).

These instances illustrate a clear association between robots and atomic energy, suggesting that, in a symbolic sense, robots serve as proxies for atomic power. While the characters within the stories express concerns about robots, contemporary readers during the time of publication were more preoccupied with the implications of atomic power—and its potential weaponization. When Asimov uses the word "atomic," we should remember that atomic energy in the 1940s was new and exciting. While it could be used to create weapons, it could also be used to make life better.

Susan Calvin had never left the surface of Earth before, and had no perceptible desire to leave it this time. In an age of Atomic Power and a clearly coming Hyperatomic Drive, she remained quietly provincial [84].

The concept of "robotics" was also introduced by Isaac Asimov in one of his first stories and became a cross-cutting theme in his entire career.

Powell reached for the "Handbook of Robotics" that weighed down one side of his desk to a nearfounder and opened it reverently.

There was a glint of sudden hope in Donovan's eyes. "You mean six robots from the First Expedition. Are you sure? They may be subrobotic machines [84].

The derivative term *subrobotic* consists of three affixes *(sub + robot + ic)*.

Given that this cycle of stories is based on stories about robots, it is natural that a large number of lexical items are related to them in one way or another. The short stories contain the names of professions related to robotic machines: "robopsychologist", "robot-engineer", "roboticist", as well as one of the areas of robotics research "robotic analysis". The names of jobs are mainly compound single-component terms (robo + psychologist; robot + engineer).

In 2008, she obtained her Ph.D. and joined United States Robots as a "Robopsychologist," becoming the first great practitioner of a new science.

" Now — there isn't a roboticist back at United States Robots that knows what a positronic field is or how it works. And neither do I. Neither do you. [84]"

The novel also contains the lexeme "*insosuit*" which is a derivative single-component term consisting of two affixes. From the context, it becomes clear that this device is a type of space suit that is adapted to abnormally high temperatures.

"We can't go after Speedy ourselves, Mike — not on the Sunside. Even the new insosuits aren't good for more than twenty minutes in direct sunlight [84].

As in the author's other short stories, the cycle of stories we are studying contains several devices with names that probably belong to the people who developed them: "McDougal's Spectroreflector", "Stillhead Dielectrode Plate", "McCormack-Wesley tester" and "McGuffy gears". These examples are particularly interesting for their structure. They are usually two-component substantive TPs with A + N model, where adjective is manifested by the proper name. The relation is regressive.

"Now you're being unfair. It was a mutual decision and you know it. All we needed was a kilogram of selenium, a Stillhead Dielectrode Plate and about three hours' time and there are pools of pure selenium all over Sunside. MacDougal's spectroreflector spotted three for us in five minutes, didn't it? [84].

The words-realities presented in this literary work, such as "visivox," "visiphone," "jet-car," and "taxi-gyro," also deserve attention. They are mainly compound terms with combination of two nouns where one is inherent English word and another one is a borrowing from Latin or Greek.

She waited for her father to maneuver the jet-car into the sunken garage, "Wait till I tell Robbie, Daddy.

In high good-humor the family took a taxi-gyro to the airport (Weston would have preferred using his own private 'gyro, but it was only a two-seater with no room for baggage) and entered the waiting liner [84].

These stories feature several types of robots at once: "multiple robot" (this robot is a whole group of robots, among which one is the main robot, five are auxiliary robots, subordinate to the first), "master robot" (a substantive two-component TPs with regressive relations.), "sub-robot" and "subsidiary" (single-component derivative terms).

Muller looked at him, "The boys back at the U. S. Robots have dreamed up a new one, by the way. A multiple robot."– "A what?" – "What I said. There's a big contract for it. It must be just the thing for asteroid mining. You have a master robot with six sub-robots under it. — Like your fingers." [84]

The novels are rich in lexemes containing the prefix "hyper-": "Hyperatomic drive/motor", "Hyper Base", "hyper-space".

"Oh, sure, you explained that. You used the Mitchell Translation Equation, didn't you? Well — it doesn't apply." "Why not?" "Because you've been using hyper-imaginaries, for one thing." [84].

Thus, it can be summarized that the work of the twentieth-century American writer Isaac Asimov is sustained in the genre of science fiction and contains a significant number of authorial neologisms. These neologisms, according to the genre, have a scientific and technical orientation and are sometimes difficult to identify. They are usually substantive two-component TPs with regressive relation or just one-word terms with simple or derivative nature; less frequent one-word compound terms. Neologisms are primarily author's nominations or realities of the fantastic space, the meaning of which may sometimes be unclear. Obviously, many neologisms were not widely used and remained in the past, but there are also those that, thanks to I. Asimov, began to be called quite real concepts in the future.

Conclusion Chapter 2

1) There are two conceptual approaches for describing a term and a system of terms: normative (prescriptive) and functional (descriptive).

2) Synonymy, antonymy, and metaphorization are natural manifestations of the general laws of vocabulary development. All of these lexical and semantic processes are characteristic for the terminology of robotics.

