PalArch's Journal of Archaeology of Egypt / Egyptology

SEMANTIC AMBIGUITY OF ENGLISH-LANGUAGE CHATBOTS

Nataliia Lazebna, Ph.D, Associate Professor
Anatoliy Prykhodko, Dr.Letters, Professor
Theory and Practice of Translation Dpt.
Zaporizhzhia Polytechnic National University
Zaporizhzhia, Ukraine

Nataliia Lazebna, Ph.D, Associate ,Anatoliy Prykhodko, Dr.Letters, Semantic Ambiguity Of English-Language Chatbots, Palarch's Journal Of Archaeology Of Egypt/Egyptology 17(9). ISSN 1567-214x, Keywords: English-language chatbots, English-language digital discourse, the theory of speech acts, genitive grammar, knowledge base models, semantic ambiguity.

Abstract
Communication in digital English-language discourse occurs in the context of programming languages and English-language mediated background. Based on Chomsky's genitive grammar and its basic principles, the theory of communicative acts, and the development of potential knowledge models this study represents an option for further facilitation of human-machine communication. To deal with semantic ambiguity, it is relevant to apply traditional linguistic methods. Despite the mathematical and linguistics basis of the English-language human-machine communication, there is an opportunity to solve this problem by looking through linguistic lenses.

Introduction

Global modes of human life trigger novice social and cultural processes, which involve not only technological factors but also are mediated by linguistic ones. A human being is not only the author and initiator of human-machine interaction but also is the recipient in the process of this communication. It is relevant to speak about the twofold model of communication in the modern computer-mediated global world.

Being the international language, the English language is dominant, which fosters and changes communication processes. A machine is not only a goal for programming, it is a mediating link between a human and a machine. Thus, the following graph represents this type of communication and a mediator is a chatbot, an English-language bot, which facilitates human communication in the modern world of technology and progress.

Problem statement

The **goal** of the study is to focus on chatbots as mediators, which facilitate the process of human-machine communication and solve the problem of misunderstanding, which occurs therein. At this point, we will refer to the problem of semantic ambiguity of messages sent by Client 1 to the machine and the inappropriate result of this message, when Client 2 receives it. At this point, an agent, who codes a message is a Programmer.

1st stage: HUMAN BEING (Sender or Client 1) – MACHINE – NATURAL LANGUAGE – HUMAN BEING (Recipient or Client2)

This is a general framework of communication between a human being and a machine. In terms of this framework, each party is responsible for its functions, but the final result of their communication is a reachable pragmatic setting.

2nd stage: HUMAN BEING1 (Sender or Client 1) – HUMAN BEING 2 (Programmer) – MACHINE – NATURAL LANGUAGE – HUMAN BEING 3 (Recipient or Client2)

The second stage of communication is more complicated as it involves at least three humans, but the machine remains the same, a mediator in this communication process. In other words, the machine mediates the communication process, which involves both interlocutors and, first, encodes a message of Client 1 and through Programmer further decodes it for Client 2.
From this perspective, one of the perfect ways out is to reduce symbols introduced to chatbots, shorten the number of questions and implement certain, and, even specific speech templates, which will trigger more effective communication between a chatbot and machine.

Literature review

Referring to NLP (Natural language processing), this scientific perspective can be applied at various stages of human activity, and the generation of appropriate answers to a machine/requests of humans are of crucial concern in the international scientific community. Specialists from different fields are involved in this process. Next to programmers, it is appropriate to refer to linguists, who can facilitate communication between a human being and a machine. For example, systems for generating phrases and texts can create a text version of the weather forecast by extracting information from weather maps, or they can also interpret complex medical information in a form comprehensible for the patient. Dialogues in dialogue systems are also developed with the use of such systems.

