TERM CREATION IN THE DYNAMIC DOMAIN OF ARTIFICIAL INTELLIGENCE

Cristina NICHITA
nichita.cr@gmail.com
Moldova State University (Republic of Moldova)

Abstract *: Ein neuer Fachbereich und seine Begriffen spielen eine wichtige Rolle die Aufmerksamkeit der Sprachbenutzer zu neuen Perspektiven zu führen. In dieser Zeit, wenn wir eine Entwicklung der Wissentechnologien erleben, haben wir die notwendige Instrumente einen Korpus zusammenzustellen, der die Terminologie vom Bereich der künstlichen Intelligenz aufwertet. Die Studie dieser Begriffe ermöglicht die Entdeckung neuer Konzepte in künstlicher Intelligenz und kann sich zugleich eine offensichtliche Beziehung mit menschlicher Intelligenz erforschen lassen. Folglich, die Bildung von Fachbegriffen in diesem dynamischen Bereich kann einen reichhaltigen Ausblick auf den interdisziplinären und transdisziplinären Ansatz erlauben.*

Stichwörter *: Begriff, Methode, Bildung von Fachbegriffen, Korpus, künstliche Intelligenz.*

A Dynamic Domain

Terminology in the domain of artificial intelligence is a prospective topic in studying term creation. The emerging domain of artificial intelligence creates new concepts and offers a valuable terminology. Its current and future perspectives develop with great dynamics while it aims at using principles that level up to human intelligence. The level that artificial intelligence has currently reached involves terms combining concepts that express a high level of complexity in operations and knowledge. In this respect, artificial intelligence develops with high productivity and offers opportunities to collect specialized corpora of texts and create terminological data banks. Currently, artificial intelligence is an advanced domain and its terminology offers grounds for carrying out research into it. The artificial intelligence has reached a certain level which can be revealing in regards to certain aspects of human intelligence.

Our paper follows our doctoral research interest (A cognitive approach on the terminology from the triad : cognitive intelligence – emotional intelligence – artificial intelligence in English and Romanian). Therefore, our analysis also includes a comparison of

artificial intelligence with the two specialized domains : cognitive intelligence and emotional intelligence.

Methods in Term Creation

Terminology created in the field of artificial intelligence uses, both for form and content, methods of term creation, which, in turn, reflect important aspects of new concepts from the domain of artificial intelligence. The studied methods of term creation reveal dynamic contiguous processes that are relevant and represent revealing current realities that can be traced by deconstruction and analysis of the terms.

The methods of term creation, with which we analyze terms within artificial intelligence, comprise categories included in the works of Juan Carlos Sager and Maria Teresa Cabré : *derivation, compounding, conversion, linguistic borrowing, abbreviation, terminologization, reterminologization and determinologization*. The methods represent a starting point in analyzing the vast array of aspects that the terms can reveal.

Presentation of the Corpus of Terms in Artificial Intelligence

We work with the terminology of a corpus of texts from the domain of artificial intelligence, namely specialized journals, where we identified *45 bilingual term records* with the main term in English and its equivalent in Romanian, out of *105 monolingual extraction records* in English and Romanian. The term records have been validated by multiple occurrence in specialized journals. Next we focus only on the main terms in English.

Terms that have been validated in our corpus of terminological records in the field of artificial intelligence : *adaptation, affective computing, artificial intelligence, backpropagation, behavior, big data, computation, concept, convolutional neural network, crowd-sourcing, data, decision making, decode, deep architectures, deep learning, encode, evolutionary computation, expression, feature extraction, feedforward, framework, fusion, fuzzy, image recognition, inference, interpretation, knowledge extraction, machine learning, mapping, memory, natural language processing, neural computation, neural network, neuron, noise, pattern, problem solving, reaction, segmentation, sensor, signal, stimulus, symbol, update, visualization*.

