Chapter 5
Meaning as Use: From Wittgenstein to Google's Word2vec

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Abstract Modern natural language processing (NLP) systems are based on neural networks that learn concept representation directly from data. In such systems, concepts are represented by real number vectors, with the background idea that mapping words into vectors should take into account the context of their use. The idea is present in Wittgenstein's both early and late works, as well as in contemporary general linguistics, especially in the works of Firth. In this article, we investigate the relevance of Wittgenstein's and Firth's ideas for the development of Word2vec, a word vector representation used in a machine translation model developed by Google. We argue that one of the chief differences between Wittgenstein's and Firth's approaches to the word meaning, compared to the one applied in Word2vec, lies in the fact that, although all of them emphasise the importance of context, its scope is differently understood.

Keywords Wittgenstein · Firth · Word2vec · Machine translation · Natural language processing

5.1 Introduction

Meaning has always been one of the essential topics in philosophy since its origin is in Ancient Greece. Some of the important philosophical questions related to meaning are: what is the relation between language and thought? what is a concept? is it a mental image? how do elements of language refer to non-linguistic entities? how are we able to know the meaning of a word or a sentence?, etc.

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On the other hand, in recent developments of artificial intelligence (AI) meaning has proved to be one of the greatest challenges. So far, artificial intelligence has been made skilled in, among other things, recognising speech and translating text and/or speech from one language to another, but it is still short of understanding human language. The problem of natural language understanding cannot yet be solved by using AI technology alone, and until now it has required huge manual efforts. However, an important step forward has been made with introducing neural networks in natural language processing, especially in machine translation.

Although it is still an active field of research, modern natural language processing (NLP) systems are based on neural networks that learn concept representation directly from data, without human intervention. In such systems, concepts are represented by vectors of real numbers. The idea which serves as the basis for models of word embedding using neural networks is that mapping words into vectors should take into account the context of a sentence because its meaning is not a simple composition of the meanings of individual words it contains. To learn vector representation for phrases, it is necessary to find words that appear frequently together, and infrequently in other contexts [7].

This fundamental idea sounds almost like a repetition of Frege's famous dictum: "Never ask for the meaning of a word in isolation, but only in the context of a sentence" ([4]: x). The idea is present in Wittgenstein's both early and later works. In the *Tractatus*, he says that "Only the proposition has sense; only in the context of a proposition has a name meaning" ([11]: Sect. 3.3), while in *Philosophical Investigations* he develops it further: "We may say: nothing has so far been done, when a thing has been named. It has not even got a name except in the language game. This was what Frege meant too when he said that a word had meaning only as part of a sentence" ([12]: Sect. 49). Outside philosophy, in contemporary general linguistics, the idea of the importance of context for establishing meaning became relevant through the works of J. R. Firth: for Firth, the complete meaning of a word is always contextual ([3]: 7).

In this article, we investigate the relevance of Wittgenstein's and Firth's ideas, as referred to above, for the development of word vector representation used in a machine translation model developed by Google, known as Word2vec. In Word2vec, the meaning of a word is identified with a vector (in standardised form) which codifies the contexts of its use; a particular context in which the word occurs is characterised as the words immediately surrounding it in a sentence. We will first present Wittgenstein's and Firth's views on the importance of context for determining word meaning. After that, we will briefly outline the most important technological aspects of Word2vec. Finally, we will compare these approaches, and highlight similarities and differences between them.

5.2 The Role of Context in Wittgenstein's Philosophy of Language

Arguably, no twentieth-century philosopher stressed so vehemently the importance of context in determining word meaning, and thereby radically transformed our understanding of the workings of language, as Ludwig Wittgenstein.

Although it is widely recognised that context plays a prominent role in Wittgenstein's later philosophy of language, for reasons of historical accuracy it should be underscored that Wittgenstein, from the very beginning, ascribed high importance to the so-called context principle, according to which words have no meaning in isolation. Already in the *Tractatus*, it is stated in Sect. 3.3: "Only the proposition [*Satz*] has sense [*Sinn*]; only in the context of a proposition [*Zusammenhange des Satzes*] has a name meaning [*Bedeutung*]. "Wittgenstein derived the context principle, as well as the terminology in which it is expressed, through the influence of "the great works of Frege", to which he admits owing "in large measure the stimulation of my thought" ([11]: Preface).

