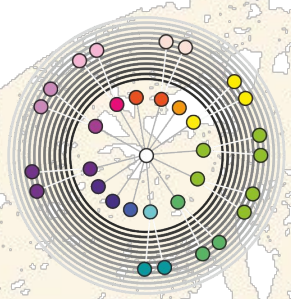

Обогатяване на
Семантичната мрежа
Уърднет с концептуални
фреймове

SEMANTIC RELATIONS

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Relational knowledge

Relational cognition is key to present knowledge and to how we reason about the world.
Conceptual relations are central to cognitive tasks such as understanding, reasoning, inference, problem solving, analogical reasoning etc.(Spellman et al. 2001)
Understanding the richness of relations leads us to explore their role in human perception of the world, on the one hand, and their role in more formal systems that represent and handle knowledge, on the other.
In addition to relations in the world, semantic relations can reflect relations in language, including relations between objects and their symbols.

Relational knowledge

Research based on relational knowledge in linguistics

- sign representation - the idea of minimal distinguishing elements, or differential signs (Jakobson and Halle 1956);
- the semantic studies of Sapir (1921) and Yelmslev (1960) give start of the component analysis of meanings.

Conceptual structural relations

- Conceptual structural relations are part of how we organize and construct our knowledge and understanding of the world. It depends on our ability to perceive and characterize relationships between concepts and create conceptual classes and relationships between them.
- Jackendoff (1990) - abstract mental representations by which speakers of a given language organize situations in the world. If concepts are the basic building blocks of the conceptual structure, then the relations between them are the link that holds them together.
- Khoo and Na (2007) - relationships between concepts are determined by simultaneously identifying a semantic relationship and a set of participants in it, each participant having their own role in the relationship.

Conceptual structural relations

- Relational structures are often represented as a triple:

  [concept1] –> (relation) –> [concept2].

  Each relation connects two or more positions that must be filled,
  and the positions can be filled only by participants belonging to a certain semantic category.
- The presence of relations at the basic level of knowledge representation allows the generation of units at a more complex level. The semantic content of relations determines the nature of higher-level entities.

Relations

Green 2002: the list of semantic relations includes both a closed number of hierarchy and equivalence relations and an open set of relations.
Each new verb carries the potential to introduce a new conceptual relationship. Any relationship between objects, processes, etc. can be reflected in the languages between the corresponding concepts. For example, love is a relationship between people, "Tom" and "An" can be individual concepts related to the semantic relationship love. Different subject areas are constantly developing new kinds of semantic relations.

Semantic relations

Semantic relations refer to the various ways in which words, phrases, or concepts are related to each other in meaning or in the context of language. These relations help us understand how different elements in a sentence or a larger discourse interact and convey information.

- Synonymy: Synonyms are words that have the same or similar meanings.
- Antonymy: Antonyms are words that have opposite meanings.
- Hyponymy/Hypernymy (Inclusion): a hierarchical relationship where a more specific term (hyponym) is related to a more general term (hypernym).
- Troponymy: Troponymy describes the relationship between a verb and its specific manner or way of action.
- Meronymy/Holonymy: a part-whole relationship, where a term (meronym) is a part or component of another term (holonym).

Semantic relations

- Homonymy: Homonyms are words that sound the same or have the same spelling but have different meanings.
- Polysemy: Polysemy occurs when a word has multiple related meanings.
- Metonymy: one word or phrase is substituted with another closely related term.
- Homophony: Homophones are words that sound the same but have different meanings and spellings.

Understanding these relations helps in interpreting language, disambiguating meanings, and building more sophisticated natural language processing systems.

Properties of relations

Determining the properties of relations includes signs related to their scope:

- identification of the level of participants (as classes or as specific entities); Semantic relations occur at all linguistic levels—between words, phrases, simple sentences, sentences, and larger text segments, as well as between documents and multiple documents.
- identification of number of participants in the relation and their cardinal or transitive orientation.

Properties of semantic relations

Murphy 2003 lists the following general properties of lexical-semantic relations:

- Productivity – potential for creating new relationships.
- Binarity (duality) – potential for connecting pairs of elements. Some relations, such as antonymy, are binary. A word can have at most one true antonym. Other semantic relations, such as synonymy, may refer to a set of words (ie, a word may have many synonyms).
- Variability – the potential to change the relationships between words depending on the meaning of the word used and the context.
- Prototypicality and canonicity – unambiguous canonical status of specific relations (for example, antonyms).
- Semi-semanticity – potential for identifying a given relation using non-semantic signs such as belonging to a given grammatical category; mutual selectivity; similarity in morphological form.
- Unenumerability – semantic relations are an open class and they cannot be enumerated or exhausted.
- Predictability – semantic relations follow certain general patterns and rules.
- Universality – the same types of semantic relations are used in all languages, and in different languages the same relations connect the same concepts.