Next we present their term creation with respect to the aforementioned methods, which can reveal processes and dynamics, the origin and the recipient domains. We present terms that are representative and have a contiguity or a precedent, in the case of terminology from the artificial intelligence field (reference field) and can be considered relevant in the case of the given study. For the definitions in the text, we used the Oxford Dictionaries and the Cambridge Dictionary.

Analysis of the Corpus of Terms

Derivation

This method includes zero derivation, prefixation, suffixation and affixation. In the terminology of the field of artificial intelligence we identify the following :

- zero derivation : *concept, pattern, symbol* ;
- prefixation : *decode, encode, update* ;
- suffixation : *adaptation*, *behavior, computation, data, expression, fusion, fuzzy, inference, interpretation, mapping, memory, reaction, segmentation, sensor, signal, stimulus, visualization*

which we analyze both as form and content below, and we also include the etymology of the term to reflect as granularly as possible the creation of terms and their structure. Next we concentrate on the notional field of the terms. Scrutinizing the definitions and contexts, we can reaffirm the field that the terms belong to, and, namely, the domain of artificial intelligence.

Encode - a term with the prefix *en* - + *code*, where the root *code* originates from medieval English, Old French and Latin *codex*, *codic*-. Initially, the term meant a systematic collection of statutes by Justinian or one of the last Roman emperors.

The definition : "convert (information or an instruction) into a particular form" and the context in which the term is found inform about the field to which it belongs :

> "In contrast to previous encoder-decoder models, our proposed modeling framework incorporates LFP spectral power to **encode** and decode a cognitive state (Yousefi, 2019)"
>
> "Two independent computing processes are used to **encode** the forward and the backward dependency (Gao, 2020)"

where it is next to notions such as : convert information, encoder-decoder models, modeling framework, LFP spectral power, decode, computing processes etc. ; which falls into the category that validates the term as part of artificial intelligence terminology.

Regarding the term **inference**, formed by the particles infer + -ence ; its root appeared at the end of the 15th century, from the Latin *inferre* (*to bring into discussion, to include*), which meant in medieval Latin - *to deduce*, from *into* + *ferre* (*to bring*). In the 16th century, in medieval Latin, the variations *inferent* and *inferentia* appeared.

The definition : "process of using a trained machine learning algorithm to make a prediction" and the context in which we find the term reflect its technical part related to the field of artificial intelligence :

> "(…) With neural computation corresponding to both approximate **inference** in continuous –valued latent variables and error backpropagation, at the same time (Bengio, 2017)"
>
> "To evaluate the learned multimodal representation, extensive tasks are carried out, such as the generating missing modality task, the **inferring** joint representation task, and the discriminative task (Gao, 2020)"

In addition, notions such as : machine learning, algorithm, neural computation, continuous-valued latent variables, error backpropagation, learned multimodal representation, modality task, joint representation task, discriminative task etc. ; are from the field of artificial intelligence and validate the term as being part of the reference domain.

Thus, we consider that derivation as a process contributes to the creation of terminology in the field of artificial intelligence through a large number of suffixes ; which suggests suffixation as a process of forming terms and enriching terminology in the field of reference.

Compounding

For compounding we have two types of terms : *compound terms* and *complex terms*. They use roots to create terms with greater accuracy than simple terms. Our corpus of terminological records in the field of artificial intelligence finds the following :

- compound terms : *backpropagation, crowd-sourcing*, *feedforward, framework ;*
- complex terms : *affective computing, artificial intelligence, big data, convolutional neural network, decision making*, *deep architectures, deep learning, evolutionary computation, feature extraction, image recognition, knowledge extraction, machine learning, natural language processing, neural computation, neural network, problem solving.*

Thus, we can highlight one of the peculiarities of terminology in the field of artificial intelligence – the creation of complex terms. Therefore, the complexity of the terminology of the field of artificial intelligence reveals and confirms the complexity of the field of artificial intelligence.