From the perspective of functionality, such systems can act both as an author and assistant. If the system becomes an author of the information, then the role of a human being is a secondary one. On the contrary, if the human being acts as an author, then he uses a system, and its functionality is in the foreground. Systems as assistants help humans to write official reports or rhymes for writing poetry. The main difficulty independently from the functionality of the system, is its complexity, integration of several blocks. The content block and planning block are interacting and, if the former depends on the system, the latter is dependent on a human being. Sentences organization, modification of requests, readability of the text, and other related issues are referring to a human being and his role in this process. To sound natural is one of the main goals, which should be reached by humans in their mediation of communication with a machine. For example, a combination of sentences or their split in some parts should be correlated with the laws of natural language. Syntactic roles of speech parts in the sentences, vocabulary used, and maps forming in correlation with concepts, – all these and many other linguistic issues are often omitted in the process of machine functioning (Austin, 1975).

When the machine generates a text, it relies on the sentences, words, and prototypes used therein. The use of synonyms, speech patterns transformation, word replacement, and other lexical matters should be correlated with the principles of natural language. At the stage of implementation, the text should be modified according to the rules of syntax, morphology, and spelling. On a higher level, if correlated with the theory of speech acts, the performance of human being and machine interaction should be correlated with the goals of the participants. The goal of expressions, the main intention of communication, and reached result dates back to findings of J. Austin (1955). Intensifiers in the process of communication are dominant keys, which outline the mode of communication (Hickey, 2014). This idea goes far beyond words/sentences/ texts or any other verbalized and evident results. It has a deeper concern, when in the process of communication one message reaches another recipient, he should react/act accordingly.

LOCUTIONARY ACT= SPEECH ACT
ILLOCUTIONARY ACT=COMMUNICATION GOAL
PERLOCUTIONARY ACT=COMMUNICATION EFFECT

If to project these acts on human-machine interaction, if to refer to voice assistants on Androids, this simple example will show that only Locutionary act is certainly effective. Both, illocutionary and perlocutionary acts depend on the correct coding of the sent message.

Researchers in this field have often discussed this problem and offered numerous solutions, but none is perfect due to a lack of linguistic knowledge, which is often neglected in resolving this problem. “The first solution uses an ontology, which is exploited in a twofold manner: to construct dynamic answers as a result of an inference process about the domain, and to automatically populate, off-line, the chatbot KB with sentences that can be derived from the ontology, describing properties and relations between concepts involved in the dialogue. The second one is to preprocess user sentences and to reduce them to a simpler structure that can be referred to existing elements of the chatbot KB” (Augello et al, 2012).

Results and Discussion

In other words, the communication between a human being and machine in terms of speech acts will be ineffective, but the machine is the only mediator of this type of communication. The following three-parties’ interaction will be violated at its intermediate stage if its mediator misunderstands the locutionary act. From this perspective, human-machine interaction does not coincide with traditional human-human communication. In terms of this theory, communication is effective, when the sender reaches his goal and the recipient acts accordingly and satisfies the needs of the sender. The same statement can hardly be true for human-machine communication because it depends on the machine if human-machine interaction is effective.

Moreover, a machine cannot evaluate the power of the message obtained (illocutionary act). It is responsible and open for any message sent: “Where is the closest supermarket” and “How to make a bomb?”, - both these voiced questions will be processed based on codes received by the machine.
At the same time, by changing voice commands, making some phonetic mistakes, or typos in Google search, the machine either modify or cannot process the sent command/request. Therefore, the ambiguous and coded nature of the machine depends on the dynamic and changing nature of a human being. To dig deeper, one can find a programmer, who, actually codes, or chooses semantic strings to code one or another command sent by a human to a machine, and, at the same time, a machine makes a choice depending on a command sent by a programmer. Before these two actors, there is a user on the stage, so to say, who asks/types what he wants and, as if, he communicates with the machine only. He does not see the programmer beyond this communication act.
That is why an attempt to modify and improve the communication act between a human being and machine is impossible by focusing on prerequisites only.
Human-machine interaction should be unfolded again and transformed into

CLIENT-PROGRAMMER-MACHINE-HUMAN RELATIONSHIP.
OR
HUMAN 1-HUMAN2-MACHINE-HUMAN 1

On the one hand, it is a mode of Self-self communication with the help of the machine, but at this point, the 2nd agent, human 2, a programmer occurs. Distortion of communication between human-machine can be caused by the involvement of this 2nd agent.

