

English Language as the Spiral Mirabilis: Mathematical Rule-Following

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The English language as the digital integral in the context of programming languages is interesting from the perspective of linguistics. The interaction of the English and programming languages, a human being and the "machine" (robot, chatbot, etc.), the processing of the natural (English) language and the role of the English language in this process, the perception of the English language by a human being and the machine, and other issues require studying the basis of the integral relationship between the English language as the natural and programming languages as the artificial ones. The socio-cultural characteristics of the languages studied, their philosophy and specifics, as well as semantics, syntax, and pragmatics, the identification of relevant linguistic markers, require a certain empirical base. This research focuses on the mathematical features of the English language and considers this phenomenon from the perspective of philosophy.

Keywords: English language, mathematics, rule-following, Wittgenstein's philosophy.

I. Introduction

The global scientific and technical potential of the modern English language as an integrative phenomenon used both to describe innovative developments in applied linguistics and the object of such research is of vital importance. Programming languages as a linguistic and mathematical conglomerate contain a huge number of names to identify their integrative elements, using syntax and semantics. The most popular programming languages are based on the English language. Supposedly, the English language and its integral role in the context of the programming languages can be considered as a logarithmic spiral, equiangular spiral or growth spiral. According to Descartes and Jacob Bernoulli, Spiral mirabilis or "the marvellous spiral", is a self-similar spiral curve which often appears in nature. The English language being in the centre of the programming language coinage, develops and turns from the means of the programming languages creation to the object of their investigation. The present research revolves around this innovative phenomenon and examines its diverse possibilities.

II. Research Questions

To correlate the principles of linguistics and programming in terms of rule-following, it is relevant to consider the phenomenon of intertextuality and the relation of texts and their processing by means of computer linguistics.

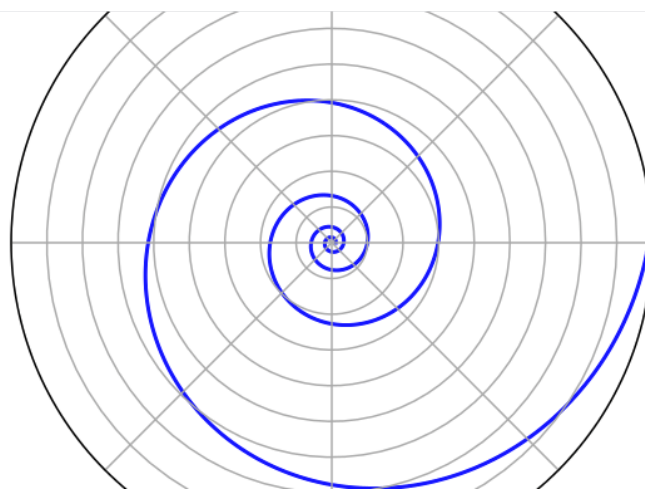
III. Article Structure

The relation of texts to each other is based, first of all, on the theory of intertextuality, which is directly related to the problem of interpretation of the text, which sends the reader to other texts. The notion of intertextuality is linked to the concept of M. Bakhtin's dialogue and is a textual interaction that interprets history. Intertextually enriched speech that evokes the feeling of déjà vu, drawn to the texts of the past and thus to the history of speech diachrony (Allen, 2000). When there is interest in the categorization of text, it is relevant to check textual spam. According to N- programming language model, it is possible to estimate the likelihood of the last word given by the previous words. Imagine that a text is a "word packet", an unordered set of words, ignoring the initial position of words in the text, keeping only their frequency.

Suppose that the text “package of words” is a simple example in two classes - positive (+) and negative (-). Below we see 5 sentences (also called documents) with their known categories, as well as 1 sentence with an unknown category. The purpose of the research is to classify the last is a sentence both positive and negative. This problem is solved by the so-called classifier Naïve Bayes, using words that are often found in the “bag of words” in each class to order to calculate

the probability of each class c (cat) and the probability of each of the word’s given class. In this example, a negative class has a probability of $3/5$. A positive grade will have a probability of $2/5$. These coefficients show that the probability of the words “predictable”, “with”, “no” and “fun” with the negative class is higher than the probability for the positive class. Because sentence “predictable with no fun” will be classified as negative ones.

