Selected aspects of sentiment analysis in the context of human communication

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Abstract

In the modern world, AI language-based solutions are more and more present in everyday life. Language users deal with chatbots or intelligent assistants (e.g., Siri or Alexa) that provide a human-machine interaction. This interaction relates not only to the knowledge of language rules but also to the way language exchange works among its users. Furthermore, such interaction definitely suggests implied meaning and cognitive aspects of the human communication. Thus, the research question of this work proposes the thesis that in the process of natural language processing, the above-mentioned aspects must be taken into account. The present article attempts to address the issue of whether the interpretation of the sentiment analysis models the cognitive background of the language interaction (human communication). Additionally, this analysis provides qualitative data that support the integrity of the NLP processes.

Keywords

Wybrane aspekty analizy sentymentu w kontekście komunikacji międzyludzkiej

Abstrakt

We współczesnym świecie rozwiązania sztucznej inteligencji, które wykorzystują język naturalny, coraz częściej stosowane są w życiu codziennym. Użytkownicy języka mają do czynienia z czatbotami lub inteligentnymi asystentami (np. Siri czy Alexa), które zakładają w swoim funkcjonowaniu interakcję pomiędzy człowiekiem, a 'maszyną' (czyli rozwiązaniami z zastosowaniem zaawansowanego oprogramowania, które potencjalnie przejmuje rolę interlokutora). Wspomniana wyżej interakcja opiera się nie tylko na znajomości zasad gramatycznych i strukturalnych języka naturalnego, ale również zasad stosowania języka pomiędzy jego użytkownikami. Używanie języka, natomiast, sugeruje wykorzystanie znaczenia implikowanego oraz kognitywnych aspektów języka w procesie komunikacji. Pytanie badawcze niniejszej pracy dotyczy kwestii, jak bardzo w procesie przetwarzania języka naturalnego powyższe aspekty są reprezentowane i jaką rolę odgrywają w rozumieniu treści poszczególnych komunikatów przez odbiorcę i nadawcę. Według autorki artykułu analiza sentymentu w znacznym stopniu egzemplifikuje kognitywne podstawy językowej interakcji pomiędzy uczestnikami sytuacji komunikacyjnej, co dostarcza również danych jakościowych potwierdzających nierozłączność w/w procesów.

Słowa kluczowe

językoznawstwo kognitywne, znaczenie implikowane, analiza sentymentu, aksjologia, przetwarzanie języka naturalnego (NLP)

1. Introduction

The relationship between language and the world has long been the focus of the research of philosophers and linguists, and it is particularly exemplified by the language determinism view (Hickman 2000) that assumes that there is a straightforward relationship between language and the world that surrounds it.

This interdependence is of particular interest to cognitive linguistics, which explains, among other aspects, the function of language in naming categories by means of which language users function cognitively; these users apply cognitive categories which construe the world around them. Additionally, semantic intuition, developed in the course of acquiring and learning a language, helps users to solve problems with meaning ambiguity, finding reference or co-reference. Furthermore, the same intuition, as well as other cultural or social aspects, allow users to make judgements or express opinions that present selected axiological content.

The procedures that seem obvious to language users, as far as the use of language is concerned, pose a significant number of challenges to be met by AI solutions. To put it in other words, one of the greatest questions is connected with modelling (by means of formal expressions, numbers or algorithms) the way people think and transferring the obtained results to solutions used in natural language processing. Thus, in this article an attempt will be made to reveal if certain formal representations (or numbers) used in sentiment analysis accurately reflect a human way of thinking subjectively.

As follows, this article focuses on selected theories and aspects related to natural language (beginning with its definition and cognitive background, as well as the process of communication). Next, the discussion moves towards axiology and sentiment analysis as fields that provide and represent qualitative aspects of the language use. Thus, in the following part there is an attempt to answer the question of whether the sentiment analysis, despite being the procedure characteristic for natural language processing, is an element of implied meaning dependent on the process of cognition.

2. Language

When discussing the phenomenon of language, two key issues must be primarily taken into account, namely the definition of language that, for the majority of language users, is simplified

to the division of language into its form and meaning. The theoretical approach towards such division is introduced in the works and ideas of Ferdinand de Saussure (de Saussure 1974 [1916]: 65–70), which mark a threshold in treating this relationship between form and meaning. In his theory the core interest is in an arbitrary relationship between form and meaning (a signifier and a signified) that are part of a language convention established among its users, where the system of language is represented by langue and the way it is used (conventionally) is called parole. Although there are other possible means of expressing meaning, still among a given community language performance is based on conventionalised turns of phrase as is highlighted by Erman and Warren (2000) as well as Buerki (2020). Yet this structuralist strand of thinking suggests some amount of objectivity both in a language form as well as in the way language rules can be formulated. In consequence it also means that language representation is objective in nature and that it is possible to formulate language rules by means of objective symbols.