Formal models of generative linguistics can also be successful in their further application to human-machine interaction. Noam Chomsky in the 50-the 60s of the 20th century has granted the world with his idea and prophesized its further effective implementation in the modern human-machine interaction. In terms of generative grammar, three basic constituent parts: syntax, semantics, and phonology are dominants, which predetermine the interpretation of human-machine interaction. Nevertheless, the structures of the sentences vary and even deep structure can reflect the challenging meaning of the sentence. The syntax focuses more on basic elements, and transformation elements, accordingly. The basic element is called a system of elementary rules. The English-language chatbots are programmed according to these rules. Referring to the following rule: $S \Rightarrow NP + VP$, each sentence consists of the subject group NP (noun phrase) and the predicate group VP (verb group). It is possible to reflect this scheme and project it on the process of sentence processing for chatbots.

```
Class ChatBot:
  denial = ("not my concern", "no", "sure, no", "nah", "not an option", "deny")
  exit_commands = ("quit", "exit", "bye bye", "bye", "delay", "stop")#Method to initiate the conversation
  def start_chat(self):
    user_response = input("Hello/Hi, I'm a chatbot developed for random dialogues. Any option to
speak?\n")

    if user_response in self.negative_responses:
      print("Ok, have a nice day!")
      return
    self. chat(user_response)#Process of answer handling
  def chat(self, reply):
    while not self.make_exit(reply):
      answer= input(self.generate_response(reply)+"\n")

  #Method to convert user input into a matrix
  def string_to_matrix(self, user_input):
    tokens = re.findall(r"[\w']+|[^\s\w]", user_input)
    user_input_matrix = np.zeros(
      (1, max_encoder_seq_length, num_encoder_tokens),
      dtype='float32')
    for timestep, token in enumerate(tokens):
      if token in input_features_dict:
        user_input_matrix[0, timestep, input_features_dict[token]] = 1.
    return user_input_matrix

  #Method that develops a response using seq2seq model we create_response(self, user_input):
    input_matrix = self.string_to_matrix(user_input)
    chatbot_answer = decode_answer(input_matrix)
    #Remove <START> and <END> tokens from chatbot_answer
    chatbot_answer = chatbot_response.replace("<START>",")
    chatbot_answer= chatbot_response.replace("<END>",")
    return chatbot_response#Method to controle output commands
  def make_exit(self, reply):
    for exit_command in self.exit_commands:
```

```
    if exit_command in reply:
      print("Ok, have a great day!")
      return True
  return False

chatbot = ChatBot()
```

This developed model (Generative chatbots using seq2seq model) represents a variant of English-language text embedded in digital discourse. In other words, this text can be modified, verbal codes can be represented continuously. Frame representation of this type of text signifies their dynamic nature. Similar to natural language, encoded or digitalized texts dominate over symbolic or semiotic constraints.

The split of the sentence “The man took the book” into the Chomsky tree. A transformation element is a set of rules that are applied to the base and generate surface structures.

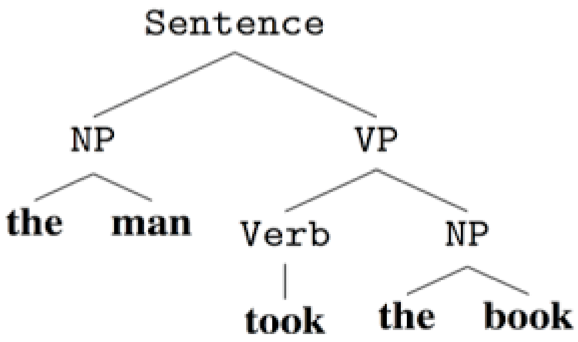
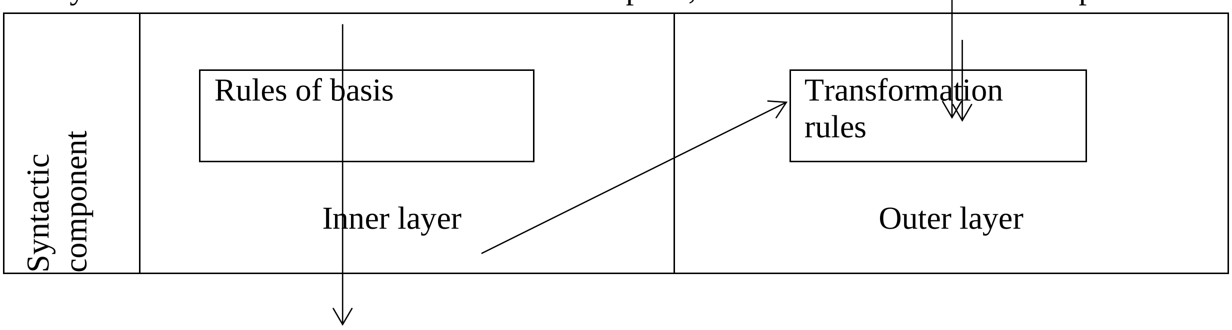