Fig 1. Spiral Mirabilis representation



Source: Research data

IV. Literature Review

To understand the paradox of rule following, it is relevant to trace tendencies of Wittgenstein’s development as a philosopher. In his early philosophy, he developed ideas of Russell borrowed from *Principia Mathematica* and was focused on discussion of false or true propositions. Wittgenstein was focused on application of logic for semantics. He was inspired by Frege and Russell and their considerations about axiomization (Kaplan, 2006). In the course of his creative activity, Wittgenstein referred to symbolic depiction and mathematic language in order to show a factual basis of the language. An integration of different approaches to solving the problem of what logic is, what language is and how these issues are reflected in an individual, make Wittgenstein a great philosopher (Stern, 2006).

A correlation between things and words is the basis of communication. Therefore, Wittgenstein uses

philosophy as a ‘tool’ in identification of the language function. From this claim it is seen that the philosopher considers correlation between separate things, thus he refers to the ideas of ‘atomism’ developed by Russell, i.e. in his early years Wittgenstein considered different phenomena separately, like ‘atoms’, and in his later years he considered different phenomena in relation to each other.

Further on, Wittgenstein developed his ideas and made remarks to his *Tractatus*. Gradually, Wittgenstein started to step back from his version of ‘logical atomism’. Firstly, in *Tractatus* he claimed that “A proposition can determine *only one place* in logical space: nevertheless, *the whole* of logical space must already be given with it” (Wittgenstein, 1968). Consequently, Wittgenstein moved to holism (Crary & Read, 2000).

Wittgenstein started to claim about a set of logical elementary proposition and considered the structure of

the language, which “might be visible on its surface and might actually be gathered from the ordinary uses that we make of words in ordinary situations” (Wittgenstein, 1968). Consequently, Wittgenstein descended to his later philosophy. The later Wittgenstein is of great importance in the modern philosophical paradigm. In a modern context of world’s development with overall processes of globalization it is important to trace the background of these tendencies, because Wittgenstein’s development from a philosopher who considered things separately to a philosopher who considered things in relation to each other symbolizes modern trends of globalization. Thus, Wittgenstein’s ideas present a fertile ground for philosophers and researchers discussing the nature of language.

Attitude of Wittgenstein to rules is the following: “any interpretation still hangs in the air along with what it interprets, and cannot give it any support. Interpretations by themselves do not determine meaning” (Wittgenstein, p. 198). Kripke argues that in mathematic language rules work because ‘+’ has been used in numerous cases. There is a meta-linguistic usage of ‘+’, i.e. the one used in the linguistic society, as it is claimed by Wittgenstein.

Kripke introduces a matter of quaddition a specially constructed function which is deviant in relation to addition. When skeptics start arguing why 68 and 57 will result in 125 and not 5 for example, there is a need to give answer to two questions: 1) “an account of what fact it is (about my mental state) that constitutes my meaning plus, not quus” and 2) to “show how I am justified in giving the answer ‘125’ to ‘68 + 57’” (Kripke 1982, p. 65). Kripke claims that no exact answer is possible. In such a way, Kripke gives up his positions thus making skeptics to be right.

Kripke intends to solve the problem of ‘meaning’ from a skeptical perspective. A well-known example of Kripke, which will be discussed throughout the paper, is determined in the following way: “But...how can I be sure that, given what I meant by ‘+’ in the past, that ‘125’ and not ‘5’ is the correct answer to ‘68 + 57?’ as I now use ‘+?’” (Kripke 1982, p. 198). Kripke argues that it is possible to mean plus by ‘+’ and to get the answer ‘125’; it is possible to answer ‘125’ based on previous facts; there is no exact answer to this question; it is not the case when one has to say ‘125’; it is not the

case when plus means ‘+’. Here are five types of Kripke’s argumentation about Wittgenstein’s rule following paradox (Fitch, 2004). Still, Kripke argues with Wittgenstein and says that it is impossible to mean plus by ‘+’ all the time, because one can lie; or it is possible to deduce with no appeal to previous facts or experiences. Kripke gives numerous arguments, but his main premise is framed by expression ‘there is no exact answer’. Thus, he reveals a skeptical nature of his problem solving: “I have no justification for thinking that I meant something or nothing by ‘+’” (Kripke, 1982).