Such ideas are strongly advocated by Chomsky (1972) and his generative approach to language in which the focus is mostly on an objective language form that can be generated in the same way as mathematical equations. In Chomsky's (1972) opinion, meaning is of secondary importance and any ambiguity in meaning can be explained at the level of a deep structure. So, this generative approach sees language primarily as a collection of syntagms which in an effective way describe the language competence of a speaker that is based on language rules stored in the form of a mental grammar. As Chomsky (1972: 118) further points out:

> The normal use of language relies in an essential way [...] on the fact that language contains devices for generating sentences of arbitrary complexity. Repetition of sentences is a rarity; innovation, in accordance with the grammar of the language, is the rule in ordinary day-by-day performance.

Thus, in effect, this approach explains how language forms are created and used by language users as well as offers a tool which allows us to look on the method by which language is represented in a standardized way.

An opposite approach to this relationship between form and meaning is represented by cognitive studies. Since the 1970s, cognitive linguistics with its followers and opponents has gained a position in the broad spectrum of theories and approaches to language. Ronald Langacker, Leonard Talmy, George Lakoff, Mark Johnson, Mark Turner, to name only a few, are frequently enumerated as scholars whose works have given grounds for this approach and they contributed enormously to its development. In their works one can read that language (a language structure) should not be studied in a purely objective way, without any insight into semantic or contextual parameters that in the opinion of the authors mentioned above exert enormous influence on the selection of language forms used/preferred by language users. Generally, language in their understanding goes far beyond language form, and following Lakoff and Johnson (2003) language is highly metaphorical because our thinking about the everyday world is also metaphor-based.

The above presented theories mark two opposite views and are provided here only to suggest how complex nature of natural language is. Yet, discussing ideas connected with natural language and artificial intelligence always raises a difficult question of how to define natural language, the answer to which offers a multitude of explanations, each making different aspects prominent. Since the major focus of this work then is on these aspects/ definitions which are crucial for application in artificial intelligence solutions, only these approaches where language can be explained by means of formal/ objective symbols (that in consequence are easily readable by algorithms) seem justified.

2.1. Communication

An attempt to define language in the context of human communication is presented Gemel (2015: 41) who suggests one of the

major functions of language (by means of which language can
be defined) is to convey successfully meaning and the intentions
of the sender of a message, so that this message evokes appro-
priate reactions on the part of the receiver. Thus, language is
understood as a tool that must be used/mastered by its users
who, by applying it, fulfill communicative intentions. Further,
Gemel (2015) suggests that the following simplified signalling
games model can be used to present this signalling convention,
which at the same time ensures an intended reaction (of course
remembering that each signal per se represents the amount of
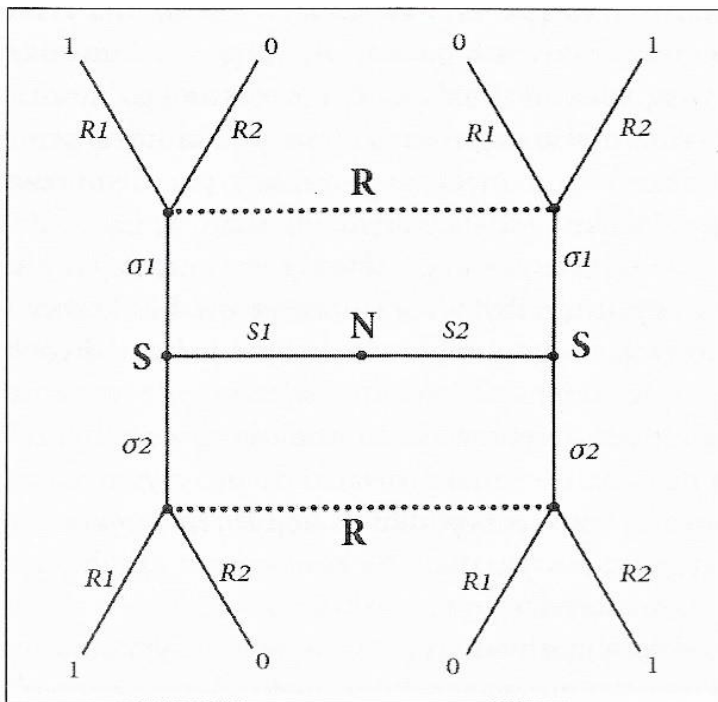information rather than information itself):