Crowd-sourcing is formed by composing the roots *crowd* and *source*, a compound term in English.

Its meaning is : "the practice of obtaining information or input into a task or project by enlisting the services of a large number of people, either paid or unpaid, typically via the internet" and the context in which we find the terms, both confirm the origin of the term i.e. artificial intelligence :

> "(…) Field Trial of Tiramisu : **Crowd-sourcing** Bus Arrival Times to Spur Co-design and Editing Behavior to Recognize Authors of Crowdsourced Content (…) (Colceriu, 2015)"
>
> "(…) Editing Behavior to Recognize Authors of **Crowdsourced** Content (…) (Wang, 2016)"

where the latter adds to notions such as : information, input, internet, editing bahavior, crowdsourced content etc. ; this confirms the complexity of the concept and its inclusion in the field of artificial intelligence, while the term is included in the terminology of the field of artificial intelligence.

Natural language processing has a complexity that derives from its components similar to cognitive processes, but as part of the terminology of artificial intelligence. "A branch of artificial intelligence that deals with the interaction between computers and humans using the natural language".

The contexts of the term confirm the term and the affiliation to the terminology of the field of reference :

> "Big Data analytics often involves the use machine learning techniques for **natural language processing** of textual data arising for example in the Web, databases and social media (Wang, 2016)"
>
> "However, research in **natural language processing** has shown that it is in fact possible to derive an approximate representation of the word meanings using only cooccurrence patterns within the verbal material itself (Dupoux, 2018)"

where it adds to notions such as : artificial intelligence, computers, Big Data analytics, machine learning, textual data, web, databases, social media, cooccurrence patterns etc. ; this validates the term to be part of the terminology of the field of artificial intelligence.

Terminologization

In the terminology of artificial intelligence, we can see terms that have been subjected to terminologization. Common language lexemes went through a process of specialization of meaning and became terms. In the terminological corpus compiled for artificial intelligence - terminologization is less frequently recorded, because few terms are formed from the common language. Examples of terminology in our terminological corpus are *computation* and *noise*. Next we present their evolution regarding the semantic method of terminologization that takes place :

- noise

- from the common language : "a sound, especially one that is loud or unpleasant or that causes disturbance"
- from specialized language : "random fluctuations that obscure or do not contain meaningful data or other information"

Here terminologization occurs *from concrete, through metaphor, to abstract - from real sounds to fluctuations or disturbances of data / information*.

- computation

- from the common language : "the action of mathematical calculation"
- from specialized language : "the use of computers, especially as a subject of research or study"

Terminologization, in this case, goes *from manual to automated*, *from mathematical operation to machine / computer and science*.

Reterminologization

As a semantic method of term creation, also called - secondary terminologization or redenomination ; reterminologization takes the concept from a domain and transfers its form by semantic restriction or extension, by metaphor and metonymy or a combination of these processes. In our terminological corpus in the field of artificial intelligence, the following terms have been subjected to reterminologization : *adaptation, affective computing, artificial intelligence, behavior, concept, decision making, deep learning, evolutionary computation, expression, framework, fusion, fuzzy, image recognition, inference, interpretation, knowledge extraction, machine learning, memory, natural language processing, neural computation, neural network, neuron, pattern, problem solving, reaction, segmentation, signal, stimulus, symbol.*

It is important to mention that the array of terminological units collected and validated as terms in the domain of artificial intelligence and created through reterminologization offers opportunities for further research and classifications. The phenomena that we decided to study, considering our terminological corpus, are the metaphor (and, namely, the conceptual metaphor) and specific cases of metonymy.

