LINGUISTICS AND VIETNAMESE LINGUISTICS

TRENDS IN RESEARCH AND APPLICATION OF COGNITIVE SEMANTICS IN THE INDUSTRIAL REVOLUTION 4.0

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ABSTRACT: The fourth industrial revolution, with the rapid development of artificial intelligence, big data, and natural language processing, has opened up new directions for cognitive semantics. This article will focus on new trends in cognitive semantics research and their applications such as improved understanding of meaning in AI, application in machine translation, or applications in language education (vocabulary teaching and learning following the cognitive model or grammar teaching and learning following the conceptual model) and smart translation (multiple meaning translation based on context of perception). The article also discusses challenges in research, application and prospects of semantics in the 4.0 industrial revolution.

KEY WORDS: Cognitive linguistics; semantics; cognitive semantics; artificial intelligence; big data.

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The Industrial Revolution 4.0 with the rapid development of Artificial Intelligence (AI), Big Data and Natural Language Processing (NLP) has opened new research directions for cognitive semantics. Research in this field does not limit to linguistics, but expands to smart technology, digital communication and other related areas.

1. Application in AI and NLP

Cognitive Semantics studies how the human perceives, organizes and processes meaning through experience, knowledge and interaction with the world. When applied in AI and NLP, this field could help machines understand languages in the same way as humans do, rather than based on grammatical rules and statistical models.

1.1. How does cognitive semantics help AI understand natural language?

In the past, NLP only worked on statistical models and principles to analyse and process textual documents. However, this approach has some limitations in providing proper understanding of meaning of words in different contexts. This is because this approach only takes into consideration the frequency of words and grammatical rules without mastering the way humans use languages in a natural manner.

Cognitive semantics helps AI understand human language in a more natural way. Instead of using frequency and rules of words, AI can learn the human way of thinking and expressing meaning through such models as:

Conceptual Metaphor: Human often use metaphors to express their mind, for example, *"Time is gold"*, *"Love is a fire"*. If AI can learn to recognize and explain these metaphors, it can have a better understanding of how humans express abstract ideas through concrete concepts.

Conceptual Metonymy: Metonymy refers to part of a concept being used to denote whole and vice versa. For example, the sentence *" I have just read Shakespeare"* means reading Shakespeare's work, not the author. If AI is enabled to recognize metonymy, it can have a better grasp of relationship between language entities.

Frame Semantics: Word meaning does not exist on its own but can be understood in the perceived context. For example, the word 'lean" refers to a frame with such factors as the learner, the teacher, the school, the class, the curriculum. When AI learns the frame, it can understand the word meaning in context better.

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Conceptual Blending: This is a process whereby various information sources are combined to create new meanings. For example, AI can understand that "information storm" does not refer to a real storm, but a large amount of data. If AI can learn to blend meaning, it can be capable of deducing meaning in a more flexible way instead of understanding the fixed meaning.

Thanks to these cognitive models, NLP can offer a more natural approach to language studies and help AI to understand human language not only at the lexical level, but also at cognitive level, resulting in hetter processing of language by AI and application in translation, chatbot and virtual assistance.

1.2. Applications in Modern Natural Language Processing

1.2.1. Improving semantic understanding in AI

(1) Understanding metaphors and figurative meaning

Traditional AI often faces difficulties in processing metaphors and figurative meaning in natural languages. This is because previous models follow rules or statistical analysis for semantic analysis without understanding how humans use metaphors to express ideas.

Following the *Conceptual Metaphor Theory*, AI can learn to recognize some abstract phrases. For example, "*Love is a fire*' can be understood by AI that love is not a real flame, but often refers to affection, strong feelings like a burning flame. Similarly, "*Time is money"* can be understood that money is not money in economic terms, but rather something that is precious that can be wasted or effectively used. By learning conceptual metaphor principles, AI can improve its understanding of figurative meaning, thereby producing more natural texts and conversations.

(2) Designing semantic frames to understand contexts

Frame Semantics helps AI understand not only single words but also relationship between words in context. For example, in the sentence "*I go eat phở in Hà Nội",* AI can understand "*Phở*" as a Vietnamese dish, "*Hà Nội*" as a location famous for phở; "*go eat*" as an action related to a restaurant. As a result, AI can analyse and understand the whole sentence in a cognitive frame and give more proper responses. In another sentence, *"He had the decisive score at the last minute".* AI can understand "*score*" in football or sports, '*last minute*" as the important moment of the match. AI then understands that the context is a football match. Thanks to this approach, AI will then have a better understanding of the real context and improve its ability in processing text and conversations.