Figure 1
Adapted from Gemel (2015)

Following Gemel (2015: 41) the model presents two states (S),
two signals (σ) and two reactions (R) in the form of a decision
tree where each player is identified as:

N – nature
S – sender
R – receiver

Each branch of this tree exemplifies mutually excluding alternative events where:

S_1 and S_2 represent existing states of nature S_1 or S_2
σ_1 and σ_2 represent sending a verbal signal σ_1 or σ_2
R_1 and R_2 represent undertaking action R_1 or R_2

Thus, as Gemel (2015: 40) points out, a given (efficient) signalling convention is then based on the correlation of a reaction with an existing state on the basis of a verbal signal, which has its consequence in a positive pay-out received by both players. This pay-out can be obviously related to a given context. In the model above, one can see that only two strategies out of four give a positive reward (1) and two of them fail (0). As follows from the above explanation, language can be defined by means of a signalling convention that is explained with the application of objective symbols; the convention and symbols can be further used by algorithms in AI solutions.

Of course, the above model does not concentrate on information content that is sent by a particular signal. This issue is explained by Gemel (2015: 51) who claims that:

> Signal information content can be analysed as a collection of elements constituting a mental space (points, regions formed out of points, dimensions and cross-domains dependencies). Elements positively correlated with a given signal carry information about it with a growing probability of the representation of this element in the mental space of an agent, after receiving this correlated signal. (translated by the present author).

So Gemel (2015: 52) proposes a formal representation of information content in the signalling games model (also mentioned in Skyrms 2010) that is supplemented by mental spaces and

has its representation in the form of a vector which has to take the form of a logarithm in order to make it possible to explicate situations in which a given signal does not carry any information at all:

$$\left\langle log\,\frac{P(\mathbb{E}_1|\sigma_1)}{P(\mathbb{E}_1)}\,,\,log\,\frac{P(\mathbb{E}_2|\sigma_2)}{P(\mathbb{E}_2)}\,,\,log\,\frac{P(\mathbb{E}_3|\sigma_3)}{P(\mathbb{E}_3)}\,,\,...\,,\,log\,\frac{P(\mathbb{E}_n|\sigma_n)}{P(\mathbb{E}_n)}\right\rangle$$

Adapted from Gemel (2015: 52)

Each informative (or communicative) act carries a given amount of information ($\mathbb{E}_{(1...n)}$; represents a constitutive element of the mental space (points, regions and dimensions); and can be schematically represented as:

$$log\,\frac{P(\mathbb{E}_n|\sigma_n)}{P(\mathbb{E}_n)}$$

So it represents the relation of the conditional (|) probability (*P*) of a given state after sending a given signal that carries a given amount of information:

$$P(\mathbb{E}_n|\sigma_n)$$

with the unconditional probability (*P*) of this state

$$P(\mathbb{E}_n)$$

As follows from the above representation, language users perform a sequence of acts in their process of communication, and owing to their skills at processing and interpreting verbal signals, they are able to distinguish which information is relevant to them and which should be excluded.

Naturally, these skills primarily concern the ability to send and receive these signals as well as the knowledge of language.

This knowledge frequently is simplified to the knowledge of words and how to use them; yet, this knowledge of words means that users can effectively link a given language form with its meaning. Thus, language is recognized by many as a phenomenon which differentiates human beings from other beings in the world. One of the reasons for this is its complexity and especially its functions that go far beyond mere communication.

3. Axiology and sentiment analysis

It should be emphasized that, as Leibnitz claims, language is "the best mirror of the human mind" (cited in Alba-Juez and Thompson 2014: 3). Thus, analysing the intricacies of language and interpreting meaning that accompanies the language form can be helpful in comprehending human reasoning. The implied part of meaning that expresses emotional and, more particularly, subjective messages is linked to the issue of axiology in language.

According to Krzeszowski (1997: 15), there is a straightforward link between categorization and evaluation in language since they both "directly manifest themselves in language". As Puzynina (cited in Krzeszowski 1997: 15) emphasizes, "the domain of valuative words and their meaning" and "the ways in which valuations are expressed in a language and in the structure of texts" provide grounds for linguistics and axiology to meet.

