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MOTIVATION OF MODELING COMMONSENSE REASONING PROCESS

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In this article, the role of classification reasoning in human commonsense (plausible) thinking is considered. Modeling this mode of thinking is a key problem for constructing Intelligent Computer Systems.
Key words: classification reasoning; plausible reasoning; machine learning; conceptual thinking.

Introduction

The symbolic methods of machine learning work on objects with symbolic, Boolean, integer, and categorical attributes. With this point of view, these methods can be considered as the methods of mining conceptual knowledge or the methods of conceptual learning.

In this article, we concentrate on the supervised conceptual learning methods. Until **now,** the theory of logical inference does not include classification reasoning as its inalienable component, although precisely the classification reasoning constitutes an integral part of any mode of reasoning. Furthermore, the current models of commonsense reasoning do not include classification too. However**,** the role of classification in inferences is enormous. Classification**,** as a process of thinking**,** performs the following operations:

1) forming knowledge and data contexts adequate to a current situation of reasoning;
2) reducing the domain of searching for a solution of some problem;
3) generalizing or specifying object descriptions;
4) interpreting logical expressions on a set of all thinkable objects;
5) revealing essential elements of reasoning (objects, attributes, values of attributes etc.);
6) revealing the links of object sets and their descriptions with external contexts interrelated with them. This list can be continued.

We believe that conceptual learning is a special class of methods based on mining and using conceptual knowledge the elements of which are objects, attributes (values of attributes), classifications (partitions of objects into disjoint blocks), and links between them. These links are expressed by the use of implications: “object ↔ class”, “object ↔ property”, “values of attributes ↔ class”, and “subclass ↔ class”.

We understand commonsense (or plausible) reasoning as a process of thinking based on which the causal connections between objects, their properties and classes of objects are revealed. In fact, commonsense reasoning is critical for the formation of conceptual knowledge or ontology in the contemporary terminology.

Studying the processes of classification within the framework of machine learning and knowledge discovery led to the necessity of reformulating the entire class of symbolic machine learning problems as the problems of finding approximations of a given classification of objects. This reformulation is based on the concept of a good diagnostic test (GDT) for the given classification of objects [Naidenova, 1992]. A good classification test has a dual nature. On the one hand, it is a logical expression in the form of implication or functional dependency; on the other hand, it generates the partition of a set of objects equivalent to the given classification of this set or the partition that is nearest to the given classification with respect to the inclusion relation between partitions.

If we take into account that implications express relations between concepts (the object ↔ the class, the object ↔ the property, the property ↔ the class), we can assume that schemes of inferring and applying implications (rules of the “if–then” type) form the core of classification processes, which, in turn, form the basis of commonsense reasoning. Deductive steps of commonsense reasoning imply using known facts and statements of the “if–then” type to infer consequences from them. To do it, deductive rules of reasoning are applied, the main forms of which are modus ponens, modus tollens, modus ponendo tollens and modus tollendo ponens. Inductive steps imply applying data and existing knowledge to infer new implicative assertions and correct those that turned out to be in contradiction with the existing knowledge. These steps rely on inductive rules of reasoning represented by inductive canons stated by British logician John Stuart Mill: the Methods of Agreement, the Method of Difference, the Joint Method of Agreement and Difference, the Method of Concomitant Variations and the Method of Residues.

The task of inferring all good diagnostic tests is formulated as searching for the best approximations of a given classification (a partitioning) on a given set of objects. A whole class of machine learning problems, namely, symbolic supervised learning can be reduced to inferring good classification tests from a given dataset (contexts). Good classification tests serve as left parts of implicative assertions, functional dependencies, and association rules.

The concept of a good classification (diagnostic) test underpins our approach to commonsense reasoning.

The analysis of algorithms of searching for all good diagnostic tests in terms of constructing Galois lattice allowed us to decompose algorithms into sub-problems and operations that represent known deductive and inductive modes (modus operandi) of commonsense reasoning. Each step of constructing a classification lattice can be interpreted as a mental act. These mental acts can be found in any reasoning: stating new propositions, choosing the relevant part of knowledge and/or data for further steps of reasoning, involving a new rule of reasoning (deductive, abductive, inductive, traductive, etc.).

The inferences of lattice construction engage both inductive and deductive reasoning rules. The implicative dependencies (implications, interdictions, rules of compatibility) generated in a process of good tests construction are used immediately in this process for pruning the search space with the aid of deduction.

Note that reasoning begins with using mechanisms for restricting the search space: 1) for each set of values (objects), to avoid constructing all its subsets, 2) for each step of reasoning, to choose a set of values (objects) without which solutions cannot be constructed. For this goal, admissible and essential values (objects) are determined. The search for the admissible or essential values (objects) uses inductive diagnostic rules.