Logical properties of semantic relations

Khoo and Na (2007):

• **Reflexivity:** a relation R is reflexive if it can connect an entity to itself. I.e. [x] –> (R) –> [x] is true for every x (e.g. the relation part of);

• **Symmetry**: a relation R is symmetric if the two participants in the relation can occupy any of the two positions. I.e. [x] –> (R) –> [y] implies that [y] –> (R) –> [x] (e.g. the relation synonymy);

• **Transitivity:** the relation R is transitive if [x] –> (R) –> [y] and [y] –> (R) –> [z] (e.g. hyponymic – hyperonymous relation);

• **Fixedness:** A relation R is fixed if a particular participant in the relation predetermines a well-defined other participant. I.e. [x] –> (R) –> [y] and [z] –> (R) –> [y] presupposes that x = z (e.g. the antonymy relation).

Relations can enter into relationships with each other. Such type of relations are, for example, similarity or opposition between relations. A relation R is the inverse of a relation S if both can accept the same pair of participants by reversing the direction of the two relations. I.e. [x] –> (R) –> [y] –> (S) –> [x] (e.g. parent-child relationships).

A relation may be a subordinate or specific manifestation of another.

Relationships can be organized in a hierarchy.

Types of semantic relations

Green (2001) defines three main metaclasses:

a) equivalence relations represented by synonymy and antonymy;

b) relations of hierarchy represented by hyponymy, inclusion and meronymy (relation between part and whole)

c) relations of associativity represented by the cause-effect relationship.

Pernishka (2014) addes,

d) subordination (inclusion),

e) intersection and opposition

f) semantic transfer (ambiguity) - metaphor, metonymy and enantiosemy,

Langacker (1987) groups the relations between the concepts in predicative groups:

g) nominal predications which name things and correspond to nouns;

h) relational predications which denote states, atemporal relations and processes and correspond to
adjectives, adverbs, prepositions and verbs;

i) terms and logical propositions of the first order.

Types of semantic relations

A number of theories underlie universal semantic parameters in language of the relationship between a certain situation and its participants. According to (Pustejovsky 1995, 1998), the meaning of words is a complex of four basic properties based on how people understand objects and relations in the world:

- A formal property (is_a; type_of; has_location) distinguishing objects within a broader category;
- Constitutive property (part_of) expressing the relationship between object and its constituent elements;
- Target property (effected_by; result_of, has_function), expressing the object's purpose and function;
- Agent property (is_agent; is_patient) expressing the origin or the occurrence of the object.