(3) Differentiating meanings of words based on cognition

In natural language, many words have different meanings depending on the context. Previously, AI had difficulties in understanding the differences, but now thanks to semantic cognition, AI can overcome the difficulties and determine the exact meaning in context. For example, the word "bank" in *"I went to the bank to withdraw money."* can be understood as a place where financial transactions are carried out, meanwhile in the sentence *"The riverbank is full of green grass"*. It can be understood as the side of the river. Similarly with the word 'run' in the sentence *"I run in the morning"* means moving by feet quickly, but in the sentence "*This car runs smoothly*" the word means operating. Modern AI can use models to recognize the relationship between the words around, thus determining the exact meanings of words in specific contexts and avoiding mistranslation and misunderstanding of textual documents.

1.2.2. Application in Machine Translation

Previously, machine translation systems such as Google Translate only do word by word translation without understanding context. This causes translated documents to be unnatural and to have semantic and syntactical mistakes. Thanks to cognitive semantics, AI can translate the way the human perceives and expresses ideas, rather than putting words together following simple rules.

(1) More natural translation of metaphors

Natural languages use metaphors frequently, so word by word translation can make it difficult to understand the sentences or to properly express common ideas in the target language. For example, "愛の炎が燃える" (*Ai no honoo ga moeru*) if translated word by word can become *"The fire of love*

burns.", which may be literally correct, but not natural in English. If translated by AI using semantic cognition, the sentence is *"Love is burning passionately."* Because AI understands that this is a metaphor and then expresses in natural English resulting a more natural and context- appropriate translation.

(2) More effective processing of multiple-meaning words in context

One word has multiple meanings depending on context. If AI translates word by word, this can lead to mistranslation. For example, the sentence "彼は足が速い" (*Karewa ashi ga hayai*) if translated word by word can become: *"He has fast legs"*, which is not wrong in terms of literal meaning, but is not the way English is worded. If translated by cognitive AI, the sentence means*"He runs fast."* Because AI understands that "足が速い" in this context means run fast, rather than referring to the characteristics of the legs.

(3) Improved accuracy in translating complex structures

Thanks to the cognitive frame, AI can not only translate single words, but also analyse the sentence in context and relationship of sentence elements. For example: 東京に行ったら、ぜひラーメンを食べてください。 (*Tokyo ni ittara, zehi rāmen wo tabete kudasai.*) if translated word by word means *"If you go to Tokyo, please eat ramen."*. This sentence is grammatically correct, but not naturally worded. But if translated as: *"When you visit Tokyo, be sure to try ramen!".* AI understands "ぜひ" (*zehi*) means encouraging, making the translation more natural and appropriate.

1.2.3. Devloping smart semantic search

Previously, Google search tools operate on key word search where users enter key words and the system displays websites with the key words without underanding the question. For example, when a user enters " Who wrote the book on AI in 2025?" search tools will go through the websites that have such words as ' who", "wrote", "book", "AI", "2025". But now, AI can understand that the user is looking for the author of the book and bring more accurate results.

1.3. Challenges in applying cognitive semantics in AI and NLP

Inspite of its big potential, the integration of cognitive semantics is facing some challenges as follows: (1) *Difficulties in quantifying cognitive models*: This is because semantic cognitition is a complex process depending on human experience, (2) *The subjectivitiy of meaning* which is caused by the fact that on sentence can be understood in many different ways depending on culture and context, and (3) *The need for better AI training data*: AI needs to be trained with big data files to recognize complex semantic phenomenon such as metaphors or feelings

It can be concluded that cognive sematics has been opening a new direction in NLP and helping AI understand natural language in a better way. The integration of cognitive models in AI not only helps chatbot and virtual assistant have human-like communication, but also improves quality of machine translation, semantic search and big data analysis. In the future, AI will be likely to understand languages the way the human perceives, as such will result in a more effective application of technology into real life.

2. Applying cognitive semantics in digiral communication and smart marketing

In the era of Industry 4.0, cognitive semantics has become an important tool that helps businesses and media platforms understand and interact with customers in a smarter way. Cognitive semantics not only helps AI understand human language but also plays an important role in digital communication and smart marketing. Several trends in applying cognitive semantics in digital communication and smart marketing are as follows.