However, Krzeszowski (1997) advocates the 'positive-negative' distinction as the most significant for semantic analysis, at the same time refuting the 'true-false' distinction typical of truth-conditional logic used in the transformational-generative grammar. So, this positive-negative scale because of its generality and universality seems useful for describing and analysing semantic aspects in such a way where:

a) following Osgood, Suci and Tannenbaum (quoted in Krzeszo-
   wski 1997), the largest part of general variance (33 %) in lan-
   guage is connected with the evaluation on the 'good-bad'
   scale
b) the categorization based on distinguishing good from bad is
   learnt and implemented by children in their early years of life
   and it precedes their language development and language
   comprehension (prior to evaluative concepts such as 'ugly' or
   'beautiful') since it is relevant for individual words as well as
   their combinations

Afterwards, it has influence on the domain of values which ac-
cording to Krzeszowski (1997) is two-dimensional, where the
vertical orientation reflects the hierarchy of values. The highest
ones are the best ones, whereas the lowest ones represent the
least desirable values. It corresponds to the model of the Great
Chain of Being which explains that "the world as experienced
by human beings consists of things arranged in a certain hier-
archical order" (Krzeszowski 1997: 64). This model groups
things into five categories that are organized in consecutive lev-
els of the hierarchy and they are: God, humans, animals, plants
and inorganic things, with God taking the highest position in
this hierarchy.

   This vertical organization is accompanied by the left-right
horizontal one (Krzeszowski 1997) which depicts the scale of
values in the form of a continuum at each level between two
extreme poles: a negative one (situated to the left) and a positive
one (situated to the right). Thus, as follows when analysing
a concept, one looks for its category in the vertical dimension
and its corresponding values in the horizontal dimension. How-
ever, the major concern of this work relates to this horizontal
analysis rather than the vertical one since it represents the ax-
iological charge of a concept.

3.1. Axiological charge

A simplified definition of the axiological charge explains it as point of reference on a positive-negative scale. According to Krzeszowski (1997), lexical items can be assigned to this scale in accordance with the following procedures:

1. eliciting absolute values of given lexical units
2. eliciting values of given lexical units as contrasted with other lexical units
3. eliciting concrete values of lexical units in given contexts

The above procedures for absolute values are accompanied by methods for eliciting the axiological charge of lexical units which, as Krzeszowski (1997) provides, are:

a. direct rating
b. sentence formation

As far as direct rating is concerned, it is commonly used in social sciences where respondents of questionnaires evaluate an idea by choosing one of a number of suggested options. The organization of the options follows the pattern of two polar terms with a number of options between. With larger scales (where the choice is between more than five options), it is a common practice to use various quantifiers to define precisely the level of intensity, among which the most common are 'extremely', 'very', 'slightly'.

Another method to elicit the absolute charge is directed towards sentence formation. In general, particular lexical units must be used in sentences formed by participants of the survey. These sentences are to reveal, then, their attitudes and opinions in connection with particular issues. So, participants may condemn or applaud the concept the term describes by explicitly expressing their subjective like or dislike or by placing the concept on a scale by identifying it as a positive one or a negative one. The answers to such surveys are analysed and presented

as a ratio of positive or negative sentences that make use of a given concept.

If we take into account eliciting values of certain lexical items in comparison to other lexical items, the intensity of a given property becomes evident. The surveys, as Krzeszowski (1997) describes them, are based on organising terms by participants from the most intensive ones (e.g., the most beautiful) to the least intensive ones (e.g., the least beautiful). Each position at which items are placed is given a number of points, so the final ranking presents a number of points ascribed to particular items.

When values of lexical units are elicited in specific contexts, positive and negative values are ascribed to contexts in which lexical units appear and in this way it is possible to estimate the axiological charge. The case study examples described in Krzeszowski (1997) come from SJP (Słownik języka polskiego – the Dictionary of Polish), as in his opinion monolingual dictionaries are the most valuable source of contexts. The more positive contexts are identified, the more positive a lexical unit is. However, because of its subjectivity, this method in Krzeszowski's (1997) opinion should be applied only as a supplementary strategy for finding evidence connected with a particular word and should be compared with more objective/ independent assessments.