Figure 1. Sentence split according to Chomsky’s tree

Text generation systems, on the one hand, depend on natural language universal laws, but, on the other hand, they are correlated with formal relations between the system components. Despite more or less clear structure of the message, which has to be interpreted, a semantic charge of this message may vary and be ambiguous for the machine. Digits are beyond culture. Nevertheless, there is an option to refer back to speech acts and build an English-language phrase and correlate it with the speech act, focusing on the illocutionary goal and the intensity of the communication charge.

First, it is possible to talk about Chomsky’s grammar and generate certain models of speech acts for English-language chatbots. Correlation and application of these perspectives underline the possibility of traditional linguistic methods to the analysis of human-machine communication. There is a strong need for templates representing sentences, which can be created and sent to English-language chatbots. Beyond this template, such characteristics as parts of speech and their functionality in a sentence, their characteristics, and other aspects can be neglected by the machine, which receives nothing but digits and symbols. It is better to look for a certain template, which will be universal and specific.



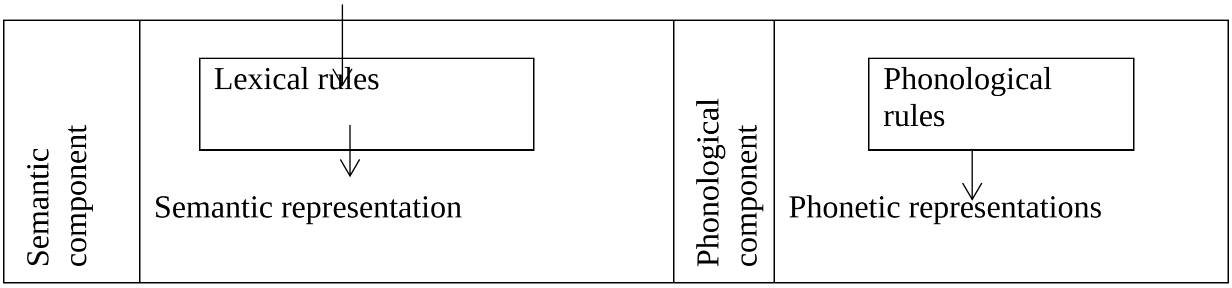


Fig. 2. Segmentation of English-language message sent to chatbot

Focusing on semantics it may seem that semantic ambiguity can be avoided only in human-human interaction. If a machine interferes in this process of communication and violates it, then it should be solved in another way. Moreover, according to the abovementioned scheme, there are often more than 2 senders and recipients in human-machine interaction. Thus, this process becomes even more challenging and complicated.

Another option is to determine the propositional content of the phrase. At this stage, we are specifying the action that will be mentioned in the phrase. Namely, we complement the future phrase with action verbs. Anyway, the main emphasis is on the illocutionary act, the one, which is easily transferred from human to machine.

If to refer to Alice's language models, the whole corpus of language is split into certain templates and categories. If to consider this ineffective communication between a human and machine, one can refer to ineffective communication between individuals, who speak different languages. Still, they have more privileges as they can transfer their ideas non-verbally.