Conceptual metaphor

Within the terminology in the field of artificial intelligence we approach metaphor from its ontological perspective, considering the migration of terms – reterminologization - from other fields. Conceptual metaphors are a combination of linguistic and cognitive elements, and this cognitive side is a very important part of conceptual metaphors, because metaphor has an ontological character and is related to the organization of knowledge and

encyclopedic knowledge. In this respect, the following classification of primary categories is the one George Lakoff and Mark Johnson presented. It is based on the source domain and provides us with the slots needed to fit the terminology in our study : *1. Things ; 2. Plants ; 3. Animals ; 4. People ; 5. Natural Phenomena* [10], selected for our study after considering also works by Eugenia Mincu, Ekaterina Minina, Maria-Alexandrina Tomoioaga and others.

Thus, we study the conceptual model - the *pattern*(s) - which conditions lead to the creation of terms in artificial intelligence, through metaphors as a source of conceptualization, inspired by the following fields : cognitive intelligence and emotional intelligence (as important part of our doctoral research) ; but also from other fields and language layers.

Below we present the English terms created by conceptual metaphor in our terminological corpus : *adaptation, behavior, concept, decision making, expression, framework, fusion, image recognition, inference, interpretation, memory, neural network, neuron, pattern, problem solving, reaction - reaction, segmentation, signal, stimulus, symbol.*

There are 20 terms created by conceptual metaphor in the terminology of artificial intelligence from a total of 45 terms from this field of reference, where the emphasis is on the target field - the terminology of the artificial intelligence domain.

Considering the origin (source domain) and the direction of the migrating terms to the field of artificial intelligence, the identified terms are distributed as follows, taking into account the specialized areas of our research paper and research interest (cognitive intelligence, emotional intelligence and artificial intelligence) :

- *behavior, concept, decision-making, framework, image recognition, inference, interpretation, memory, neural network, neuron, pattern, problem-solving, signal, stimulus, symbol : cognitive intelligence → artificial intelligence (15 terms)* ;
- *adaptation, expression : emotional intelligence → artificial intelligence (2 terms)* ;
- *fusion, reaction, segmentation : other fields → artificial intelligence (3 terms).*

Their pattern can be identified following an analysis of the slots of terms subject to the process of reterminologization through conceptual metaphor.

Neural network is a complex term in artificial intelligence, defined in *cognitive intelligence* as : "an interconnected *system of neurons*, as in the *brain* or other parts of the *nervous system*" and in *artificial intelligence*, neural network is defined as "a computer system modeled on the *human brain* and *nervous system*".

As the definition in artificial intelligence says, the conceptual model of the neural network is the brain and nervous system. It mimics the notion of system, brain and nervous system. The term first appears recorded for cognitive intelligence, but is often used in artificial intelligence. It is observed that it has obtained a current semantic restriction. The source domain is from the slot *People*. The conceptual model is the *neural system* - biological neural networks, interconnected neurons with cognitive function. As a computer term, it has several hyponyms, among which *recurrent neural network*, *convolutional neural network*, *deep neural network* etc. This confirms the level of security of the term and validates a perspective for further complex technological development in the field of artificial intelligence.

Behavior first appears in human intelligence / living bodies, at the intersection and through the integration of *cognitive and emotional intelligence* and is defined in the source domain as : "the way in which *an animal or person responds* to a particular situation or stimulus" and in the field of *computer science* : "the way in which a *machine* or *natural phenomenon works* or functions".

Thus, the conceptual model is *the way something* (animal, person, machine, phenomenon) *acts* (works / reacts). The slots can be *Plants*, *Animals* or *People*.

Expression is present in all our fields of interest, but, in general, it first was used within the human intelligence, afterwards being taken over by the exact sciences and computer science. The meaning in *human intelligences* is : "the action of *making known one's thoughts* or *feelings*", "a look on someone's face that *conveys* a *particular emotion*" and in artificial intelligence : "a collection of symbols that jointly *express a quantity*".

The model here is *something that conveys content* ; the slots can be Animals and People and it is a classic example of reterminologization and a representative conceptual metaphor in the sense of migrating terms, considering the evolution of the term.