In his *Grundlagen der Arithmetik*, Gottlob Frege mentions the context principle twice: in the foreword, he stresses that one of his fundamental principles is "never to ask for the meaning of a word in isolation, but only in the context of a proposition [*Satzzusammenhange*]" ([4]: x); and later, in Sect. 60, he advises that "we ought always to keep before our eyes a complete proposition [*Satz*]", since "only in a proposition have the words really a meaning [*Bedeutung*]". For Frege, the context principle is mainly a powerful shield against the temptation to succumb to psychologism in the philosophy of mathematics. Since the numerical singular terms do not stand for physical objects that we find in our experience, in attempting to determine their reference (*Bedeutung*) without considering the sentential context in which they occur we are often inclined to wrongly assume that they stand for mental objects, or ideas (*Vorstellungen*), and that, accordingly, a psychological investigation of these ideas will provide us with the foundations of mathematics. Another reason which Frege had for endorsing the context principle is to be found in his subsequent article "On Concept and Object": there he points out that a word can refer to entities of radically different kinds in various sentences, and that, hence, its reference cannot be determined outside a specific context. For instance, in the sentence "Vienna is a big city" the word "Vienna" behaves like a name and thus stands for an object, a saturated entity, namely, the capital of Austria; but in the sentence "Trieste is no Vienna" it has the role of a predicate and refers to an unsaturated entity, a concept, namely, that of being a metropolis ([5]: 50).[1]

[1]Frege divided linguistic expressions into saturated (or names) and unsaturated (or functional) expressions: the unsaturated expressions contain a gap, an empty place for an argument usually marked by the occurrence of a variable. This linguistic division is strictly paralleled by an ontological division: references of saturated expressions are saturated entities (or objects), while references of unsaturated expressions are unsaturated entities (or functions). Predicates are functional expressions which need to be supplemented with a name to form a proposition: analogously, at the level of reference, concepts, which are references of predicates, are first-order functions of one argument,

Wittgenstein opposed psychologism in the philosophy of mathematics as ardently as Frege. In fact, he considered psychological investigations of mental processes accompanying the uses of language as irrelevant for explaining meaning, not only of mathematical terms but also of words in general: his early statements against such a view can already be found in the *Tractatus* ([11]: Sect. 4.1121), but their most elaborate and conclusive form was to wait until *Philosophical Investigations* ([12]: Sects. 143–184). The second reason Frege had for endorsing the context principle was also well received by Wittgenstein in the *Tractatus*: words may have different meanings in different sentences, which is why he warns us that we should distinguish between a mere sign (*Zeichen*) and the symbol (*Symbol*) it expresses, since "two different symbols can /.../ have the sign (the written sign or the sound sign) in common" ([11]: Sect. 3.321), as well as that "in order to recognise the symbol in the sign we must consider the significant use" ([11]: Sect. 3.326), that is, the use that the sign has been put to in the context of a meaningful sentence.

In the so-called transitional period, in the late 1920s, Wittgenstein's views on the context of use of a sign have undergone an important change.[2] He no longer believed that a sentence was the least independent linguistic unit endowed with meaning, but embraced a more large-scale semantic holism instead. According to his new understanding, a word has meaning only within a *Satzsystem*, a system of propositions relatively independent of the rest of the language. While in the *Tractatus* language was described as a monolithic great "mirror of the world" ([11]: Sect. 5.511), which represents the world by sharing its logical structure, in his new view the language was broken up into smaller, autonomous, overlapping linguistic systems, each constituted by its own set of explicit rules that prescribe the use of its primitive terms. A *Satzsystem* is, perhaps, best thought of by analogy to an axiomatic system. His motivation behind this change was twofold. One reason was his dissatisfaction with both the Fregean realism and formalist antirealism in the philosophy of mathematics: while formalists denied meaning to mathematical signs, realists claimed they referred to objects whose existence was completely independent of our thought, language and mathematical practice. Wittgenstein saw a fruitful third way in comparing mathematics to a game of chess: it is not true that chess figures have no meaning, only that they mean something exclusively within the game; their meaning is not to be identified with an object they refer to, but with rules of the game which command the moves one can make with them ([15]: 142–161). The other reason stemmed from his dissatisfaction with his own views expressed in the *Tractatus*. Discussing his book with Frank Ramsey made him realise that he had a problem with explaining how the proposition that something is red implies the proposition that it is not green. Early on, Wittgenstein espoused the view that has recently become known as modal monism: he believed that there is only one kind of necessity, namely, logical necessity ([11]: Sect. 6.37). While it is necessary that a red thing is not green at the same time, the

whose value is a truth value. Frege [5] claimed that the division is absolute: nothing can be an object in one context and a function in some other.