Restructuring of requests sent to the machine, one can interpret referring to subdivision of questions "definition, measure, list, comparison, factual and reasoning" (Augello et al). There are two main directions for further discussion from this perspective, first, if to follow and convert Semantic Web content to AIML format, and the second direction is to detect the main sent message/information, or, concentrate on the input, and then develop a potential answer "by querying an OWL ontology with Protege API" (Augello et al).

These approaches offered by researchers in the field of programming and Informatics need an essential linguistic modification. Linear thinking of programmers, which will be looking for synonyms only in broader terms and wider contexts, it is necessary to broaden contexts and saturate the basis for answers choice focusing on versatile background freely available on the web.

Still, this research focuses on the first stage of semantic ambiguity problem solution. We consider this in the development of certain knowledge representation models or semantic models.

There are two types of knowledge representation:

1) Formal models;
2) Informal (semantic, relational) models.

Knowledge representation models in communication human-machine can be developed according to these logical underpinnings (Classifying Knowledge Representation, 2020).

Let us consider the English-language communication model as a system of rules for the interpretation of human knowledge. Unlike formal models, which are based on a rigorous mathematical theory, informal models adhere to other laws. Each informal model is suitable only for a specific subject area and therefore is not a universal one. The same is appropriate for semantic models of English-language chatbots. In terms of formal models, which can refer to the mathematical or formal representation of English-language content of chatbots, this model helps to reach a logical conclusion of communication. Semantic ambiguity roots deeply primarily in chatbots' users and programmers.

1) Logical models. Models of this type are based on a formal system defined by a quadruple: LM = <A,B,C,D>. Basic symbols, digits and signs are included. This frame predetermines functional frame for English-language chatbots and also predetermines human-machine communication. This frame includes also syntax rules. Though, within these models, semantic ambiguity occurs. First, limited vocabulary, predetermined communication situation, and context are pitfalls on the way to successful communication between a human and machine. There should be a certain correlation within the logical model context. Interference of semantic nucleus, syntactic functions, and logic of communication situation can be found within this model. In other words, all information units are introduced into this logical model in the form of background knowledge. In other words, a formal system is a generator of new knowledge, which forms a set of inferred knowledge in a given system. These set templates for English-language chatbots are mainly used by the developers.

2) Network models specify the variability of semantics embedded in chatbots. Human-machine message <S1, S2, ..., Cn>. The main information units embedded within this model are more related to the semantic nucleus of the message.

Depending on the types of links used in the model, it is possible to outline functional networks and their scenarios. Within this model, it is possible to outline different hierarchical relationships between information units in knowledge bases represented in human-chatbot communication. Certain causal and relations can be analyzed within these models.

3) Generating models combine some elements of logical and network models. Both, the inference of rules from logical models and semantic variability of network models donates a dynamic variability of knowledge represented. From this perspective, a semantic network is transformed by changing its fragments, building up the network, and removing redundant fragments. Thus, in generating models, chatbots can operate dynamically, modifying their semantic content despite syntactic frames and limits.

4)

4)Frame models. Unlike models of other types, frame models fix a rigid structure of information units. This model has a zest of universality enabling information embedding. For example,

(Frame name:
Slot 1 Name (Slot 1 Value)
Slot 2 Name (Slot 2 Value)
... ...
K slot name (K slot value).

The slot value can integrate any elements (digits, symbols, signs, words, texts, etc). Therefore, it is relevant to correlate linguistic models of chatbots with one of the abovementioned models. Formal models of knowledge representation refer to logical knowledge representation. For a human being, it is relevant to identify a certain predetermined logical conclusion of a message sent to the chatbot. This logical model can be interpreted and correlated both with the laws of natural language and mathematical language. At this point, logical unity and combination of symbols (either letters or digits) plays a dominant role and represents in symbolic form the entire set of basic concepts, and further this unity will be ordered with the help of certain syntactic rules. Moreover, the logical model can also be correlated with Boolean expressions, when values 1-0 or True-False statements are keys to facilitate human-machine communication. These expressions may generate new expressions. If the listed parameters are met, then the system is said to satisfy the requirements of the formal theory. According to Hinchey et al, a formal theory must satisfy the following definition: any formal theory F = (A, S, S2, R), which defines some axiomatic system, is characterized by the presence of the alphabet (dictionary), A, many syntax rules, S, the set of axioms underlying the theory, S2 (suggestions), set of inference rules, R.