2.1. Analysing languages in digital marketing and social networks

In the digital media and social media environment (Facebook, Twitter, TikTok, YouTube...), language is not just a simple text but also carries emotions, nuances, and metaphorical meanings. Previously, AI primarily recognized information based on single keywords, leading to many errors in understanding user intent. Thanks to cognitive semantics, AI is increasingly capable of analyzing

language more naturally, thus giving better understandings of users' emotions, reactions, and intentions in the digital space.

2.1.1. Analysis of user feelings and reactions

Modern AI can analyze comments, posts, and messages to identify emotions and nuances in language, rather than only recognizing simple keywords. This helps social media platforms better understand user reactions to the content being posted. For example, the sentence written by users as "*This advertising campaign really exploded*". Traditional AI detects the word "exploded" as very negatively meaning danger, but with cognitive semantics, AI understand the word as a big success, and thus categorises this comment as positive.

2.1.2. Automatic detection and management of negative contents

The language on social media is very diverse, including a lot of negative, harmful content, fake news, and inciting language. Cognitive semantics helps AI better understand context and speaker's intent, thus control negative contents in a more accurate way. For example, the comment "*I hate this advertisement because it is ridiculous*" may be labelled by traditional AI as negative because of the word "hate". However, when integrated with cognitive semantics, AI can understand that this is a really negative response about the advertisement that can be flagged for content management or customer feedback analysis. Another example about recognizing context to avoid false censorship is seen in the sentence "This advertisement is crazy and makes me burst into laughters". Traditional AI looks at the word "crazy" and labels as negative content. Cognitive semantics- based AI understands that in this context, crazy denotes humor and enjoyment, so it put the comment in the positive group rather than flag it as negative.

2.2. Cognitve semantics and smart advertising

In advertising, language is not only a tool for conveying information but also for stimulating emotions and creating a strong impression on customers. Thanks to cognitive semantics, AI can understand and replicate how humans use language in advertising, creating engaging content tailored to different groups of customers.

Advertising language often uses metaphors, metonymies, and emotions to attract customers. AI can learn to use languages more naturally to create attractive advertising contents. For example, the perfume advertisement "The enchanting fragrance, like a touch full of allure" uses metaphors that make users relate to not only the fragrance but also their experience and feelings. AI can learn from advertisements to create content in a similar style. Another example is in a car advertisement "*An exhilarating driving experience-Master the speed*!" that emphasizes safety, speed and luxury. AI can understand "exhilarating" as feeling of the driving experience.

2.3. Personalisaing customer experience with smart AI

- *Smart virtual assistant in marketing:* AI can use cognitive semantics to understand customer needs and recommend suitable products. For example, when chatting with a virtual assistant, a customer notes "*I want a pair of shoes that are light and ventilated*", AI understands "*light*" and *"ventilated*" as important criteria and then gives proper suggestions.

- *Smart content recommendations based on user preferences:* Netflix, Spotify, Amazon use AI to recommend content based on cognitive meanings, rather than key words. For example, if users prefer films about self-discovery journeys, AI can recommend the movies that give the same feelings and styles rather than only searching for key words.

Thus, it can be said that cognitive semantics is revolutionalising digital marketing and smart marketing, thus helping businesses understand and interact with customers more effectively. From analyzing language on social media, optimizing advertisements, personalizing customer experiences, to intelligent chatbots and virtual assistants, cognitive semantics helps AI become more knowledgeable and natural in communicating with humans. In the future, AI will be more likely to not only understand words, but also understand how humans think, feel and respond, thus helping to create an absolutely smart and effective digital marketing platform.

3. Cognitive semantics in education and smart translation

Cognitive semantics not only helps understanding how humans process language but also brings about important application in language education and smart translation. When applied in these two fields, cognitive semantics improves quality of teaching and learning and machine translation by assisting AI to translation more accurately and naturally.

3.1. Applying cognitive semantics in language education

3.1.1. Teaching and learning vocabulary following cognitive models

(1) Vocabulary learning via conceptual metaphors

In cognitive semantics, vocabulary does not exist on its own, rather connect with conceptual networks. One of the important approaches to help humans understand and use languages is conceptual metaphors. Conceptual metaphor is the way people use a familiar cognitive domain to understand a more abstract one.

For example, in English the sentence *"Time is money"* shows the way humans perceive time as a kind of resources that can be managed like money. This affects the use of time-related vocabulary, for example Saving time is understood like saving money, Spending time is similar to spending money, wasting time is understood like wasting money. This conceptual metaphor also exist in Vietnamese and Japanese *"Thời gian là vàng bạc"* (Time is gold- Vietnamese), "時間を無駄にする" / (Wasting time- Japanese).