3) Within the field of robotics, there exist terms that can be classified as general scientific, interdisciplinary, and highly specialized. All noun terms in the English language pertaining to robotics can be categorized into three distinct groups: simple, derivative, and compound (or complex) words.

4) A terminological phrase (TP) is a syntactic construction composed of interconnected components. Terminological phrases can be analyzed based on their structure, the number of components, the morphological characteristics of the main word (core), the grammatical categories of the core component, the compatibility

of components, the syntactic features, and the grammatical relationship between the core and dependent components.

5) The two-component TPs are the most efficient structure among the models of English terminological phrases. The composition of these TPs varies. The most dynamic models are those that have a structural nature and pertain to attributes. Two-component TPs consist of a primary component that identifies the main concept and a secondary definition. The main component is predominantly represented by a noun. There exist prepositional and postpositional attributes. Nouns, adjectives, participles, gerunds, adverbs, and numerals can all be used to express positive attributes. Positive attribute combinations are more concise constructions compared to attribute groups in postposition, making this method commonly used in robotics terminology.

6) There are three types of relations between the words of a multicomponent term, namely: subordinating, predicative, and conjunctive.

7) The relation can be regressive, progressive, combined.

8) When considering numerical data, two-component terminological phrases are the highest ranked among phrases that have multiple components. The N + N structure is the most efficient model for two-component terminological phrases. The A + N model is less effective compared to the N + N model mentioned earlier, which indicates the advantage of using a noun in this terminology as a definition.

9) The enrichment of robotic terminology is accomplished through various methods, such as the utilization of commonly employed words in a terminological context, including the conversion and metaphorical transfer of word meanings, as well as the implementation of morphological and syntactic techniques. Additionally, terms may be borrowed from other scientific and technological domains, tailored to the specific requirements of each individual terminology system.

10) The study of the robotics terminology system is carried out in the following areas:

1) compilation of various terminological dictionaries;

2) theoretical research;

3) applied research.

11) A considerable number of authorial neologisms connected with robototechnology are present in the science fiction works of Isaac Asimov. Author's nominations play a crucial role in science fiction; they function as names of newly created realities that are exclusive to the author's work. Their purpose is to assist the reader in becoming immersed in the world of the work. He was the first to introduce the concept of "robotics". We meet significant number of lexemes in his works that denote names of devices, processes, jobs, etc.

GENERAL CONCLUSION

The research analyzes and clarifies the linguocognitive and linguocultural features of robotics terminology; it also examines the characteristics of its composition in terms of structural, semantic and functional properties of terms based on English sources (journal articles, media texts, conference papers, etc.). The data obtained in the course of the study allow us to draw certain conclusions.

The English professional language of robotics is a complex linguistic phenomenon, which uses a set of intra-industry, inter-industry and general scientific terms, professionalisms and jargon. We have studied the theoretical works of Ukrainian and foreign scientists, traced the process of terminology development, defined the terminological apparatus for the study of the terminology. The research is based on the complex methodological approach employing qualitative and quantitative research methods. Using lexicographic and textual methods, an initial register of terms in the field of robotics has been identified. We have managed to define the role of terminology. In addition, an inventory and systematization of English robotics terms has been carried out through linguistic descriptions and observation. With the help of functional and semantic-component analysis, the semantic structure of the studied linguistic units has been determined.

We identified the ways of formation and origin, structural types and models of robotics terms, structural features of robotic technology terminology. Clarification of internal connections and relations within the robotics terminology allows to draw conclusions about the systematic nature of this set of concepts, the presentation of scientific terminology as a systemic and structural whole, in which elements (single-component and multi-component terms) are combined in a multilevel set on the basis of functional and semantic commonality that ensures their interaction. The single-component terms of the robotics sublanguage are characterized by the same ways of word formation as the commonly used vocabulary; the main way of term formation in the studied terminosystem is morphological, less common is semantic, and occasionally borrowings from other languages. Terminology systems may incorporate terms adopted from other scientific and technological fields, with modifications made to suit their particular specifications.

We have considered the quantitative composition of the selected terms in the field of Robotics and have identified 6 substantive models with attributive relations: N + N (44,2%), A + N (34,4%), Ving + N (9,4%), N + Ving (5,3%), Ved + N (5%), and A + Ving (1.7%).

We highlighted the lexical and semantic features of English within Robotics in a variety of texts. A morphological feature of English professional robotics texts of different types is the frequency of use of certain parts of speech. One-component terms are mainly expressed by nouns (88,2% of terms), although there is a significant number of terms expressed by adjectives (8,3% of terms), verbs (1,75% of terms) and participles (1,75% of terms). Regarding robotics, every term in the English language can be classified into one of three distinct categories: simple, derivative, or compound (or complex). Three distinct types of relationships exist among the words comprising a multicomponent term: predicative, conjunctive, and subordinating. There are three possible relations: regressive, progressive, and combined. The semantic processes of synonymy, antonymy, and metaphorization play a significant role in English robotics terminology.