[2] A nice overview of the development of semantic holism in Wittgenstein can be found in Shanker [10].

necessity in question seems not to be logical: in order to reduce it to logical necessity, Wittgenstein was forced to claim that impossibility of anything being both red and green stems from the meaning of the colour words. In his new opinion, words such as "red" or "green" have meaning only inside the propositional system for attributing colours to objects, and the rules which constitute this system forbid predicating two colours to the same object ([14]: Sects. 76–86).

In the next phase of Wittgenstein's philosophical development, *Satzsysteme* were replaced with an even richer concept of *Sprachspiele*, or language games. Wittgenstein introduced the notion of a language game in the *Blue Book*, while in the *Brown Book* he gave many examples of them, some of which later reappeared in *Philosophical Investigations*. He describes language games as primitive forms of language, complete in themselves ([13]: 81), but easily imagined as evolving, in changed circumstances, into new and more complex ones ([13]: 17). In his many remarks, Wittgenstein suggests that it may be useful to think of language games as a language of a primitive tribe that one encounters ([13]: 81), since they are "ways of using signs simpler than those in which we use the signs of our highly complicated everyday life" ([13]: 17). He also compares them to "the forms of language with which a child begins to make use of words" ([13]: 17), and indicates that later in life one is initiated into novel language games when one, for instance, learns "special technical languages, e.g., the use of charts and diagrams, descriptive geometry, chemical symbolism, etc." ([13]: 81). Wittgenstein now sees ordinary language as a complicated network of interconnected language games, in which words are being used as extremely diverse tools for multifarious purposes ([12]: Sect. 11). The most important difference between *Satzsysteme*, which he previously considered as basic contexts of word use, and the subsequent *Sprachspiele* is that in language games the meaning of words is inextricably tied to speakers' non-linguistic practice: by the term "language game" Wittgenstein understands "the whole, consisting of language and the actions into which it is woven" ([12]: Sect. 7). To explain the words meaning in a language game, it is not sufficient, as in a *Satzsystem*, to lay down semantic rules, but it also needs to be specified who constitutes the linguistic community, what kind of non-verbal activities members of the linguistic community are typically engaged in when uttering the words, what props are thereby being used, what appropriate non-verbal reactions to hearing the words uttered are, how they are being taught to novices, and what customs and institutions already have to be in place so that the linguistic training may succeed and language application can get off the ground ([12]: Sects. 2–7). Wittgenstein repeatedly stresses that the meaningful use of language presupposes participation in a community, whose members must already agree in their behavioural responses, both to one another and to their common surroundings. Words have meaning only inside a language game ([12]: Sect. 49); their meaning is the way they are used therein ([12]: Sect. 43); since language games are already independent miniature languages, to understand a single word means to understand a whole language ([12]: Sect. 199); and as our linguistic behaviour can appear only against the background of shared and rule-regulated non-linguistic practices, mastering the technique of using words presupposes being initiated into a certain culture or a form of life ([12]: Sects. 19, 23, 199, 241).

When we use words in a proper environment, while taking part in activities in which these words are at home, misunderstandings only seldom occur and are easily resolved. On the other hand, we run into troubles, are confused and perplexed with paradoxes when we divorce words from their original surroundings: according to Wittgenstein, misuse of language is the source of all philosophical puzzles; they arise when "language goes on holiday" ([12]: 38). Philosophical problems should, in his view, disappear once the words are brought back to their everyday use: the successful treatment thus consists in producing an *Übersicht*,[3] a perspicuous presentation with which to remind ourselves of the roles that the words have in various contexts ([12]: Sects. 122–133). A particular source of philosophical troubles is that quite often words are used differently in different language games: if we successfully apply a word on a certain occasion, we are inclined to think that in a new context, in which its meaning has been altered, it must conform to the same rules as before. Another powerful philosophical prejudice that Wittgenstein was persistently striving to free us from is that there has to be a common core to all the different context-relative meanings of a word, a set of context-transcending necessary and sufficient conditions for its application. He pointed out that this is not the case with all words and that some words, such as "game", stand for family resemblance concepts: different cases of their use show similarities in pairs, even though there is no "one fibre running through the whole thread" ([12]: Sects. 65–75); a detailed *Übersicht* of their variegated uses within specific language games will make that manifest.