Reasoning requires a lot of techniques related to increasing its efficiency such as valuation, anticipation, making hypotheses, probable reasoning, generalization, and specification. One of the important techniques is decomposition of the main problem into sub-problems. It implies using the following operations: choosing sub-problems, ordering sub-problems (ordering arguments, attributes, objects, variables, etc.), optimizing sub-problem selection, and some others. The most familiar examples of sub-problem ordering are so called tree-like scanning and level wise scanning methods. Some interesting variations of selecting sub-problems are the choice of a more flexible sub-problem, for example, one with minimal difference from a previous sub-problem and a sub-problem with minimal possible number of new solutions [Zakrevskij, 2013]. Intermediate results of reasoning are used for decreasing or locally bounding the number of sub-problems. Furthermore, it is required, in some cases to use equivalent transformations of data structures. As a whole, reasoning can be considered as gradually extending and narrowing the context of reasoning.

1. Commonsense reasoning in Intelligent Computer Systems

We shall consider the intelligent computer system as a system capable to communicate with the users by means of commonsense reasoning on conceptual knowledge rather than by means of special formal query languages. One of the main principles, which is posed in the foundation of intelligent computer systems, says: “Knowledge is a Means of Data Organization and Management”.

The inseparability of data from knowledge with respect to their interacting is manifested in the fact that knowledge governs the process of inputting data in databases. First, there is a mechanism (or it must exist) of recognizing the fact that an inputted portion of information was already earlier perceived or already known, and revealing data not having appeared earlier or not corresponding to what earlier was known. For example, if it was known that birds have wings and fly, but information appears, that X is a bird, has wings, but it does not fly, then “knowing system” must ask how it is necessary to change the knowledge. The formation of knowledge cannot be without this ability to ask. Probably, the computer knowledge base must know how to pose these questions and to obtain the answers to modify the knowledge Base.

In the process of analyzing new data, the necessity also occurs to generate an appropriate context of reasoning. We believe that knowledge must serve for managing the processes of data entering and organization and data must aim at developing knowledge.

The queries to intelligent computer systems can be of the following types:

The factual queries when the answers can be obtained directly from the data;

The conceptual queries when the answers can be obtained via the knowledge.

Consequently, the intelligent system must be capable of recognizing the type of query. The conceptual queries must be interpreted (understood) via the knowledge. Furthermore, answering conceptual questions requires communication between data and knowledge. An intelligent system works like a thinking individual as follows:

PERCEPTION PHASE or ENTERING THE QUERY;

COMPREHENSION or UNDERSTANDING THE QUERY (pattern recognition phase);

FULFILLMENT OF ANSWER TO THE QUERY (commonsense reasoning phase);

QUERYING THE USER if it is necessary and RETURNING to the phase of PERCEPTION.

Entering data/knowledge can have different goals:

"IT IS NECESSARY TO KNOW" is a simple message of the user;

"ENTERING NEW DATA WITH ASSIMILATIONS OF THEM by the INTELLIGENT SYSTEM"; it implies the implementation of a dialog interface and a supervised or unsupervised learning process; the result of this process is the upgraded knowledge.

The incorporation of a commonsense reasoning mechanism into data-knowledge processing is becoming an urgent task in intelligent computer systems and conceptual data-knowledge design.

We take into account that data are the source of conceptual knowledge and that knowledge is the means of data organization and management. The following processes are based on commonsense reasoning.

1. Entering and eliminating data:

a) Entering data: by the user or by querying from the side of an intelligent system;

b) Eliminating data: by the user or by an intelligent system (for example, "freezing" data-knowledge).

Entering data by the user implies solving a pattern recognition task. In fact, entering data means enlarging and correcting knowledge such that it will be consistent with the current situation (data).

Eliminating data implies eliminating knowledge inferable from this data. This is the deductive phase of commonsense reasoning.

2. Deductive and inductive query answering requires commonsense reasoning in the form of a dialog between a user and an intelligent system or/and between an intelligent system and an ontology. This reasoning includes:

a) Pattern recognition of the meaning of query (what is required: fact, example, sets of examples, concept, dependency, or classification?);

b) Forming the context of a query (domain of reasoning);

c) Pattern recognition of conceptual level of a query:

Factual level;

Conceptual level with a certain degree of generalization.

There can be the following variants of answering questions:

Reply is in the context of reasoning;

Reply is inferred from the context of reasoning;

Reply requires entering or inferring new knowledge.

Answering questions is connected with extending data about the situation (query) consistent with the system's knowledge or enlarging the context of reasoning and involving inductive steps of inferring (machine learning) new knowledge.

3. Knowledge optimization is a task for the intelligent system itself, consequently, it requires unsupervised conceptual learning (self-learning) based on unsupervised conceptual clustering (or object generalization) and interpreting the results of clustering (or generalization) via the system's or ontological knowledge.

4. Automated development of intelligent systems with the incorporated commonsense reasoning mechanisms is currently not supported by any programming language or programming technology. This technology must include:

The possibility to specify concepts (objects) with their properties and inferential links between them;

The possibility to induce some constituent elements of the intelligent system's knowledge from data by the use of learning mechanisms;

The possibility to incorporate the mechanisms of commonsense reasoning in intelligent systems.