Over the past decade, general linguistic studies of various terminology systems have been conducted. At the same time, they have mainly studied terms taken from dictionaries, glossaries, etc. In our opinion, the terminology system of a certain field of science or technology should be studied not only with the help of dictionaries and reference books, but also in the real sphere of their functioning. Hence we analyzed the functioning of the terms of Robotics in professional texts of different genres (articles, conference materials, fiction prose, etc.), since only such study can form the basis for the creation of normative documents, such as state standards (GOST), compilations of recommended terms. Examples of robotics terminology has also been found in fiction texts, in particular in the form of neologisms, as demonstrated by the works of Isaac Asimov. Thus, it is advisable to identify the terminology system on the basis of texts of various genres.

The results of the study show the need for further research on terminology in the field of robotics. Since the robotics terminology system is open and dynamic, the process of its formation continues and is characterized by continuous enrichment. New terms and phenomena require detailed analysis, which will be the subject of our further research. The current state of intercultural communication and the globalization of the world require similar studies on the material of other languages.

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SUMMARY

Бакалаврська робота присвячена дослідженню термінології в галузі робототехніки. У роботі здійснено ґрунтовний аналіз лінгвокогнітивних та лінгвокультурологічних особливостей термінології робототехніки, а також розглянуто її характеристики з точки зору структури, семантики, функціональних властивостей.

В основі роботи лежить комплексний методологічний підхід із застосуванням аналітичних та статистичних методів дослідження. За допомогою системно-функціонального методу досліджено специфіку функціонування мовних одиниць у текстах робототехніки та технічної комунікації; за допомогою описового методу пояснено особливості функціонування принципу протиставлення в мові та мовленні. Метод стилістичного, композиційного та структурного аналізу використано для дослідження стилістичних, композиційних та структурних особливостей аналізованих текстів.

Складні мовні явища становлять англійську професійну мову робототехніки, яка використовує сукупність міжгалузевих, внутрішньогалузевих та загальнонаукових жаргонізмів, професіоналізмів і термінів.

Бакалаврська робота починається з історичного огляду термінознавства, його зародження та розвитку як самостійної наукової дисципліни з початку 1900-х років. Розглядаються три основні термінологічні школи: віденську (австрійську), радянську та чеську (празьку). аналіз зосереджується на таких поняттях: «термінологія», «термін», «терміносистема».

Докладні практичні розділи присвячені вивченню наукових праць, статей та новинних статей про найновіші робототехнічні розробки, які збагачені термінологією з робототехніки. В дослідженні проведено комплексний аналіз термінів робототехніки у різних аспектах, виходячи з

їхньої структури, лексико-семантичних ознак та закономірностей утворення. Окремий розділ присвячено художнім неологізмам.

Отримані дані свідчать про використання синонімії, антонімії та метафоризації як закономірних проявів загальних законів розвитку лексики у термінології робототехніки.

У дослідженні стверджується, що у галузі робототехніки існують терміни, які належать до категорій загальнонаукових, міждисциплінарних та вузькоспеціалізованих, а кожен іменник в англійській мові можна віднести до однієї з трьох різних категорій: простий, похідний або складений (або складний). У бакалаврській роботі обговорюється, що однослівні терміни робототехніки можуть бути виражені не тільки іменниками, як вважають багато лінгвістів, але й прикметниками та дієсловами, хоча кількість іменників значно більша, ніж інших частин мови: іменникові терміни - 88,2 %, прикметники - 8,3 %, дієслова - 1,75 %, дієприкметники - 1,75 %.

Отримані дані свідчать, що двокомпонентні ТС є найпродуктивнішою структурою серед моделей англійських термінологічних словосполучень. Найбільш динамічними моделями є ті, що мають структурну природу і відносяться до атрибутивних. Структура N + N є найпродуктивнішою моделлю для двокомпонентних термінологічних словосполучень. Модель A + N є менш ефективною порівняно з вищезгаданою моделлю N + N, що свідчить про перевагу використання іменника в цій термінології в якості означення.

Як показав аналіз мовного матеріалу, збагачення робототехнічної термінології відбувається за рахунок різних способів, зокрема застосування морфологічних і синтаксичних прийомів, конверсії та метафоричного перенесення значень слів, а також використання часто вживаних слів у термінологічному контексті, запозичення з інших науково-технічних галузей,

APPENDIX

Table 1. **Morphological structure of terminology in robotics.**

N	Parts of speech	The number of units	%	Examples
1	Noun	120	88,2	sensor
3	Adjective	12	8,3	autonomous
3	Verb	2	1,75	transmit
4	Participle	2	1,75	datadriven
	All	136	100	

Table 2. **Substantive models with attributive relation.**

N	Model	Number of WC	Percentage	Example
1	N + N	159	44,2	*trajectory record*
2	A + N	124	34,4	*detectable failure*
3	Ving + N	34	9,4	*sliding joint*
4	N + Ving	18	5,3	*material handling*
5	Ved + N	18	5	*eliminated job*
6	A + Ving	4	1,7	*adaptive learning*