The abovementioned theory outlines further development of linguistic models, which can be effectively embedded in human-machine interaction. If to consider some drawbacks of this formal approach, one can refer to its closed cyclic nature. Frames are set and constant, but semantic content is dynamic and reaching far beyond such frames. Thus, a possible way out is to look for a modification of these structural rigid boundaries of the frame. This model, a formal or logical one, can be effective in the surrounding, which is set and constant [Hinchey et al, 2005].

"Hypothetically, the strongest limitation of Alice derives mainly from the pattern matching algorithm used by its engine for the dialogue management, and the rigidity of its knowledge base, based on the definition of specific, unmodifiable rules, organized as question-answer pairs" [Krantz et al, 2017].

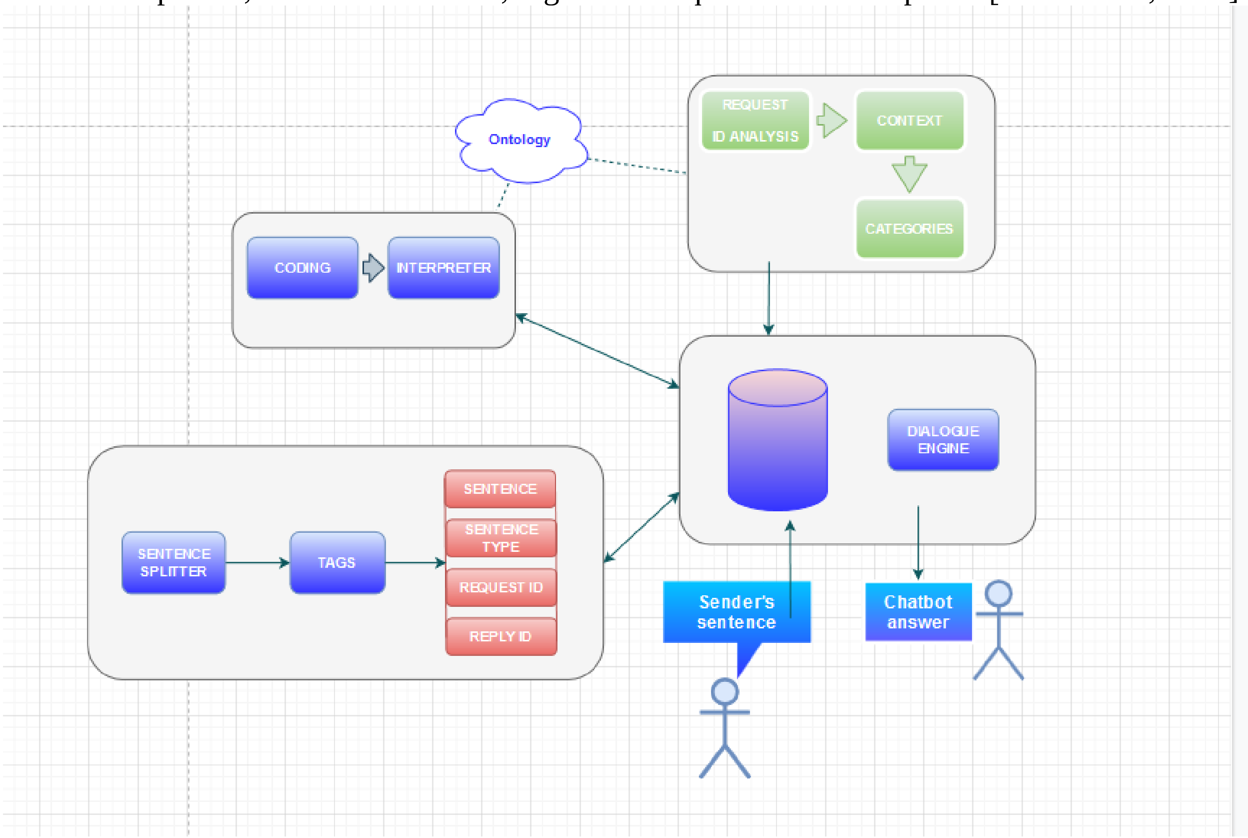


Figure 3. The functionality of the dialogue engine

The abovementioned scheme represents the functionality of the dialogue engine and its possible modification. Initially, to deal with the semantic ambiguity of Alice's chatbot, one has to refer to a more refined definition of question/answer pairs. Inserting special symbols (*and) enables programmers to type in more generic categories (default categories) to make a partial or total match with the user question (Augello et al). From this perspective, it is better to create more specific categories and develop a certain number of default and ontology categories with short and simple questions embedded. At this point, the solution to the semantic ambiguity problem refers mainly to programmers, who are responsible for finding the best match between the schema and its patterns.

One of the solutions can be found in the Classes of sentences in the analyzed domain. In this paradigm, it is possible to analyze a corpus of documents with sets of sentences and a machine should be able to analyze and identify these sentences and give certain answers to them within a certain corpus of documents. For example, in communication between a human and a chatbot, it is relevant to identify specific features of a discussed product. In other words, the formal solution to semantic ambiguity can be outlined as follows:

Definition: what is the product
What = {which|what|who}
Is={about|be|be meaning of|be definition of|be sense of|mean|appear}
Product={SUBSTANCE} |{ENTITY}|{TASK}|{AGENT}

Question analysis would further split the text into certain fragments, identify speech parts and their grammatical categories, their functionality. Further, one can see specific patterns with specific roles and interdependencies therein. Further split and schematization of the sentence can be mediated by NLP models considered above in this study.