5.3 Firth's "Context of Situation" and "Collocation"

What links Word2vec with Wittgenstein's philosophical insights about the meaning of a term as its rule-governed use within a particular language game is the application which these philosophical ideas received in the linguistic theory of English linguist John Rupert Firth.

The breakpoint for contemporary general linguistics was the publication of Ferdinand de Saussure's *Course in General Linguistics* in 1916. One of de Saussure's most important ideas was to consider language as a system of signs (as compared to systems in many other fields). Linguistic sign is constituted of the signifier, or sound pattern, and the signified, or mental concept. Language signs belong to the language as a system, so that a change in any sign affects the system as a whole [9]. A couple of decades later, Firth expanded on de Saussure's conception of the linguistic sign: signs are not only dependent on the language system, but also their meaning can change with the context in which they are used.

Firth has repeatedly stressed that linguistics should not abstain from addressing the question of meaning ([3]: 190) and that "the complete meaning of a word is always

[3]In their analytical commentary on *Philosophical Investigations*, Baker and Hacker suggest that this technical term of Wittgenstein's should be translated with the English word "surview" ([1]: 531–545).

contextual, and no study of meaning apart from a complete context can be taken seriously" ([3]: 7). Contextual considerations must include "the human participant or participants, what they say, and what is going on" ([3]: 27), since "language is a way of dealing with people and things, a way of behaving and making others behave" ([3]: 31); language is used by persons in a social environment ([3]: 187), insists Firth, with the aim of maintaining a certain "pattern of life" ([3]: 225). The fundamental notion in Firth's linguistic theory is that of the *context of situation*, which he acknowledges inheriting from his collaborator, anthropologist Bronisław Malinowski ([3]: 181). A context of situation is specified when the following is known: (1) the verbal and the non-verbal actions of the participants, (2) the objects involved, and (3) the effects of verbal action ([3]: 182). Firth immediately stresses the similarity between his concept of context of situation and Wittgenstein's notion of the language game. He approvingly cites Wittgenstein's dictum that "the meaning of words lies in their use" ([2]: 179) and that "a language is a set of games with rules or customs" ([2]: 139). The notion of the context of situation is meant to emphasise the social dimension of language. Just as Wittgenstein, and Frege before him, Firth argues against mentalistic accounts of meaning: the theory of Ogden and Richards [8], influential in his time, which identifies meaning with "relations in a hidden mental process" ([3]: 19), he considers as an unacceptable remnant of Cartesianism. Again, entirely in tune with the later Wittgenstein is his forsaking the universal theory of language in favour of a descriptive and detailed study of what he calls "restricted languages", i.e. languages scaled down to particular contexts of situations; the examples of restricted languages he provides are: air-war Japanese, Swinburnese lyrics or modern Arabic headlines ([2]: 29).

In further analysing the contextual meaning of a word, Firth distinguishes its many dimensions and singles out the one most eligible for empirical investigation: collocation. Collocation is "quite simply the mere word accompaniment, the other word-material is which [the word is] most commonly or most characteristically embedded" ([2]: 180). The idea is that if two words have different accompaniments, they are already semantically distinguishable by that feature alone. To cite Firth's example: it is evident that "cow" does not mean the same as "tigress" since "cow" appears in collocations such as "They are milking the cows", while "tigress" does not ([2]: 180). In introducing the notion of collocation, Firth paraphrases Wittgenstein in asserting that "a word in company may be said to have a physiognomy" ([3]: xii). A non-Wittgensteinian move, however, which Firth made, and which significantly paved the way for Word2vec, is that he explicitly declared collocation—a limited excerpt of the purely linguistic element of the context—to be a part of the word's meaning [3]: 196); his famous and most quoted line is: "You shall know a word by the company it keeps" ([2]: 179). It is evident that the vector which Word2vec associates with a word as its meaning is designed to capture its collocations.