Table 3. **Multi-component terms models.**

Num. of com-po-nents	Example	Model	Type of connection	Structure
2	*automatic mode*	AN	regressive	–
2	*machina speculatrix*	NA	progressive	–
3	*horizontal hand velocity*	ANN	regressive	bush
3	*point light source*	NNN	regressive	chain
3	*general purpose processor*	ANN	regressive	hierarchical
3	*product of inertia*	NPrpN	progressive	hierarchical
4	*first generation industrial robot*	NumNAN	regressive	hierarchical
4	*passive degree of freedom*	ANPrpN	regressive-progressive	hierarchical
4	*algorithmic robot control system*	ANNN	regressive	bush
4	*compressed air supply source*	VedNNN	regressive	chain
5	*real time computer control system*	ANNNN	regressive-progressive	hierarchical
5	*robot with continuous path control*	NPrpANN	regressive-progressive	hierarchical

Table 4. Compilation of robotic terms with analysis of substantive models, number of components and parts of speech (click here).

TERM	# of COMP	PART OF SPEECH	MODEL	FREQUENCY IN TEXT

	ON EN TS			
3D-Working Space	2		Ving + N	1
Accuracy	1	Noun		18
Action-Based Learning	2		N + Ving	3
Active	1	Adjective		26
Active compliance	2		A + N	3
Active flow control (AFC)	3		ANN	4
Active RFID		Abbreviation		4
Actuation system	2		N + N	1
Actuator	1	Noun		34
Adaptation	1	Noun		3
Adaptive control	2		A + N	6
Adaptive Learning Control	3		AVedN	34
Adaptive rate modem	3		ANN	2
Adjustable slider	2		A + N	8
Aerospace	1	Noun		2
Airstar (specific robot)	1	Noun		6
AIS		Abbreviation		58
AIS Data		Abbreviation		4
AISim		Abbreviation		28
Algorithm	1	Noun		1
Algorithmic robot control system	4		ANNN	11
Alkali vapor cell	3		NNN	6
Amplifier Circuit	2		N + N	9
Annealing Process	2		Ving + N	6

Anomaly detection	2		N + N	12
Anoto Technology	2		N + N	12
Antenna	1	Noun		14
Articulated Figure	2		Ved + N	3
Artificial intelligence	2		A + N	6
Assembly system	2		A + N	7
Atomic magnetometer	2		A + N	10
Automated system	2		Ved + N	1
Automatic mode	2		A + N	2
Automation	1	Noun		21
Axle	1	Noun		8
Bandwidth	1	Noun		11
Base Module	2		N + N	13
Bayesian Reasoning	2		N + Ving	1
Behavioral Neuroscience	2		A + N	7
Blue-collar robot	2		A + N	7
Breakpoint	1	noun		3
Cable-driven manipulator	2		Ved + N	5
CAD		Abbreviation		16
Camera	1	Noun		10
Canny edge detection	3		ANN	13
Capsule endoscope	2		N + N	2
Carrier	1	Noun		7
Cartesian	1	Adjective		12
Center of gravity	3		NPrN	1
Chip-scale atomic magnetometer	3		NAN	6
Chromosome	1	Noun		1

CIM (Computer-Integrated Manufacturing)	2		Ved + N	15
Classifier	1	Noun		4
CNC (Computer Numerical Control)	3		NAN	3
Cognitive Abilities	2		A + N	9
Cognitive System	2		A + N	4
Collision	1	Noun		1
Collision sensor	2		N + N	3
Communication	1	Noun		8
Communication Mechanism	2		N + N	1
Compensation Component	2		N + N	4
Competency Development	2		N + N	9
Compressed air supply source	4		VedNNN	5
Computer vision	2		N + N	1
Computer-Aided Design	2		Ved + N	5
Computer-Integrated Manufacturing	2		Ved + N	2
Concurrency Control	2		N + N	9
Concurrency Control Program	3		NNN	14
Concurrent Execution	2		A + N	3
Condition Based Maintenance	3		NVedN	9
Condition Indicator	2		N + N	1
Congestion Control	2		N + N	8
Conservative motion	2		A + N	1
Constraint	1	Noun		1
Control	1	Noun		30
Control Algorithm	2		N + N	17

Control device	2		N + N	1
Control Input	2		N + N	17
Control Loop	2		N + N	8
Control Performance	2		N + N	3
Control Protocol	2		N + N	2
Control Stability	2		N + N	2
Control Strategy	2		N + N	4
Control system	2		N + N	26
Control Variables	2		N + N	4
Controller	1	Noun		6
Controller Setting	2		N + Ving	3
Controller Tuning	2		N + Ving	4
Coolness	1	Noun		7
Coordinate System	2		N + N	4
Cost	1	Noun		5
Covariance Matrix	2		N + N	1
Creep Force	2		N + N	4
C-Space	1	Noun		1
Curving	1	Noun		8
Cyber-Physical System	2		A + N	4
Data	1	Noun		6
Data Communication	2		N + N	1
Data Items	2		N + N	8
Data processing	2		N + Ving	1
Data Synchronization	2		N + N	4
Data Transmission	2		N + N	10
Database Operations	2		N + N	4