Therefore, Kripke introduces a problem of absence of justification about what individuals really mean, or, in other words, what the meaning of an intentional phenomenon is. Kripke considers the problem of meaning as a paradox.

Both, Wittgenstein and Kripke apply paradox for the rule following problem’s solution. Wittgenstein agrees upon the fact that “there couldn’t be determinate facts about meaning, if meaning were construed in the way the skeptic assumes” (Wittgenstein, 1968). From the skeptical perspective, the premise must be rejected; the usage of ‘+’ can’t be based on personal experience only; the linguistic community determines the meaning of ‘+’. From skeptical consideration, the “truth-conditions of sentences” will fail in this problem solving. It would be more relevant to involve “use-conditions’ and claim that ‘125’ is the only right answer, because linguistic community acclaims this legitimate usage of the expressions. The latter explanation is closer to Wittgenstein and is developed based on the principles of the meaning usage by the community developed by him. Consequently, it is impossible to talk about a private language, because any meaning used separately from community’s criteria and every meaning is used in a ‘rule-governed way’.

Wittgenstein claims that whether he meant something or nothing by ‘+’ does not matter, because no exact solution exists. The essence of finding solution to the paradox by Kripke is in skeptical discard of the community approved decisions, unlike Wittgenstein, who managed to solve this problem in terms of an individual and society relation. Interpretation (Deuten) is defined by Wittgenstein as “There is an inclination to say: every action according to a rule is an interpretation. But we ought to restrict the term “interpretation” to the

substitution of one expression of the rule for another” (Wittgenstein, 1968). Wittgenstein protects his idea of the important rule of interpretation, because it is a way to perception of the rightness of following the rule and not a blind following. Therefore, interpretation is the solution to a problem. Wittgenstein shows a practical approach to the solution of a word meaning problem. In spite of the fact that Wittgenstein’s explanation of the word’s meaning can be found in the interaction of an individual and the society, makes a philosophy of language a special bound between the society and an individual. Therefore, approach of Wittgenstein to philosophy in language is not atomized, as it was in his early years, but generalized. Unlike the latter, Kripke appeals to philosophy as to a certain helpful tool used for restoration of the meaning in individuals’ minds.

V. Research Methodology

Models of language as “bag of words” is based on TF (term frequency, a statistical measure used to assess the importance of words in context), as the second determines how many times a word is repeated in a given text or document. The word pack helps you to analyze the tone of the text. This model recognizes the language in which the text is written. It is also used to determine author’s characteristics, such as gender and age. It is also possible to use TF to develop additional functions, such as the number of positive words (“great”, “nice”, “enjoyable”), or the number of first and second person pronouns (“I”, “me”, “you”) and develop more sophisticated classifiers based on logistic regression and even neural networks.

To give an example, in the explanatory dictionary there is a definition of the word “mouse”, but there is no definition of its plural form. The same with the verb “sing”, we can find in the dictionary definitions for “sing”, “sang”, “sung”, but not of other grammatical categories. For example, a word “plant” can have different meanings depending on the context (e. g. “Tesla is building new plants”, “Climate change has a negative effect on plants”).

Currently, vector semantics is the best approach to building a computational model that successfully handles various aspects of the meaning of a word, including hyponym, hypernym, antonym, synonym, homonym, similarity, affinity, lexical fields, lexical frames, connotation. In the example of “Tesla is building new plants”, if we count the

words in the context of the word “plant” in many other sentences written by individuals, we will see inclined words like “build”, “machine”, “worker” and even “Tesla”. The fact that these words and other similar contextual words also occur together with the word “factory”, we can understand the similarity between the words “plant” and “factory”. In this case we will know that “plant” is not “vegetable”. Therefore, a person can define and understand a word by context, and this word serves as a vector, a list of numbers, a point in N-dimensional space.