A solution to this situation, where a monolingual dictionary is used, is offered by a balanced corpus data which provide contexts for particular words. But this method is not without flaws, since one of its disadvantages may be too much data to evaluate and annotate manually for positive or negative contexts. It is possible to have access to corpora that are annotated for sentiment but they are extremely rare and are mostly oriented towards a given category (e.g. *An Annotated Corpus for Sentiment Analysis in Political News* or *Awais Athar – Citation Sentiment Corpus),* bearing in mind that sentiment is usually marked there by assigning polarity scores to sentences or longer pieces of a text and not individual words.

3.2. Sentiment analysis

Axiological charge present in a text that is automatically evaluated is the major concern of sentiment analysis (Taboada 2016). This analysis, according to Esuli and Sebastiani (quoted in Taboada 2016) follows three main steps, namely deciding on the subjectivity of a text (if it contains subjective information that can be evaluated), then establishing the polarity of a text, and as the final step estimating what the strength of that polarity is. As Taboda (2016) points out, a lexicon-based model and a machine-learning model represent two major methods in sentiment analysis, with the lexicon-based one being the primary focus of the present work. What must be also highlighted is that from the standpoint of IT studies, this lexicon-based method seems outdated and nowadays sentiment analysis (similarly to other processes) are realized by means of machine-learning methods. Yet, in the opinion of the present author this is the lexicon-based method that in the context of human communication reveals selected cognitive aspects of language to a large extent.

3.2.1. Lexicon-based method

This approach (also called a dictionary-based method or a rule-based method) basically applies lists of evaluative words in order to identify individual lexical units in a text as positive or negative and further use this information to decide about the axiological orientation of the whole text. By the application of these lists (also called dictionaries) of evaluative words, it is possible to establish the position of a word on a plus-minus scale (i.e. if a word expresses a positive axiological charge or a negative one). Such dictionaries, as Taboda (2016) writes, may use different models whose range may start from 5,000 words (e.g. Semantic Orientation Calculator (SO-CAL) that uses a 10-point scale, from -5 to +5) to almost 76,000 words: the Macquarie Semantic Orientation Lexicon as Mohammad et al. (2009) describe. Yet, Taboada et al. (2011) highlight that the larger the dictionary, the more semantic noise it includes, thus the less

accurate the results may be. Additionally, as Taboada (2016: 13–14) remarks, one has to take into consideration in a rule-based method the role of intensifiers, i.e. "devices that change the intensity of an individual word, whether by bringing it up or down". In order to facilitate the calculation of values affected by them, Taboada et al. (2011: 275) present the following solution:

+100 %
  – really +25 %
  – very +15 %
  – somewhat -30 %
  – arguably -20 %

This scale illustrates that calculating sentiment is not only limited to content words, but as it turns out the intensity of sentiment can be modified or even changed by various modifiers and must be taken into consideration when the total value is calculated. For example, if the opinion word 'bad' has a value -5 and is modified by a word 'really' then:

$$-5x0{,}25 + (-5) = -6{,}25$$

Yet, if we change the modifier to 'arguably' then:

$$-5x(-0{,}2) + (-5) = -4$$

The above results show that modifiers play a significant role in presenting sentiment values and what follows in presenting one's opinions. Another matter concerns the fact that there is a need for the most advanced lexicon-based models to include dictionaries in which there are various modifiers with assigned values listed.

Obviously, a question arises concerning the issue of negation and the ways of analysing it while processing a text. Taboada (2016:18) explains the approach in which "the effect of a negator is to shift the negated term in the scale by a certain amount, but without making it the polar opposite of the original term".

In Asghar et al. (2017) the method of reversing the value of a negated opinion word by multiplying it by -1 is advocated, arguing that the role of negation is to tone down an evaluative phrase rather than to reverse it.

3.2.2. Applications of the sentiment analysis

Although the practical applications of sentiment analysis are many, the focus here is drawn to only a major selected aspect. As follows, it is connected with the first and probably the most obvious use that comes to mind, namely the sentiment analysis software (some call them engines) that provides a researcher with information concerning the polarity of the analysed texts of different kinds coming from different sources. Thus, this software is frequently used to analyse reviews or opinions connected with particular products and, as Taboada (2016) points out, the results of this analysis are reflected in marketing or political campaigns.

4.   Discussion

A natural question that comes to mind concerns the relation between the above mentioned theories and their role for the present work. It must be highlighted again that the aim of this discussion is to reveal linguistic intricacies of sentiment analysis rather than IT procedures that are more applicable nowadays for the same sake, e.g Machine Learning. That is why, at first, the sketch of definitions of language are given in order to provide insight into the nature of language, on the one hand, and the possibility of approaches to language and its functions, on the other hand.