5.4 Word2vec

It is straightforwardly understandable that the concepts *beer* and *wine* are more similar to each other than the concepts *beer* and *cat*. A possible explanation for this being so is that the words for these concepts, "beer" and "wine", appear in the same contexts more often than the words "beer" and "cat" do. This way of thinking is in the background of Word2vec model of word embedding, and it is called the distributional hypothesis.[4] Here, neural networks are used to recognise such similarities.

Neural networks, or more precisely, artificial neural networks, such as those used in Word2vec models for word embedding,[5] are computing systems intended to emulate the functionality of the (human) brain. A model most similar to the human brain would be a computer system that processes numerous data in parallel. Both generally accepted models of computing—von Neumann and Harvard architectures— greatly differ from the concept of neural network: from building block types to the number of "processors", connections and information type.

In the early beginnings of AI research, two models emerged—the symbolic and the connectionist. The symbolic approach tends to aggregate specific domain knowledge with a set of atomic semantic objects (symbols) and to manipulate those symbols through algorithms. Such algorithms, in real-life applications, have almost always an NP-hard complexity or worse, rendering massive search sets in problem-solving. This makes the symbolic approach suitable for certain restricted artificial use cases only. On the other hand, the connectionist approach is based on building a system with internal architecture like that of a brain, which "learns" from experience rather than have a preset algorithm to follow. It is used in numerous practical cases, which are too difficult for the symbolic approach; it is applied in the domain of formal languages for solving: the string-to-string correction problem, the closest string problem, the shortest common supersequence problem, the longest common subsequence problem, etc.

Several critical differences between the paradigms of classic computation architecture and (artificial) neural network can be displayed in the Table 5.1.
Thus, a neural network can be roughly defined as a set of simple interconnected processing elements (units, nodes), whose functionality is based on the biological neuron used in the distributive parallel data processing. It is purposely designed for answering the problems of classification and prediction, that is, all problems that have a complex nonlinear connection between input and output. It is significantly advanced in solving assessments of nonlinearity, robust on data errors, highly adap-

[4]One of the first formulations of the distributional hypothesis is often associated with the already mentioned Firth's ([2]: 179) dictum "You shall know a word by the company it keeps". More precise, and anticipating Word2vec, was Harris's claim: "All elements in a language can be grouped into classes whose relative occurrence can be stated exactly. However, for the occurrence of a particular member of one class relative to a particular member of another class it would be necessary to speak in terms of probability, based on the frequency of that occurrence in a sample." ([6]: 146).

[5]Word embedding is a process in which semantic structures (words, phrases or similar entities) from a certain vocabulary are mapped to and mathematically modelled as Euclidean vectors of real numbers.

Table 5.1 Differences between the paradigms of classic computation architecture and (artificial) neural network

Standard computing architecture	(Artificial) neural network
Predefined detailed algorithms	Self-sustained or assisted learning
Only precise data is adequately processed	Data can be unclear or fuzzy
Functionality dependable on every element	Processing and result are not largely dependable on a single element

tive and capable of learning; it works well with fuzzy or lossy data (from various sensors or non-deterministic data) and can work with a large number of variables and parameters. As such, it is beneficiary for pattern sampling, processing of images and speech, optimization problems, nonlinear control, processing of imprecise and missing data, simulations, the prognosis of time series and similar uses. Artificial neural networks generally work in two phases: learning (training) and data processing.

Word2vec suitability for semantic similarity is based on the implementation of word representations, which rests on the aforementioned distributional hypothesis. In other words, the context, in which a word is used, is provided by its nearby words. The goal of such representations is to capture the syntactic and semantic relationship between words.

As model examples, Word2vec uses two similar neural network-based distributional semantic models for generating word embeddings—CBOW (Continuous Bag-of-Words) and Skip-gram. Tomas Mikolov's team from Google created both models in 2013. CBOW attempts to predict the current word based on the small context window surrounding that word. CBOW suggests a concept where the projection layer is shared between all words and the nonlinear hidden layer is removed; the word distribution and order in the context do not influence the projection. This model also proved to be of substantially lower computational complexity. Skip-gram architecture is similar, but instead of predicting the current word on the basis of its context, it tries to predict the word's context with respect to the word itself. Therefore, the Skip-gram model intends to find word patterns that are useful for predicting the surrounding words within a specific range in a sentence. Skip-gram model estimates the syntactic properties of words slightly worse than the CBOW model. Training of the Skip-gram model does not involve dense matrix multiplications, which makes it extremely efficient [7]. Let us consider a simple example. For the words "cat", "wine" and "beer", we have the following vectors:
vec ("cat") = (0.1, 0.5, 0.9)
vec ("wine") = (0.6, 0.3, 0.4)
vec ("beer") = (0.5, 0.3, 0.3)
As can be seen, the vectors corresponding to the words "wine" and "beer" have more similar values than any of them has to the vector for the word "cat", hence the concepts expressed are more similar to each other than to the concept cat. We