Conclusion

Unwrapping simple templates is also a long-term and challenging process. Each sent message can be interpreted in many ways. Language is dynamic and machine functions mainly as a static entity. From this point of view, a machine can be a certain frame for language, which can transform it, reshape it, or make it more comprehensible within its digital system. If to refer to transformations, we can see a certain cyclic manner of their processing and interpretation. Focusing on deep syntactic functions and coming up to the main sentences, this representation reminds us of trees in nature and their branches. At the same time, it is possible to talk about different syntax in semantically identical sentences, suitable for different languages. The English-language model for English-language chatbots can be considered a universal one due to global digitalization and internalization of scientific space. This is the perspective of further studies.

References

Augello, Agnese & Pilato, Giovanni & Machì, Alberto & Gaglio, Salvatore. (2012). An Approach to Enhance Chatbot Semantic Power and Maintainability: Experiences within the FRASI Project. 186-193. 10.1109/ICSC.2012.26.

Austin, J. L. (1975). How To Do Things With Words. The William James Lectures delivered at Harvard University in 1955. Second edition. Edited by J.O. Urmson and Marina Sbisà. Cambridge, Massachusetts: Harvard University Press.

Chomsky, Noam; Gallego, Ángel J.; OTT, Dennis. (2019). Generative Grammar and the Faculty of Language: Insights, Questions, and Challenges. Catalan Journal of Linguistics, [S.l.], p. 229-261, dec. 2019. ISSN 2014-9719. Retrieved from: <https://revistes.uab.cat/catJL/article/view/sp2019-chomsky-gallego-ott>.

Hickey, R. (2014). Language and Society. Speech Act Theory.

Classifying Knowledge Representation In Artificial Intelligence. (2020). Retrieved from: https://www.fingent.com/blog/classifying-knowledge-representation-in-artificial-intelligence/

Generative chatbots using seq2seq model. Retrieved from: https://towardsdatascience.com/generative-chatbots-using-the-seq2seq-model-d411c8738ab5

M. G. Hinchey, J. L. Rash and C. A. Rouff (2005). A formal approach to requirements-based programming. 12th IEEE International Conference and Workshops on the Engineering of Computer-Based Systems (ECBS'05), Greenbelt, MD, USA, pp. 339-345, doi: 10.1109/ECBS.2005.7.

Krantz et al. (2017). Generating Topic-Based Chatbot Responses. Retrieved from: https://www.diva-portal.org/smash/get/diva2:1118159/FULLTEXT02