Data-Based Method	2		Ved + N	1
Datadriven	1	Participle		1
Deadlock	1	Noun		3
Deep learning	2		A + Ving	4
Degrees of freedom	3		NPrN	6
Demodulator	1	Noun		12
Dependency Component	2		N + N	3
Derivative Action	2		A + N	9
Device	1	Noun		4
Diagnosis Performance	2		N + N	1
Diagnosis system	2		N + N	6
Diesel engine	2		A + N	3
Differential phase error	3		ANN	2
Digital Pen	2		A + N	18
Digitalisation	1	Noun		7
Displacement	1	Noun		3
Distance	1	Noun		22
Distance measurement	2		N + N	12
Doppler radar	2		N + N	6
DQPSK		Abbreviation		4
Drift	1	Noun		3
Drone Surveillance	2		N + N	6
DSJ actuator		Abbreviation		10
DSP		Abbreviation		2
DTW (Dynamic Time Warping)	3		ANVing	15
Dual neural network	3		NumAN	2
Dynamic Friction Coefficient	3		ANN	9

Dynamics	1	Noun		12
Efficiency	1	Noun		2
Eigenvalue	1	Noun		3
Eigenvalue Decomposition	2		N + N	1
EKF		Abbreviation		12
E-learning	1	Noun		1
Electrical Characteristic	2		A + N	4
Electromagnet	1	Noun		3
Electromagnetic system	2		A + N	2
Electro-Mechanical Actuator	2		A + N	4
Electromechanical system	2		A + N	1
Emotional experience	2		A + N	2
End effectors	2		N + N	23
End-effector tooling	2		N + Ving	6
End-to-End Congestion Control	3		ANN	1
End-to-End Transmission	2		N + N	3
Engineering Design Process	3		VingNN	6
Engineering Education	2		Ving + N	5
Envelope power deviation	3		NNN	2
EPC		Abbreviation		6
Error Dynamics	2		A + N	13
Error probability	2		N + N	1
ESPRIT 278		Abbreviation		3
Estimator	1	Noun		9
Execution monitoring	2		N + Ving	3
Failure scenario	2		N + N	1
Fault classification algorithm	3		NNN	3

Fault Detection	2		N + N	4
Feature Extraction	2		N + N	1
Feature recognition	2		N + N	7
Feedback	1	Noun		11
Feedback Control	2		N + N	22
Feedback Controller	2		N + N	8
Feedback Error	2		N + N	3
Feedback Gain	2		N + N	19
Feedback Mechanism	2		N + N	3
Feedback Stabilization	2		N + N	2
Feedforward Control	2		N + N	14
Feedforward neural network	3		AdvAN	6
Ferroelectric Layer	2		A + N	3
Ferroelectric Polymer	2		A + N	13
Ferroelectric Property	2		A + N	6
Fire Extinguishing	2		N + Ving	7
Fire Robot	2		N + N	18
Firebreaks	1	Noun		4
Firmware	1	Noun		3
First generation industrial robot	4		NumNAN	1
Fitness Calculation	2		N + N	3
Fitness Measure Function	3		NNN	7
Fixture	1	Noun		12
Flange	1	Noun		3
Footstep	1	Noun		7
Force sensor	2		N + N	1
Forest Fires	2		N + N	12

Forward and backward direction	4		APrAN	2
Fréchet Distance	2		N + N	7
Frequency	1	Noun		9
Functional value	2		A + N	12
Functions and Terminal	3		NPrN	6
Gain Adjustment	2		N + N	2
Generalized Coordinates	2		Ved + N	9
Genetic Algorithms	2		A + N	3
Genetic Operations	2		A + N	1
Genetic Programming (GP)	2		N + Ving	2
GPS		Abbreviation		8
Graph	1	Noun		40
Gray coding	2		A + N	2
Grid Node	2		N + N	9
Grid Partitioning	2		N + Ving	4
Grid Sequence	2		N + N	4
Gripper	1	Noun		4
Gripper System	2		N + N	3
GUI (Graphical User Interface)	3		ANN	4
Guidance	1	Noun		10
Hall Effect Sensor	3		NNN	3
Haptics	1	Noun		3
Hardware	1	Noun		11
Heterogeneous	1	Adjective		15
High Sensitivity	2		A + N	3
Human Brain	2		A + N	3
Human-Like Appearance	2		A + N	6

Human-Machine Interface (HMI)	2		N + N	7
Human-Robot Interaction (HRI)	2		N + N	30
HVAC Systems		Abbreviation		4
Hydraulic pump	2		A + N	2
Hydraulic system	2		A + N	5
Image Detection	2		N + N	4
Image processing	2		N + Ving	25
Improved PID algorithm		Abbreviation		10
IMU		Abbreviation		13
Independently Rotating Wheelset (IRW)	3		AVingN	7
Indoor	1	Adjective		9
Industrial manipulator	2		A + N	4
Industrial robot	2		A + N	40
Industry 4.0	2		N + Num	10
Inertial	1	Adjective		10
Information	1	Noun		8
Innovation	1	Noun		3
Integral Action	2		A + N	14
Integral Gain	2		A + N	3
Integrated Sensor-Based Robot	3		VedVedN	6
Intelligent robot	2		A + N	12
Intentional Agent	2		A + N	18
Interaction Partner	2		N + N	6
Interface	1	Noun		5
Internet Mobile Robot	3		NAN	1