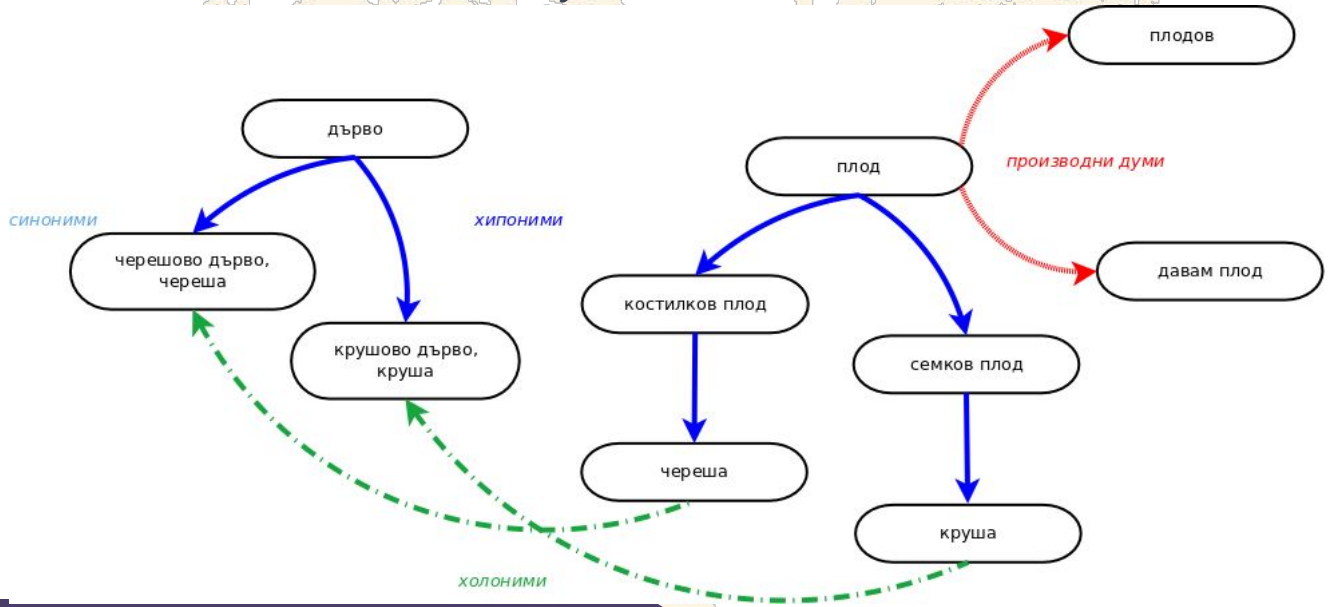
Types of semantic relations

Research derives semantic relations from the ability of words to express typical meanings when they are combined, manifested through the lexical combination of words.

Such are the descriptions, for example

- on predicate-argument relations based on syntactic properties and behavior (Levin 1993; Goldberg 1994, etc.),
- on thematic structure (Longacre 1976; Van Valin and LaPolla 1997), on lexical conceptual structure (Jackendoff 1990),
- on frame semantics (Fillmore 1982).

WordNet is a lexical database - semantic network where a word or words (simple or compound) name a unique concept and form a synonymous set and provides semantic relations between these synsets.



Semantic relations in Wordnet

WordNet is a lexical database that organizes words into synsets (sets of synonymous words) and provides semantic relations between these synsets.

Koeva (2007; 2014) groups relations in Wordnet in two types:

- lexical - between literals,
- and conceptual - between synonym sets.

“lexical relations can be semantic or derivational, and conceptual – semantic, morphological-semantic or extralinguistic.
Conceptual relations refer to all literals from the two synonym sets they link.
Lexical relations connect individual words within one or two synonymous sets'. They also form a network in which nodes are words, not synonymous sets, and arcs are lexical relations.

Semantic relations in Wordnet

Semantic relations (between synsets) from PWN

- Synonymy: WordNet primarily focuses on synonymy and organizes words into synsets, which are groups of words that are synonymous or have similar meanings. Synonyms are linked together within a synset.
- Antonymy: antonyms are words that have opposite meanings. Antonym pairs are linked through the "Antonym" relation.
- Hyponymy/Hypernymy: WordNet represents hierarchical relationships between words through hyponymy and hypernymy relations. A hyponym is a more specific term, while a hypernym is a more general term. For example, "apple" is a hyponym of the hypernym "fruit.
- Troponymy: WordNet represents verb relationships through troponymy. Troponyms are verbs that specify the manner, means, or method of an action. For example, "walk," "run," and "crawl" are troponyms of the verb "move."

Semantic relations in Wordnet

- Meronymy/Holonymy: a part-whole relations. A meronym is a part or component of a whole, while a holonym is the whole itself. For example, "wheel" is a meronym of "car," and "city" is a holonym of "building."
- Entailment: the relations between verbs where one verb action implies another verb action. For example, "sleep" entails "rest."
- Attribute: relations between adjectives and nouns. Adjectives that describe inherent properties or qualities of nouns are linked through attribute relations. For example, "big" is an attribute of "elephant."
- WordNet also includes words that are in the same category or share a similar context but are not hierarchical, linked through the "Also see" relation.

The semantic relations in WordNet allow for the exploration of word meanings, lexical relationships, and hierarchical structures, making it a valuable resource for natural language processing, semantic analysis, and knowledge representation.