Instrument(s)

Formal semantics is based on three very simple ideas. First, this is the idea of compositionality: the meaning of a sentence should consist of the parts, which are integrated in the sentence. The second idea is that the parts of the sentence represent truth. The third idea is that there is no significant difference between the languages of logic/synthetic and natural languages. First idea belongs to G. Frege. The second idea was formulated by L. Wittgenstein, which was considered previously. Let us consider, for example, sentence (1). The proper name “James” indicates an object, an individual, namely James. The symbol “James” indicates an individual. The word “smart” denotes a function related to the individual and gives out the truth value.

James is smart.

Thus, the meaning of the whole sentence arises as a result of elements combined in the sentence.

The value of an affirmative sentence is the condition of its truth. Consider this idea using the example of sentence (2). This sentence is meaningful. We do not know whether it is true or false. However, we understand this sentence because we know what the situation should be, if it is true, and what the situation should be, is the sentence is false.

(2) There are planets in the space, where there is life other than on the Earth.

The idea that any natural language can be analyzed by formal methods was expressed by R. Montague, who said that there is no important theoretical difference between natural languages and artificial languages of logicians. Actually, the sentences like (1) are not of

great interest for formal semantics, since their interpretation is very simple and the result is not very interesting. The researchers would rather be interested in the sentence (4). They are interesting because they contain functional elements such as “every” or “each”.

(3) Every hunter wants to know where the pheasant sits.

Functional elements differ from referential ones, as they do not point to any particular item or many items.

“Every hunter” does not indicate any particular object or set of objects. Formal semantics is primarily interested in functional elements of this type. The task of formal semantics is translation of expressions, including functional expressions into the language of logic. This translation should correctly reflect the true message of sentences with the functional elements and also correctly predict the interaction of these expressions with other functional elements of the sentence. For example, in the sentence (3) the word “every” is interpreted as a universal quantifier. This correctly predicts that a negative sentence (4) will be true if and only if there are hunters who do not want to know where the pheasant sits.

(4) Not every hunter wants to know where the pheasant sits. Due to the interaction of negation and the word “every” we understand that the phrase “every hunter” is not a reference that indicates the totality of all hunters. Not all functional elements are quantifiers, but they all represent the interest for formal semantics. In particular, he draws attention to the fact that this analysis may not be true for subordinate clauses. Consider his examples in the sentences (5) and (6). The sentence (5) is true. However, the sentence (6) is false. (5) Copernicus believed that the Morning Star is an Evening Star. (6) Copernicus believed that the Morning Star is Venus.

Frege suggested that in an indirect context, a sentence denotes its meaning. The meaning of a sentence is a way of representing it. In the works of Frege it is not clear what the method is and how the method of given may be the referent of the proposal in an indirect context. In different languages there are different functional elements, therefore the project of formal semantic descriptions is implemented as applied to different languages. Natural language is logical and can be studied by the formal methods.

VI. Research Results

Frege was the first to apply the achievements of mathematical logic to the analysis of natural languages. Even if Frege wrote the article “Meaning and Significance” (Sikander, 2010) only to clarify his logical ideas, one thing is that he uses the examples of everyday language. Thus, Frege was interested in the principles of the structure of natural languages.

However, in early analytical philosophy it is known that any language cannot be studied by formal methods due to its inaccuracies. In particular, Russell, in the framework of his polemic with P. Strawson, writes that his theory of descriptions could never express the state of mind of an uttering expression containing a description. According to Russell, any language does not have exact logic, therefore, it is a source of philosophical problems.