Internet Protocol (IP)	2		N + N	17
Internet Robot	2		A + N	3
Internet-based Telerobot	2		Ved + N	2
Interpolator	1	Noun		2
Intersymbol interference	2		N + N	2
Joint Component	2		N + N	25
Joint Cone	2		N + N	2
Joint Cone Component	3		NNN	3
Joint Limit	2		N + N	3
Joint Set	2		N + N	8
Joint Set Function	3		NNN	3
Kinematics	1	Noun		12
Larmor precession	2		N + N	9
Lateral	1	Adjective		18
Learning Algorithm	2		Ving + N	10
Learning Control System	3		VingNN	13
Learning Controller	2		Ving + N	9
Learning Factory	2		Ving + N	19
Learning Framework	2		Ving + N	4
Learning Input	2		Ving + N	9
Learning Input Update	3		VingNN	2
Learning Performance	2		Ving + N	4
Learning Rule	2		Ving + N	16
Learning Rule Development	3		VingNN	2
Learning Scheme	2		Ving + N	4
Learning System	2		Ving + N	6
LIDAR		Abbreviation		25

Lifting mechanism	2		Ving + N	3
Limiting device	2		Ving + N	1
Linear Actuator	2		A + N	6
LNA (Low-Noise Amplifier)	2		N + N	4
Load capacity	2		N + N	2
Loading Vector	2		Ving + N	1
Localization	1	Noun		17
Location	1	Noun		3
Lock	1	Noun		3
Lock Mode	2		N + N	3
Locking Protocol	2		Ving + N	6
Logistics	1	Noun		3
Loop Tuning	2		N + Ving	3
Low-magnetic-field heaters	2		A + N	1
Machine intelligence	2		N + N	2
Machine learning	2		N + Ving	5
Machine tool	2		N + N	2
Machine Vision	2		N + N	20
Machine vision hardware	3		NNN	2
Magnetic actuation	2		A + N	5
Magnetic actuator	2		A + N	3
Magnetic control	2		A + N	1
Magnetic field	2		A + N	5
Magnetic guidance	2		A + N	1
Magnetic levitation	2		A + N	1
Magnetic localization	2		A + N	2
Magnetic manipulation	2		A + N	5

Magnetic material	1	Noun		4
Magnetic navigation	2		A + N	1
Magnetic objects	2		A + N	3
Magnetic propulsion	2		A + N	1
Magnetic shield	2		A + N	2
Magnetic steering	2		A + Ving	1
Magnetic tweezers	2		A + N	1
Magnetocardiography	1	Noun		12
Manipulator	1	Noun		4
Manipulator	1	Noun		8
Manipulator Dynamics	2		N + N	3
Manufacturing System	2		Ving + N	13
Mapping Service	2		Ving + N	5
Matched filter	2		Ved + N	2
Material handling	2		A + Ving	1
Matrix Multiplication Component	3		NNN	5
MDPSK		Abbreviation		7
Mechanical arm	2		A + N	42
Mechanical fault	2		A + N	4
Medical robotics	2		A + N	7
Memory option	2		N + N	2
MEMS		Abbreviation		4
Mentalizing	1	Noun		5
Metric	1	Noun		18
Micromanipulation	1	Noun		2
Microrobotics	1	Noun		7
Mobile chassis	2		A + N	2

Mobile Control Station	3		ANN	7
Mobile manipulator	2		A + N	3
Mode	1	Noun		3
Model	1	Noun		10
Model dimension	2		N + N	2
Model Train	2		N + N	4
Modulation	1	Noun		7
Modulator	1	Noun		14
Monte Carlo Simulation	3		NNN	5
Multi-Agent Remote Control System	4		NANN	23
Multi-Purpose	1	Adjective		8
Multivariate Analysis	2		A + N	2
Navigation system	2		N + N	25
Network Congestion	2		N + N	6
Network Protocol	2		N + N	3
Neural Network	2		A + N	37
Neuroscientific Method	2		A + N	12
Neuroscientific Principle	2		A + N	3
Node	1	Noun		13
Node Type	2		N + N	5
Non-Orthogonal Rotation Axe	3		ANN	2
Objective Function	2		A + N	1
Obotic manipulator	2		A + N	12
One-to-Many Mapping Component	3		NumVingN	3
Open Source	2		A + N	8
Operating robot	2		Ving + N	2