Semantic relations in Wordnet

Organised around sets of related words (‘synonyms’): synonym sets (‘synsets’)
Relational structure:

- Main relation between nouns and between verbs: hypernymy/hyponymy.
- Nouns: meronymy;
- Verb - noun: morpho-semantic relations (derivational, semantic: agent, material, location, instrument…);
- Adjectives: antonymy; similarity; also see
- Adjective - noun: attribution; derivation; pertainimy
- Adjective - adverb: derivation
- Extralinguistic relations: …

Bulgarian Wordnet BulNet

- Parallel to the Princeton WordNet: manually > automatically (using machine translation) > manually
- Closed part-of-speech were added (in PWN: only open POS: nouns, adjectives, verbs, adverbs); in BulNet: prepositions, conjunctions, pronouns, interjections (added within the project for Bulgarian Sense Annotated Corpus)
- Culturally specific synsets: proper names, foods, drinks…
- Bulgarian Culinary WordNet 2020 (CulNet 2020): http://dcl.bas.bg/en/culnet-2020/

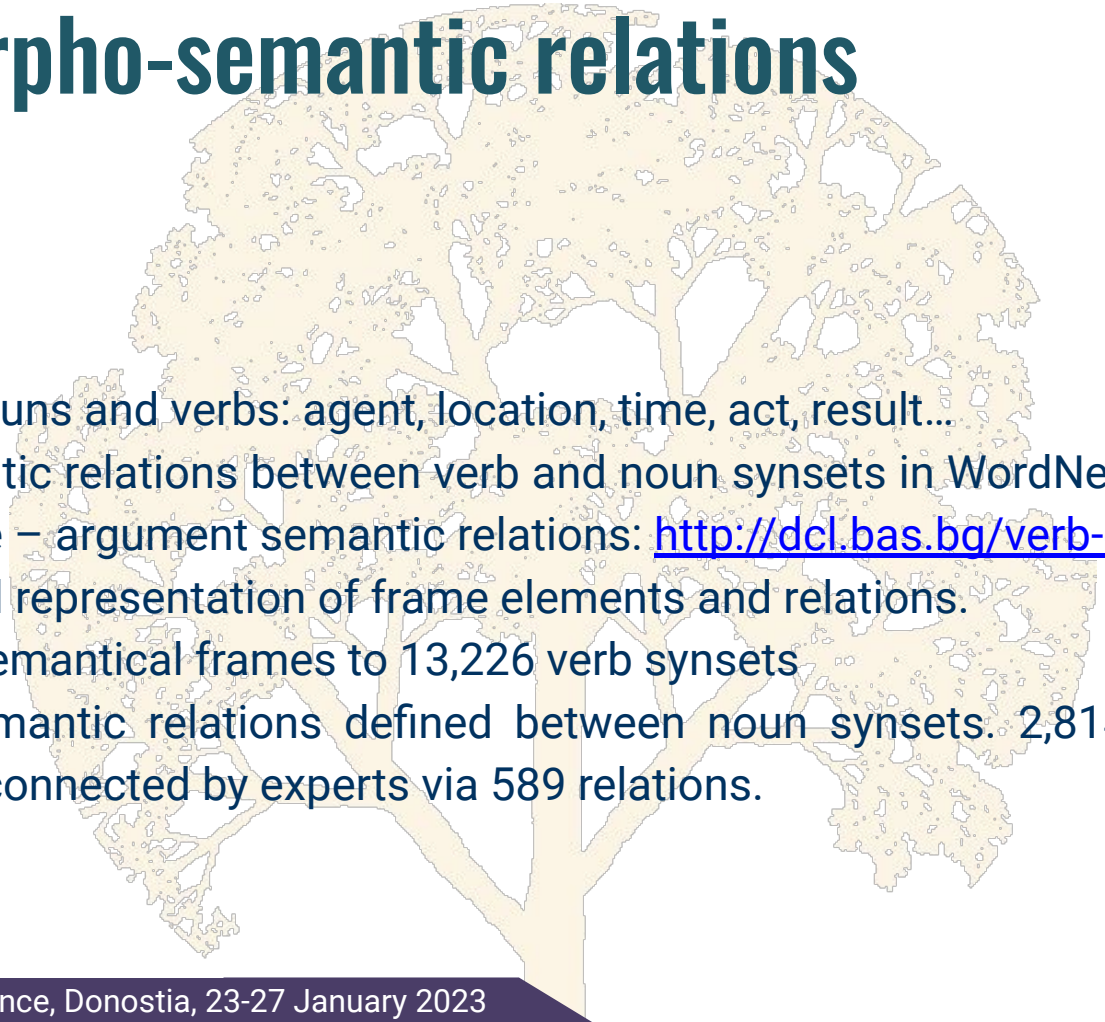
Classes (semantic primitives/primes)