Like Russell, Wittgenstein made a distinction between a strict logical language and a natural language. In particular, he writes that it should distinguish between the apparent form of sentences of everyday language and genuine work by L. Wittgenstein and his contribution to semantics and logical forms. Wittgenstein was the first to express the idea that natural language obeys the laws of logic and can be analyzed by formal methods. The work by Wittgenstein states that all sentences of our everyday language, in the form as they are, are logically quite ordered. Otherwise, there could be an illogical language or illogical thoughts.

Thus, in an explicit form, the idea of natural language and its consistency was expressed by Wittgenstein. G. Frege in his works formulated the idea that the sentences are the names of two abstract objects: Truth and False. All true sentences, according to Frege, point to Truth, and all false sentences indicate False.

VII. Research Analysis

It was Wittgenstein who formulated an exact sense, and it is his understanding of meaning that formed the basis of modern formal semantics. Like Frege, he associates meaning with understanding: what we understand is the meaning of the sentence (Sikander, 2010). Wittgenstein said that to understand the sentence, we must also know what will happen if it is

true and that what will happen if it is false. The sentence has two poles corresponding to the truth or false of the sentence. This is the meaning of the sentence. B. Russell, in the *Philosophy of Logical Atomism*, indicates that it was Wittgenstein who pointed out to him that sentences are not names of facts. The idea of the truth as the meaning of a sentence is formulated as follows: to understand a sentence means to know what happens, if it is true. Therefore, we can understand it without knowing if it is true or false. This is key to modern semantics. At present time, this idea is generally accepted knowledge. However, the above polemic with Russell and Frege shows that this observation is not trivial, and Wittgenstein was the first to formulate it. The concept of the situation is a prototype of modern situational semantics. An important concept of modern semantics is the concept of a situation. The situation is understood as the spatial and temporal part of the possible world. In this sense, they talk about possible situations. There is a number of arguments to introduce situations. Most natural language sentences belong to some limited situation. For example, if we say "James is back," we do not evaluate this sentence regarding our entire world and its entire history. Or if we say "all students got an excellent grade", we are not talking about all the students of the whole world. We mean some specific situation. How do sentences relate to situations and how do we identify the situation? An important concept in modern situational semantics is the concept of a minimal situation in which some of sentences are true. This situation does not contain anything that would not relate to the truth of the sentence, i.e. it does not contain in itself a part in which the sentence would also be true. Take, for example, the sentence "James is smart." Minimum situation of this sentence is true. The sentence that contains a word James and only one of his features is to be smart. Other characteristics of this individual, to be young or to be from America do not exist in the framework of this situation. The concept of a minimal situation is effective for analyzing sentences in natural languages, especially conditional sentences. You can draw parallels between the concept of a minimum situation in situational semantics and the concept of Sachverhalt (co-being, state of affairs). Sachverhalt is that which corresponds to the elementary (simple) sentence, if it is true. Thus, we can understand the situation as a possible situation. The state of affairs

(or events) are represented by sentences and what is represented by the sentence that is its meaning. The sentences should make sense regardless of their truth or false, which means that Sachverhalt is a possible situation. Wittgenstein did not give any examples of simple sentences from a natural language. Such a sentence would consist of the names of simple objects, but the objects of our world are not simple, according to Wittgenstein. In situational semantics, any sentence corresponds to its own minimal situation (or, more precisely, the set of possible minimal situations).

VIII. Conclusion

Wittgenstein wrote that natural language behaves as if the names point to simple objects: it seems that all the names in a certain sense are genuine names. Moreover, in modern linguistics we are not talking about that suggestions allow us to learn something about the structure of the world. The sentences only allow us to know what the structure of the world is. Wittgenstein formed the basis of modern linguistics and philosophy, namely formal semantics. He also formulated the very idea that natural language is logical and that an illogical language cannot exist. Perspective of this study is to determine the potential of the English language as the digital integral in the context of programming languages. The English language and its linguistic basis created for the studied artificial languages, at the same time, acting as an object for processing in applied linguistic research and programs, as well as the linguistic basis for creating English-language chatbots, robots and other communication "machines" of human interlocutors.

IX. Conflict of Interest

None declared.

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