Characterizing the conceptual metaphor, we can conclude a representative character of metaphors in artificial intelligence. Regarding the terminological corpus and the conceptual metaphors in the terminology of artificial intelligence, the terms frequently migrate from cognitive intelligence. The main slot is People and the pattern or conceptual model that these metaphors refer to is the imitation of living bodies and functions.

Other cases of reterminologization : *affective computing, artificial intelligence, deep learning, evolutionary computation, fuzzy, knowledge extraction, machine learning, neural computation* ; most of which are complex terms, therefore, a combination of roots that follow a partial reterminologization, including metaphors from other domains of origin or can also be considered roots that stand for two domains of origin. In this respect, we choose to discuss *cases of metonymy*. It is a perspective that undergoes research, taking into consideration a subsequent combination of the methods of metaphorization and metonymy.

Cases of Metonymy

The current perspective we observed in artificial intelligence is a combination of human qualities and functions and technology. The latest representative terms in the domain of artificial intelligence have the highest level of complexity and form a growing list of terms created using metonymy. Metonymy in this respect can be regarded from the point of view of a combination of language units that each stand for their domain of origin, together forming a complex term, due to the complexity of the concept created in artificial intelligence. The constituents of the term stand for their origin in the direction of *content→container* and, specifically, CONTENT→SOURCE. In this respect, we discuss the following terms as cases of metonymy : *affective computing*, *deep learning*, and *neural computation* ; the term *affective computing* representing the highest complexity in artificial intelligence, hence, we analyze it at last.

Deep learning is made up of the roots *learning* and *deep*.

Learning in *cognitive intelligence* stands for : "the acquisition of knowledge or skills through study, experience, or being taught" while in *artificial intelligence* we find it as a hypernym in : "the use and development of computer systems that are able to learn and adapt without following explicit instructions, by using algorithms and statistical models to analyze and draw inferences from patterns in data".

First it appeared in cognitive intelligence, and the pattern consists of an *independent ability to study / learn*.

Deep, which is based on something *deep for our understanding*, as the definition indicates : "profound or penetrating in awareness or understanding" or *difficult to understand* and also refers to *deep emotions or feelings* : (of an emotion or feeling) intensely felt - is conceptually part of the field of *human intelligence*, indicating complex processes, beyond simple and immediate understanding. This particle serves to describe the tendency of the field of artificial intelligence to simulate human intelligence in complex tasks and functions.

Deep learning is a term formed at the intersection between the fields of human intelligence and artificial intelligence/computer science, revealing a high level of interdisciplinarity, which we can see in its definition : "a type of machine learning based on artificial neural networks in which multiple layers of processing are used to extract progressively higher level features from data" and in the following description :

> "Speech is not the only area where **deep learning** has shaken the AI landscape : object recognition (…), language translation (…), and speech synthesis (…), are all areas where neural networks have displaced by a large margin the previous state-of-the-art, while approaching human performance (Dupoux, 2018)"

Therefore, ***deep learning*** is a representative *state-of-the-art* term in the domain of artificial intelligence and it confirms the metonymy of two units that stand for two domains of origin : human intelligence and artificial intelligence.

Neural computation is composed of two roots with different domains of origin. **Computation** is from the terminology of *computer science*, and **neural** is defined as part or related to the nervous system : relating to a nerve or *the nervous system*, which is a hyperonym in *human intelligence*, a relationship that achieves interdisciplinarity between human intelligence and artificial intelligence.

Its definition : "the operations of a computer that uses *neural networks*" and collected description and studied contexts :

> "The ideas presented in this article could be an element of a theory for explaining how brains perform credit assignment in deep hierarchies as efficiently as backpropagation does, with **neural computation** corresponding to both approximate inference in continuous-valued latent variables and error backpropagation, at the same time (Bengio, 2017)"

confirm a conceptual assimilation of the field of human intelligence through a term / terminology within artificial intelligence, and this interdisciplinarity validates not only the complex term **neural computation** as part of the terminology in the field of artificial intelligence, but also the metonymy of the units (conceptually) standing for the domains of origin as in CONTENT→SOURCE, where the sources are human intelligence and artificial intelligence.