(2) Vocabulary learning via conceptual metonymy

Along with conceptual metaphor, conceptual metonymy is an approach to help learners expand their vocabulary. Metonymy is a phenomenon in which a word or phrase not only carries a direct meaning but can also represent a larger related concept. For example, *"White House"* represents the US government, *"Hollywood"* -the US movies industry. In Japanese, 桜 (さくら - cherry blossom), not only represents the flower, but also represent: (1) spring (because the cherry blossom blooms in spring, (2) youth, (3) modesty.

3.1.2. Teaching grammar following the way humans think

Grammar is often seen as the dry and difficult part of learning a language. However, if grammar is taught in a way that aligns with human thinking rather than relying on rigid formulas, learners can understand grammar more naturally and use it more effectively. Cognitive semantics helps teach grammar according to the principles of the frame semantics and cognitive grammar to help learners approach grammar in a way that aligns with how they perceive about the world around them.

(1) Grammar teaching following frame semantics

Conceptual frame is a theory in cognitive semantics proposed by Charles Fillmore. This theory holds that each word or grammatical structure not only carries a single meaning but also fits within a conceptual frame, which is a collection of relationship and information related to the word or structure. In teaching grammar, the use of conceptual frame helps learners understand a grammatical structure based on related components rather than just memorizing discrete rules.

Japanese has many complex grammatical phenomena, but if teaching is based on how people think about cognitive space, learners can master them more easily. For example, when teaching the two prepositions に」và「で」using cognitive space, in a traditional way, a teacher can explain 「に」is used to refer to the destination, and 「で」refers to the place where the action happens. This may confuse learners who do not understand the nature of cognition of these two words. But in the cognitive space, the teacher can make it clear that**「に」** (ni), refers to Goal/Target so learners can visualize it as a target in space. For example, 学校に行く (*Gakkou ni iku* - go to school). School is the *target*, or **椅子に座る** (*Isu ni suwaru* – Sit on chair). Chair is the target of the action sit. Meanwhile **で** (de) refers to the location of action where the action actually happens, so learners can visualize it as a space around the action. For example, **学校で勉強する** (*Gakkou de benkyou suru* -

Learn at school). The action “learn” happens in the space of “school”, or in **公園で遊ぶ** (*Kōen de asobu* - Play in the partk), the part is the place where the action takes place.

3.2. Applying cognitive semantics in smart translation

3.2.1. Smarter machine and AI translation thanks to cognitive semantics

(1) More accurate translation of metaphors and metonymies

Traditional machine translation used to operate by translating word by word, resulting in unnatural translations. Currently, machine translation has begun to apply cognitive semantics to translate based on context and concepts instead of translating each individual word. For example, the sentence in Japanese "彼は鉄の意志を持っている" can be traditionally machine translated as *"He has an iron will”,* but if translated following cognitive semantics can be: *"He has a strong determination."* This is because AI understand that “iron” is not literally translated, but means power. Another example is the translation of the metonymy “The White House has announced a $100b USD aid:”, AI can understand that The White House refers to the US government, not a house that is white as its literal meaning.

3.2.2. Multiple meaning translation based on cognitive context

In language, many words have different meanings. Cognitive semantics helps AI distinguish meanings based on context. For instance, the word “bank” can be translated as the “financial entity” as in: *"I deposited money in the bank.", or* as the “side of the river” as in *"He was sitting on the riverbank”,* or the word *“run”* can be translated as ‘moving’ as in *:This car runs fast’,* but as *“operate”* as in *“He runs Facebook advertising”.*

3.2.3. Automation of multi-language translation for businesses

Companies use smart AI translation to translate documents faster while still maintaining the naturalness of the language. For example, Netflix uses AI to translate movie subtitles based on emotions and cognitive meanings. Amazon translates product descriptions into multiple languages using cognitive semantics integrated AI.

Cognitive semantics is also changing the way human teach, learn languages and smart translation.

In education, it helps learners understand vocabulary, grammar, and semantics in a way that is similar to human thinking.

In translation, it helps AI translate more accurately, understand context better and reduce errors related to metaphors, metonymes and multiple meaning words.

In the future, learning a language will become easier with AI personalized to each individual's way of thinking. Also, AI translation will be more human-like, making global communication easier.

4. Challenges and prospects

Cognitive semantics as an important linguistic branch provides understanding of reflective languages and structured human cognition about the world. In the Industrial Revolution 4.0, this field has a potential of offering application in AI, NLP, education, translation and smart media. However, its research and application present challenges and prospects.