- Nouns: 25 semantic classes: person, body, animal, plant, location, object, instrument, time, state, cognition, feeling, substance, material, food…
- Verbs: 15 semantic classes: act, event, state, result, cognition, consumption, body, contact, perception
- Adjectives: 3/4 in PWN: adj.all, adj.pert, adj.ppl; in Bulgarian Wordnet: 17 semantic classes: based on information from the related noun and verb synsets: body, feeling, behavior, substance, time, state, perception; (further: multiple - two or even three - classes)

Enriching BulNet with semantic relations

- Nouns: ontological hierarchy - CPA/Corpus Pattern Analysis (Hanks) that were additionally introduced: narrative, beverage, solid food, liquid food, skill, human role… http://dcl.bas.bg/PWN_CPA/
- Verbs: A newly proposed classification of verb synsets in WordNet according to their semantic primitives, common verb classes and subcategorization frames (validated against the hierarchical structure of FrameNet): http://dcl.bas.bg/verb-classification/
- Verified and extended models of the Pattern Dictionary of English Verbs – PDEV are added to the XML file of the Princeton WordNet and is available under the Creative Commons license: http://dcl.bas.bg/PWN_PDEV/

Morpho-semantic relations



- Between nouns and verbs: agent, location, time, act, result…
- New semantic relations between verb and noun synsets in WordNet corresponding to predicate – argument semantic relations: http://dcl.bas.bg/verb-classification/
- Hierarchical representation of frame elements and relations.
- Assigned semantical frames to 13,226 verb synsets
- 21 new semantic relations defined between noun synsets. 2,814 noun synsets have been connected by experts via 589 relations.

Semantic relations in FrameNet

FrameNet is a lexical database that focuses on the meaning and structure of words in relation to the frames or conceptual structures they evoke. IFrameNet provides a rich network of semantic relations that connect frames, lexical units, frame elements, and other linguistic units. This allows for a detailed analysis of how words and concepts are related and how they contribute to the overall meaning of a sentence or discourse. n FrameNet, semantic relations are organized around frames, which represent specific concepts or scenarios.

- Frame-to-frame relations: Frames in FrameNet are related to each other through several relations, such as inheritance, using frames as a subframe or superframe, or by being in the same frame hierarchy.
- Frame elements (FEs): FEs are the roles or semantic components associated with a frame. They represent the participants, attributes, or other semantic aspects of the frame. Each FE has a name and a description, and they are linked to lexical units (LUs) that evoke the frame.
- Lexical units (LUs): LUs are words or multi-word expressions that evoke a specific frame. LUs are linked to FEs, indicating the role they play within the frame. Different LUs may have different syntactic realizations but evoke the same frame.