Operational Efficiency	2		A + N	4
Operator Control	2		N + N	4
Operator Interface	2		N + N	5
Operator Workplace	2		N + N	6
Optimization	1	Noun		1
Organic Thin-Film Transistor (OTFT)	3		ANN	8
Output tensor	2		N + N	2
PA (Power Amplifier)	2		A + N	4
Packet Loss	2		N + N	7
Parallel manipulator	2		A + N	5
Parameter Convergence	2		N + N	7
Parameter Error	2		N + N	5
Parameter Estimation	2		N + N	26
Parameter Update	2		N + N	2
Particle-image-velocimetry (PIV)	2		N + N	4
Passivation Layer	2		N + N	10
Passive degree of freedom	4		ANPrpN	5
Passive RFID		Abbreviation		4
Payload	1	Noun		11
PCA health monitoring tool		Abbreviation		2
Perceived coolness	2		Ved + N	6
Perceived smartness	2		Ved + N	9
Performance Index	2		N + N	3
Permanent-magnet system	2		A + N	3
Persistent Excitation	2		A + N	6
PGM (Probabilistic Graphical	3		AAN	4

Models)				
Photodetector	1	Noun		2
Physical Model	2		A + N	1
Pick and place robot	4		VPrNN	11
PID algorithm		Abbreviation		27
PID Control		Abbreviation		25
Piezoelectric	1	Adjective		7
Piezoelectric Polymer	2		A + N	11
Piezoelectric Response	2		A + N	6
PLC (Programmable Logic Controller)	3		AAN	2
Plexiglas chamber	2		N + N	3
PLL (Phase-Locked Loop)	2		Ved + N	11
Points Generation	2		N + N	1
Poly(Vinylidene Fluoride-co-Trifluoroethylene)		Abbreviation		3
Poly-Joystick	1	Noun		10
Polymer Composite	2		A + N	5
Polymer Matrix	2		N + N	5
Position	1	Noun		14
Predefined Tree	2		Ved + N	3
Pre-Training	1	Noun		11
Principal Component Analysis	3		ANN	4
Printed Sensor	2		Ved + N	8
Problem Solving	2		N + Ving	3
Process Control	2		N + N	3
Prognostics	1	Noun		6
Program Generation	2		N + N	9

Programming	1	Noun		8
Programming Environment	2		Ving + N	4
Programming Interface	2		Ving + N	9
Programming Methodology	2		Ving + N	5
Programming Tool	2		Ving + N	4
Proportional Control	2		A + N	3
Proportional Gain	2		A + N	18
Proportional Offset	2		A + N	5
Proportional-Integral-Derivative	2		A + N	3
Protocol	1	Noun		19
Prototype	1	Noun		15
Python	1	Noun		5
Quality Control	2		N + N	17
Quasi-analytic (QA)		Abbreviation		1
Quasi-analytic simulation	2		A + N	3
Rail	1	Noun		19
Raspberry Pi	2		N + N	9
Rate Adjustment	2		N + N	1
Rate Control	2		N + N	4
Rate-based Protocol	2		Ved + N	4
Reader	1	Noun		21
Real Position Point	3		ANN	6
Real time computer control system	5		ANNNN	1
Realistic Articulation	2		A + N	2
Real-time	1	Adjective		9
Real-time Application	2		A + N	1

Real-time experiment	2		A + N	3
Real-Time Monitoring	2		A + Ving	3
Receive (RX)	1	Verb		5
Recurrent neural network	3		AAN	6
Reducing	1	Participle		6
Redundancy resolution	2		N + N	1
Regression Matrix	2		N + N	6
Reliability	1	Noun		2
Remote Control	2		N + N	33
Remote Environment	2		A + N	1
Remote manipulation	2		N + N	2
Repeatability	1	Noun		11
Rescue Operations	2		N + N	4
Response Time	2		N + N	3
RFID		Abbreviation		34
Ride Quality	2		A + N	3
Robot	1	Noun		171
Robot arm	2		N + N	13
Robot Controller	2		N + N	8
Robot Manipulator	2		A + N	19
Robot Programming	2		N + Ving	12
Robot repeatability	2		A + N	1
Robot System	2		N + N	1
Robot with continuous path control	5		NPrpANN	1
Robotic arm	2		A + N	17
Robotic assembly system	3		AdvAN	4
Robotic Complex	2		A + N	26

Robotic device	2		A + N	1
Robotic Element	2		A + N	5
Robotic end-effector	2		A + N	1
Robotic Gripper	2		A + N	18
Robotic intervention	2		A + N	1
Robotic manipulator	2		A + N	1
Robotic Mini-Harvester	2		A + N	9
Robotic positioning arm	3		AVingN	1
Robotic System	2		A + N	33
Robotic Trencher	2		A + N	8
Robotics	1	Noun		3
Rotating mechanism	2		Ving + N	2
Rotation Component	2		N + N	4
Rotational	1	Adjective		4
RSS (Received Signal Strength)	3		VedNN	4
RTT		Abbreviation		7
Safety	1	Noun		2
Satellite	1	Noun		3
Satisfaction	1	Noun		9
Scapula Constraint Component	3		NNN	3
SCARA (Selective Compliance Assembly Robot Arm)		Abbreviation		15
Schedule	1	Noun		4
Schlieren system	2		N + N	4
Screen Printing Technique	3		NVingN	4
Sending Rate	2		Ving + N	5
Sensitivity Measurement	2		N + N	7
Sensor	1	Noun		40