4.1. Challenges

4.1.1. Human language is too complicated for AI to fully understand

Cognitive semantics studies life experience, culture and core knowledge of humans. AI and computers in the meantime do not have practical experience, making it difficult to understand the human mind.

Meanwhile, AI and computers lack practical experience, making it difficult to understand meaning in the way humans think. AI can understand the literal meaning of *My heart breaks* but cannot think that this is a way to express feelings. Even with modern language models like ChatGPT or Google Bard, AI can still misunderstand or misinterpret sentences with multiple layers of meaning, metaphors, or metonymies. To solve this problem, researchers need to develop AI that can model the real world better by combining Knowledge Graphs and Deep Learning.

4.1.2. The meaning is subjective and culturally dependent

The same statement can be understood differently by people from different cultures. For example, the sentence *Love is a journey* can be easily understood by Western people, but Asian cultures have some metaphor for love. The word "thầy" in Vietnamese can have many meanings: teacher (thầy giáo); traditional medicine doctor (thầy thuốc); person with supernatural powers-fortune teller (thầy bói); monk (thầy chùa). If AI cannot have a strong cognitive modeal, it can mistranslate this word into "teacher" when people refer to an "Oriental doctor". Therefore, it is necessary to develop an AI model that can learn context and recognize cultural nuances of language. In addition, it is necessary to compile semantic databases of cultures to help AI understand the context correctly to solve this problem.

4.1.3. Quantifying meaning in cognitive semantics

Cognitive semantics is abstract in nature, making it difficult to quantify by mathematical models. For example, it is very hard to understand "happiness" as a feeling when humans feel happy in different ways. Or some words can carry different shades of meaning depending on the tone and context, making it difficult for AI to process the implicature. For example, the sentence "Today is March 8th, I wash my shirt for you" will be very difficult for AI to understand and translate the implicature.

The solution to this problem is to combine cognitive semantics with modern machine learning models such as Machine Learning, Deep Learning, Transformer Models so AI can understand meaning based on real data. At the same time, Contextual Learning and Semantic Knowledge Networks can be used to help AI recognize nuances better.

4.1.4. Limited ability to integrate into AI and NLP technology

Although there have been advances in integrating cognitive semantics into AI, current NLP systems still rely more on statistical models and machine learning than on human cognitive reasoning. Tools like Google Translate, ChatGPT, and DeepL still struggle with semantic translation, especially with idiomatic expressions, local culture, and indirect speech. For example, the translation of the sentence *"He has a lot on his plate",* AI can misunderstand the literal meaning that *He has much food on the plate,* not that *He is very busy.*

4.2. Prospects in the Industrial Revolution 4.0

Despite many challenges, cognitive semantics is opening up new opportunities for the development of smarter technologies and their widespread application in life

SmarterAI with the ability to understand natural language as human. NLP models are integrating the concept of cognition to understand meanings more deeply. Chatbots and virtual assistants like Google Assistant and ChatGPT may be able to better recognize emotions, nuances, and metaphors in the future. AI can understand a humorous or sarcastic remark to respond more appropriately.

Applications in education and smart translation: AI can personalize language education based on each individual's learning style. Machine translation can become more accurate by understanding the way humans perceive languages rather than just translating following rules.

Cognitive semantics working with Big Data và AI to analyse social data: Big Data Analytics can use cognitive semantics to evaluate psychology, public opinion and consumer behaviour. AI can read millions of posts on social media and analyze whether users have positive or negative feelings about a product or event.

Applications in content writing and communication: AI can create content that aligns with the emotions and culture of each customer group, which are no longer systematic like before. For example, when writing movie scripts, AI can create dialogues with emotional depth and natural nuances that do not sound "mechanical" any more.

In brief, cognitive semantics in the era of Industry 4.0 faces many challenges regarding the complexity of language, subjectivity, and the ability to integrate into AI. However, there are big opportunities to create technology that understand natural language like humans. In the future, AI

will increasingly understand and communicate with humans in a more natural, smarter and creative way, thus bringing about more applications in education, translation, communication and data management.

5. Conclusion

Cognitive semantics is an important research field in cognitive linguistics, helping people understand how language reflects thoughts and perceptions of the world. In the era of Industry 4.0, this field is no longer limited to theoretical research instead, it has many practical applications in artificial intelligence, natural language processing, digital communication, language education, and smart translation

Current research trends focus on helping machines understand language in the way humans think, thereby creating smarter systems, more natural communication, and supporting humans in various fields. This is an important step in AI development, making it closer to human-like perception.

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