can presuppose that the second value in the vectors for "wine" and "beer" stands for a feature like *is an alcoholic drink*. The similarity in meaning between words can be calculated as the cosine of the angle between vectors. In order to train another model using the already mentioned representations, we can feed them into a different machine learning model. Values assigned to each word are the result of the Skip-gram model, which has a role in determining which words often appear in similar contexts. In case two words can often be found surrounded by similar other words, their resulting vectors will be similar and the cosine of their angle will approach 1. Therefore, the word vector can be regarded as a compressed representation of its contexts of use. When the whole process is over, each word in the dictionary has been assigned its vector representation, and those representations can be listed alphabetically (or otherwise): the results will be N-dimensional vectors, where N is the number of words in the whole vocabulary. Additional technical details would exceed the scope of this chapter.

5.5 Conclusion: Differences Between Wittgenstein's Understanding of Word Meaning and that Facilitated by Word2vec

One of the chief differences between Wittgenstein's and the Word2vec approach to word meaning lies in the fact that although both emphasise the importance of context, its scope is differently understood. Word2vec offers a restricted view of what constitutes a context of use of a certain word: it is limited to directly neighbouring words only; neighbouring phrases with several words are not considered, let alone whole sentences in which they occur. Such a determination of context, even if derived from Firth's notion of collocation, seems too austere in comparison to its linguistic ancestor: the examples of collocation, as given by Firth, are typically more complex and often include sentences. The divergence from Wittgenstein is even starker: a meaningful sentence was his narrowest understanding of context, which was in the transitional period replaced with the wider *Satzsystem*, and, still later, with an even more encompassing language game. However, this simplification of context and restriction to a single mode of meaning—collocation—enabled the creation of such a widely applicable formalisation as Word2vec.

In the *Tractatus* period, Wittgenstein believed that all sub-sentential expressions, at least when the sentence is fully analysed, have the role of names ([11]: Sect. 4.22), and that their meaning is fully exhausted in their reference (*Bedeutung*)—an extra-linguistic object (*Gegenstand*) that they stand for in the context of the sentence. As names, in his view, refer directly, without the mediation of sense (*Sinn*) ([11]: Sect. 3.142), they have no linguistic meaning at all. According to Wittgenstein in the *Tractatus*, meaning is a relation between names and their bearers; it does not connect words with other words of the same language ([11]: Sects. 3.202, 3.22).[6] Although Wittgenstein later changed his mind and criticised his early views on this matter ([12]: Sect. 38), he never denied that at least *some* expressions in language have a referential role: it is part of their meaning to aim to pick out something in the extra-linguistic reality and represent it within a language game. The referential aspect of meaning, however, eludes Word2vec. Vectors delivered by Word2vec track only collocations, they register exclusively inter-linguistic connections between words.

Throughout his philosophical development, Wittgenstein thought that words have meaning only in a wider context in which they are used, but he did not identify the context with the meaning. A word has meaning inside a language game, but from that it does not follow that its meaning is the language game itself, or an exhaustive list of all the various language games the word is employed in. The Wittgensteinian conception of word meaning would be better represented with a function that to every language game (in which the word is used) ascribes the meaning the word has in that particular game: a set of rules governing the use of the word in the game. If the meaning of a word consisted simply in the list of contexts it is used in, then any two words employed in the same language games would automatically turn out synonymous, even if their uses were governed by different semantic rules in each game. Specifying the contexts in which a word is applied tells us something important about the word's meaning, but it falls short of its full account: it still does not amount to Wittgenstein's *Übersicht*. This is especially so since words that belong to the same semantic category have a tendency to occur in the same linguistic surroundings, even though their meanings may vary considerably.