Sensor array	2		N + N	5
Sensor Fabrication	2		N + N	5
Sensor Polarization	2		N + N	6
Sensor Response	2		N + N	3
Sensor technology	2		N + N	1
Sequential	1	Adjective		9
Sequential Virtual Grids	3		AAN	4
Serial Schedule	2		A + N	4
Serializability	1	Noun		3
Service robot	2		N + N	25
Set Point	2		N + N	6
Shared Control Variable	3		VedNN	4
Shear Force	2		N + N	12
Signal	1	Noun		17
Signal Feature	2		N + N	1
Similarity	1	Noun		12
Simulation	1	Noun		3
Slippage Detection	2		N + N	15
Smart airport	2		A + N	4
Social Brain Area	3		ANN	5
Social Cognition	2		A + N	11
Social Connection	2		A + N	4
Social Engagement	2		A + N	4
Social Interaction	2		A + N	5
Social Robots	2		A + N	20
Soft Sensor	2		A + N	21
Software	1	Noun		15

Software Development Kit (SDK)	3		NNN	8
Solid Axle Wheelset	3		ANN	8
Solid fault	2		A + N	3
SOM (Self-organizing maps)	2		Ving + N	5
Sophistication	1	Noun		5
Spatial	1	Adjective		19
Spatial anomaly	2		A + N	1
Spatial Dependency	2		A + N	5
Spatial Grid	2		A + N	5
Spatial Structure	2		A + N	4
Speed	1	Noun		9
SQL (Structured Query Language)	3		VedNN	3
Square-root raised-cosine (SRC)	2		A + N	3
SQUID magnetometer		Abbreviation		3
Stability	1	Noun		3
Stability calculation	2		N + N	1
Stabilization	1	Noun		10
State vector	2		N + N	5
Steady-State Operation	2		A + N	1
Steering	1	Noun		15
Stick-Slip Motion	2		N + N	3
Superparamagnetism	1	Noun		2
Supervisory Control	2		N + N	5
Symbol error probability	3		NNN	4
Synthetic jet actuator	3		ANN	15

System Automation	2		N + N	6
System Configuration	2		N + N	4
System Dynamics	2		N + N	19
System Integration	2		N + N	8
System Output	2		N + N	4
System Parameter	2		N + N	11
System performance	2		N + N	3
System Stability	2		N + N	4
System Uncertainty	2		N + N	8
Tactile Sensing	2		N + Ving	8
Tactile System	2		N + N	4
Tag	1	Noun		21
Taguchi Method	2		N + N	9
Task Management	2		N + N	4
Task Specification	2		N + N	5
TCP		Abbreviation		13
TCP Implementation		Abbreviation		1
TCP-friendly		Abbreviation		2
Teleoperation	1	Noun		5
Teleoperation-based Task	2		Ved + N	1
Teleoperator	1	Noun		4
Telescopic arm	2		A + N	2
Template Matching	2		N + Ving	4
Temporal anomaly	2		A + N	3
Temporal graph	2		A + N	5
Testbed	1	Noun		3
Throttling Range	2		Ving + N	6

Timestamp-Ordering Protocol	2		Ving + N	5
Torque	1	Noun		4
Tracking Error	2		Ving + N	9
Trajectory	1	Noun		56
Trajectory Control	2		N + N	10
Trajectory Points	2		N + N	3
Trajectory tracking	2		N + Ving	1
Transaction	1	Noun		18
Transformation Matrix	2		N + N	3
Transient Operation	2		N + N	1
Transmission	1	Noun		16
Transmit (TX)	1	Verb		5
Transport Protocol	2		N + N	4
Trinomial Protocol	2		A + N	14
Tuning Parameter	2		Ving + N	3
Two-Phase Locking Protocol	3		NVinN	5
UDP		Abbreviation		11
UHF		Abbreviation		11
Unified Human-Machine Interface	3		VedNN	13
Unimate robot	2		A + N	14
Untact technology	2		A + N	2
Upsampler	1	Noun		2
User Interface	2		N + N	10
Variable	1	Noun		5
Variance Analysis	2		N + N	1
Vector-adjusting characteristic	2		Ving + N	5
Vectoring angle	2		Ving + N	12

Vehicle	1	Noun		20
Velocity	1	Noun		6
Velocity vectors	2		N + N	7
Versatran robot	2		A + N	3
Vibrating diaphragm	2		Ving + N	5
Virtual Factories	2		N + N	3
Virtual Grid	2		N + N	14
Vision system	2		N + N	6
Voltage Generation	2		N + N	4
Wearable Sensing Technology	3		AVingN	5
Wheeled robot	2		Ved + N	14
Wheelset	1	Noun		38
Winner-take-all	1	Noun		2
Wireless accelerometer node	3		ANN	2
Wireless actuation	2		A + N	2
Wireless data	2		A + N	3
Wireless Sensor Network (WSN)	3		ANN	12
Word of mouth (WOM)	3		NPrN	8
Workpiece Handling	2		N + Ving	2
Yaw	1	Noun		18
Zero-forcing equalizer	2		Ving + N	2