Affective computing is a complex term that is formed by the roots **affective** and **computing**. **Computing** is a term from *computer science*, and **affective** is taken from *emotional intelligence*, or psychology of feelings.

Affective is the seme added to **computing** to include and involve the conceptual combination assimilated by the complex term **affective computing** between the field of emotional intelligence and the field of artificial intelligence ; **affective** meaning a term that *refers to mood, feelings, and attitudes*.

The definition of the term **affective computing** : "the study and development of *systems and devices that can recognize, interpret, process, and simulate human affects*" shows that the term encompasses the basic principles of emotional intelligence for application in the field of artificial intelligence. This is also confirmed by the context in which the term is found :

> "In order to analyze the expressive patterns of emotions in international cyber languages, a comparative study of Chinese, English, and Spanish languages was conducted in this paper, and finally an intelligent method was proposed for **affective computing** on the readable texts and nonreadable symbols in a unified PAD emotional space (Huang, 2015)"

Affective computing being a complex term in the terminology of artificial intelligence that includes systems, programs and machines / devices that are based on the principles of emotional intelligence and studies emotions for these systems to recognize them ; is a representative term for a branch of artificial intelligence that ensures the interdisciplinarity between human emotional intelligence and artificial intelligence. Thus, the term is a case of metonymy that includes semes that stand for a combination of domains, corresponding to the CONTENT→SOURCE category.

Conclusions

In the field of artificial intelligence we can find methods for term creation such as : derivation, compounding, terminologization and reterminologization (with cases of conceptual metaphors and metonymy). A peculiarity of the terms in the field of artificial intelligence is their interdisciplinarity, the relationship between computer science and human intelligence ; and in human intelligence, it refers mostly to both cognitive intelligence and emotional intelligence. This clearly reveals the development of technology and its prospective dynamic evolution, with room for further studies and research from a terminological perspective.

Bibliography :

CABRÉ, M.T, (1999), *Terminology. Theory, methods and applications,* Amsterdam/Philadelphia, John Benjamins Publishing Company.

LAKOFF, G., JOHNSON, M., (1980), *Metaphors we live by*, Chicago, University of Chicago Press.

SAGER, J. C., (1997), *A Practical Course in Terminology Processing*, Amsterdam & Philadelphia, John Benjamins.

Corpus :

BENGIO, Y., et al, (2017), *STDP-Compatible Approximation of Backpropagation in an Energy-Based Model in Neural Computation,* no 29, Massachussetts, Institute of Technology, pp. 555-557.

COLCERIU, R. D, et al, (2015), *Localizarea utilizatorului prin prelucrarea contextului spațial*, Revista Română de Interacţiune Om – Calculator no 8 (2), Bucuresti, ACM SIGCHI Romania, pp. 79-100.

GAO, J., et al, (2020), *A Survey on Deep Learning for Multimodal Data Fusion,* Neural Computation no 32, Massachussetts, Massachussetts Institute of Technology, pp. 829-864.

HUANG, S., et al, (2015), *Neural Cognition and Affective Computing on Cyber Language*, Computational Intelligence and Neuroscience Volume 2015, Hindawi, Hindawi Publishing Corporation.

WANG, Y., et al., (2016), *Cognitive intelligence : Deep Learning, Thinking, and Reasoning by Brain-Inspired Systems,* International Journal of Cognitive Informatics and Natural Intelligence vol. 10 no 4, Calgary, IGI Global.

YOUSEFI, A., et al, (2019), *Decoding Hidden Cognitive States from Behavior and Physiology Using a Bayesian Approach*, Neural Computation no 31, Massachussetts, Massachussetts Institute of Technology, pp. 1751-1788.

www.dictionary.cambridge.org

www.oxfordlearnersdictionaries.com