In Word2vec, every word is assigned a *unique* vector which codifies all its collocations and thus represents its meaning. Consequently, if two words are such that there is a context in which one of them cannot be substituted with the other, their Word2vec vectors will, expectedly, be different. However, it may happen that some words do not have the same overall meaning but are synonymous within some specific contexts: one of them may not be used in all the language games in which the other is, but still in some language games they may be applied according to the same rules. To borrow an example from Firth ([2]: 179), in utterances like "You silly ass!" and "Don't be such an ass!" the word "ass" is used synonymously with the word "fool", although these words have thoroughly different meanings in some other contexts and cannot be interchanged therein, for instance, in the utterance "An ass has longer ears than a horse." Such cases of synonymy-relative-to-a-context cannot be accounted for in Word2vec, precisely because Word2vec does not operate with the notion of meaning in a particular context, but instead identifies the meaning of a word with a list of contexts (understood as collocations). With his concept of *Übersicht*, as a perspicuous presentation of (potentially divergent) meanings a word has in separate contexts, Wittgenstein, on the other hand, has a powerful enough tool to elucidate cases of local synonymy.

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[6] If the meaning of a word is explicated by means of a definition, such word cannot be a name, since names are semantically simple, but only an abbreviation for the definition in question.

Wittgenstein's extremely influential distinction between words which have sharp and clear necessary and sufficient conditions of application, on the one hand, and words for family resemblance concepts, on the other, is also inexpressible in Word2vec. An *Übersicht* of different uses a word is put to in various language games is supposed to transparently exhibit if there is a common thread which runs through all these uses or not; this, however, cannot be read off the Word2vec vectors. Vectors that correspond to words denoting family resemblance concepts, such as "game", are not in any apparent way distinct from vectors that correspond to sharply defined words: in both cases, the vectors only register the contexts of use and are silent on whether there is a shared core meaning in all these contexts. The inability to articulate this Wittgensteinian distinction in Word2vec is another consequence of the fact that Word2vec does not map contexts (in which a word is used) to meanings (the word has in each of them), but conflates them.

To conclude, although Word2vec and similar models are a significant step forward in natural language understanding, as it is clear from the discussion above, there are still a lot of components contained in the meaning of words in natural language that cannot be captured using this method. There is no doubt that, in recent years, neural networks have made an important improvement in natural language processing, including their use in machine translation. On the other hand, artificial intelligence still does not have the capacity to go deep inside the problems of meaning in general, especially as far as specific features of natural language, such as synonymy, are concerned.

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References

1. Baker GP, Hacker PMS (1980) Wittgenstein: understanding and meaning. Basil Blackwell, Oxford
2. Firth JR (1968) Selected papers 1952–1959. Longmans, Green and Co Ltd., London and Harlow
3. Firth JR (1969) Papers in linguistics 1934–1951. Oxford University Press, London
4. Frege G (1884/1953) The foundations of arithmetic. A logico-mathematical enquiry into the concept of number. Basil Blackwell, Oxford
5. Frege G (1892/1960) Concept and object. In: Translations from the philosophical writings of Gottlob Frege. Oxford, Basil Blackwell, pp 42–55
6. Harris ZS (1954) Distributional structure. Word 10(2–3):146–162. https://doi.org/10.1080/00437956.1954.11659520
7. Mikolov TS, Sutskever I, Chen K, Corrado G, Dean J (2013) Distributed representations of words and phrases and their compositionality. In: Advances in neural information processing systems, neural information processing systems foundation, Inc., pp 3111–3119
8. Ogden CK, Richards IA (1923) The Meaning of meaning: a study of the influence of language upon thought and of the science of symbolism. Harcourt, Brace and World Inc., New York
9. de Saussure F (1916/1959) Course in general linguistics. Philosophical Library, New York
10. Shanker SG (1987) Wittgenstein and the turning-point in the philosophy of mathematics. State University of New York Press, New York

11. Wittgenstein L (1922/1999) Tractatus logico-philosophicus. Dover Publications Inc., Mineola, New York
12. Wittgenstein L (1953/2001) Philosophical investigations. Blackwell Publishing, Oxford
13. Wittgenstein L (1958/1997) The blue and brown books: preliminary studies for the 'Philosophical investigations'. Blackwell, Oxford
14. Wittgenstein L (1964/1998) Philosophical remarks. Basil Blackwell, Oxford
15. Wittgenstein L, Waismann F (2003/2013) The voices of Wittgenstein: the Vienna Circle. Routledge, London and New York