Moreover, these definitions are followed by an attempt to explain the nature of the process of human communication. For the sake of this discussion, only one representation is given, namely the one provided by Gemel (2015). This choice is justified by the fact that Gemel (2015) explains human communication by means of objective symbols and procedures, although

the process of human communication is to a significant extent subjective and context-dependent. Thus, as a matter of fact Gemel (2015) manages to cope with human communication performed by means of human language but defined with the application of formal representations; yet, these representations include cognitive aspects as well (mental spaces can serve as examples here), which contributes to the thesis of this work assuming that sentiment analysis or generally opinion (being highly subjective) can also have its formal representation.

As follows, the above discussion introduces the issue connected with using a natural language that obviously requires the knowledge of the language form and meanings that this form evokes. This knowledge is, then, practically applied in the process of communication, with the assumption that knowing language includes meanings that can be implied or expressed in an indirect way. Thus, AI solutions which are natural-language-oriented have to meet the challenge of dealing with both kinds of meanings mentioned previously as well as cooperating efficiently and successfully in the process of communication by means of sending, receiving and processing communication signals. Without any doubt, such solutions demand also applying/understanding cognitive bases of how a natural language functions among its users.

Ultimately, the research question centres on the issue of to what extent cognitive aspects of language use (communicative situations) can be formally represented, or in other words, whether such solutions can really imitate a human way of thinking. One of the options that replies to this question is strongly connected with sentiment analysis inasmuch as it reveals in what way axiological charge (emotions) is expressed by means of language constructions. What follows, as far as sentiment analysis is concerned, is that it makes use of cognitive aspects, since sentiment analysis actually focuses on implied meaning and communicative intentions more than only on conveying denotational meaning.

Consequently, sentiment analysis serves to process opinions which by definition are subjective in nature, and subjectivity

apart from the experiential attitude is one of the aspects of the cognitive approach (Lakoff and Johnson 2003). For AI solutions, then, it means that by applying certain mathematical formula they can effectively imitate human thinking and function cognitively well in understanding and processing meaning. Thus, in the sentence:

I find C.S..Lewis' books more than excellent.

the sentiment analysis will point to a positive charge that is implied by the combination of:

an intensifier: more than
and a content word: excellent,

which, when interpreted in a regular conversation, would mean a highly positive opinion about a given author. An additional task for the software is to respond to this comment in such a way that the flow of the dialogue is not interrupted in any way (one of the prototypes for this kind of interaction between a machine and a human being is ELIZA, in which Weizenbaum (1966) used the principle of looking for some key content words and in the flow of the conversation the computer programme responded to these words in such a way as to imitate a human-human verbal interaction). Thus, a successful human-machine interaction involves not only focusing on the language level but also on reading and analysing implied meanings.

Another challenging case for AI solutions involves situations where emotional charge is expressed by means of such strategies as, for example, irony or metaphor, where the focus is on meaning represented by a language form and cognitive categories that are activated when they are used; however, even more challenging are cases where implied meaning is coded by means of prosodic features, such as when ironic meaning depends on pitch or intentional articulation strategies that are meant to mock others. Thus, the example quoted above, if pronounced in a mocking way, may carry an implied meaning connected with

emotions (to be more precise, with attitudes) which has a completely different axiological charge (a negative one) in comparison to the one expressed in the written form. Yet, although the idea of context does not fit within the scope of this work, it must be mentioned that the interpretation of given language structures may vary depending on this context and that context itself partially represents cognitive bases of language.

5.   Conclusions

As discussed above, language-based modern technologies face a number of obstacles that must be surmounted for these technologies to function effectively. Taking the research question of this work into consideration, one of these issues relates to the way in which cognitive aspects that accompany human language use are voiced in natural-language based software. In order to prove the thesis, the example of sentiment analysis is given which illustrates that AI solutions depict selected cognitive intricacies related to language use. Language modelling through sentiment analysis effectively reflects cognitive aspects of real-world modelling.

   Furthermore, following the model of communication presented by Gemel (2015), it is expected that the algorithm will be able to distinguish which tracks in the communicative situation should be taken into account when processing language and which ones should be excluded. Such expectations are justified by practical reasons, namely that natural-language-oriented software, apart from facilitating/enhancing language production and language comprehension has to respond within the shortest time possible. Consequently, the human-machine interaction should be reliable as far as language form is concerned but in addition the pace of this interaction must resemble the human one as much as is achievable.

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