Semantic relations in FrameNet

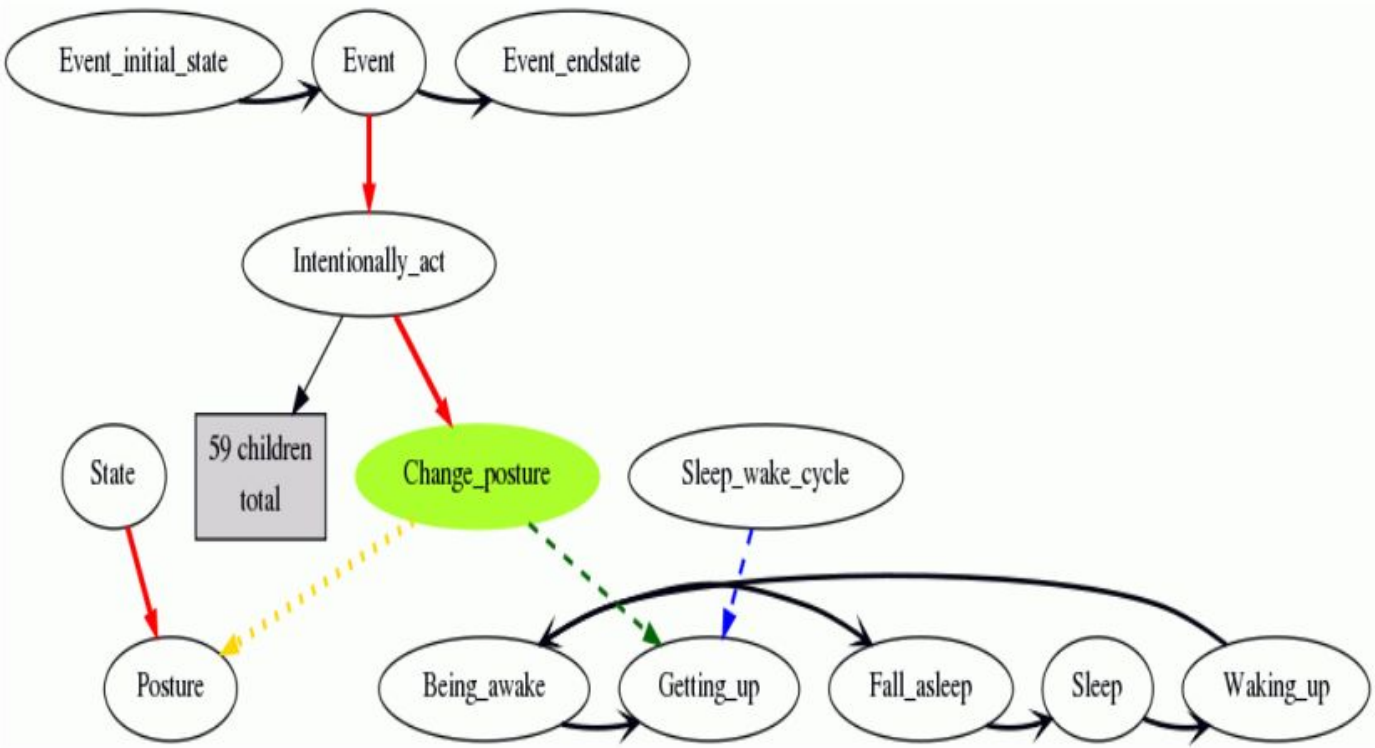
- Frame-to-LU relations: Frames and LUs are connected through relations such as "exemplifies," where an LU exemplifies a frame, or "subframe-of," where one frame is a subframe of another frame.
- Coreference: Coreference refers to the relationship between two or more LUs that refer to the same entity or concept. Coreferential LUs share the same frame and are related through coreference relations.
- Dependency relations: FrameNet also captures the dependency relations between words within a sentence. These relations help identify the role of a word in a sentence and how it relates to other words.
- Semantic roles: Semantic roles describe the grammatical and conceptual relationships between predicates and their arguments. FrameNet identifies and labels these roles within a frame's structure.

Semantic relations in FrameNet

FrameNet is internally organized into a network of relationships between conceptual frames, some of which internally organized into a network of relationships between conceptual frames,

- Inheritance - given frame is a subtype of parent frame. For example Change_posture frame is a descendant of I act_intentionally (Intentionally_act);
- Uses – the subframe implies or is placed in the context of the parent - Getting (Getting_up) Uses Change_Pose;
- Subframe – A subframe is a composite part of a more complex event represented by the parent frame, for example Getting up, Being_awake, Falling asleep (Fall_asleep), Sleeping (Sleep), Waking_up are subframes of Cycle_sleep_waking_up (sleep_wake_cycle);
- Precedes – a given frame precedes in time another frame with which it participates in a more complex event, for example Sleep Precedes Waking_up and Is_preceded_by Fall asleep (Fall_asleep).

Semantic relations in FrameNet



Applications

The complex representation of lexical and semantic knowledge has general theoretical importance, and its application is important for the successful development of linguistic resources and computer models for natural language processing at the semantic level.

- Modeling information about the relationships between concepts, between words, and between words and concepts in Wordnet finds various applications in automatic natural language processing: for automatically extracting relationships between different objects; for the purposes of searching and retrieving information and knowledge; to automatically resolve semantic ambiguity; for categorization of texts to certain thematic areas; to generate summaries of texts; for machine translation and many more.
- Machine learning, a part of the so-called artificial intelligence, is a system in which the computer receives input data and is trained to process it closer and closer to the human one. Algorithms are used to find patterns in data and make predictions or perform various tasks based on them.
- Modern language models use neural networks (generally, a system of information-filtering algorithms) to process and extract patterns and correlations in data. Different elements of the input data pass through the layers of the neural network, which consist of nodes called artificial neurons that "analyze" the data and create an output containing the analysis. The potential of a neural network to "capture" interesting and useful relationships in the data depends on the number of layers and nodes.

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Thank you for your attention!

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