2. The system of Interrelating Classification Operations

2.1. The Operations of Addition and Multiplication Given on the Set of Classes

Two operations are given on the set of classes' names: the addition operation + and the multiplication operation °. To add classes *A* and *B* means to define class *D* of all objects possessing the common properties of classes *A* and *B*: $d = a \cap b$, where *a*, *b*, *d* are the set of properties of objects of classes *A*, *B*, *D*, accordingly.

We call $I(x)$, where *x* is the set of properties of some set of objects the interpretation of *x* in the power set 2^G, where G is the set of all objects to be considered.

For example, *A* - the class of '*blue wooden beads*', *B* - the class of '*white wooden beads*', *D* - the class of '*wooden beads*': *I*(*wooden beads*) = *I*(*blue wooden beads*) $\cup$ *I*(*white wooden beads*) and at the same time *d* = '*blue wooden beads*' $\cap$ '*white wooden beads*' = '*wooden beads*'.

It is insufficient to have only addition operation to deals with classes. How could one form the set of objects possessing at the same time the properties of different classes, for example, "water transport", "mountain landscape", throat-microphone, "snow-slip", "tragicomedy" and so forth. We need in multiplication operation.

To multiply classes *A* and *B* means to define class *D* of all objects having all the properties of class *A* and all the properties of class *B*, that is $d = a \cup b$. For example, *A* - '*a person who has a child*', *B* - '*a person who is a man*', *D* - '*father*': *I*(*father*) = *I*(*a person who has a child*) $\cap$ *I*(*a person who is a man*) and *d* = '*has a child*' $\cup$ '*is a man*'.

For the completeness of operation's definition, we shall consider the cases of empty interpretation and empty description. It is possible that the multiplication operation has not a result because of obtaining empty interpretation. In this case, the description obtained is said to be contradictory and to be equal to the special symbol α - 'inconsistent description'.

Also, it is possible that the result of addition operation is a class with empty description. It means that the objects of the class obtained have no common property. In this case, the description of this class is said to be equal to the special symbol ω.

2.3. The Operations of Subtraction and Division Given on the Set of Classes

One of the important aspects of mental operations is their reversibility [Piaget & Inhelder, 1959]. Addition operation has subtraction as its reverse operation. (A = D - B). Reverse operation with respect to multiplication operation is division (A = D : B). If subtraction is easy to understand (it is the dissociation of classes), then for division operation it is not the case. Consider the meaning of division operation. For example, a child saw a fox at the picture but he said that it is a dog. According to a child, a dog and a fox are very similar. However, an adult does not agree with the child, he begins to explain: it is not a dog, it does not bike, a fox is wild, it lives in the forest, steals hens, a dog does not do this, it lives at home with people, and it guards hens, eats meals of people and so on. Division operation is necessary for differentiating two concepts. Let's the concept Z be equal to DOG + FOX, z be the common property for dog and fox. To divide concepts is to find a property y such that the union of y and z results in the property $c = y \cup z$ corresponding only with the set of dogs and only with this set: I (c) = I(DOG).

2.4. The Operations of Generalization and Specification Given on the Set of Objects' Descriptions

Two operations are given on the sets of objects' descriptions: the operation *, or the generalization operation, and the operation $\bullet$, or the specification or refinement operation. The first one produces for any pair of descriptions $C(o_1)$, $C(o_2)$ their maximal common part $C(o_1) \cap C(o_2)$, the second one produces the minimal description including (containing) $C(o_1)$ and $C(o_2)$, that is $C(o_1) \cup C(o_2)$.

If the result of generalization operation is equal to ω, then it means that object o_1 is unlike o_2. The specification operation is not defined in case of $C(o_1)$ and $C(o_2)$ are inconsistent ($I(C(o_1) \cap I(C(o_2) = empty$). Then the result of this operation will be equal a special symbol α. It means that there is no object which possesses $C(o_1)$, ($C(o_2)$ at a time.

Boldyrev, N.G. (1974) advanced a formalization of object description procedures as algebra with two binary operations of refinement and generalization defined by an axiom system including lattice axioms. This work turned to be basic for developing the classification theory in the scope of algebraic lattices.

2.5. The Set-Theoretical Operations Given on the Set of all Subsets of Objects

The set-theoretical operations of union $\cup$ and intersection $\cap$ are given on the set of all subsets of objects and, consequently, on the set of all classes of objects.

Let X be a set of objects. A non-empty class $L(X)$ of subsets of X such that the union and the intersection of two sets belonging to $L(X)$ also belong to $L(X)$ is an example of a lattice, called a *lattice of sets* or *set lattice* (Rasiova, 1974).

The coordination of classification operations means that the operations on classes' names, on conceivable objects and on objects' descriptions are performed simultaneously and they are in agreement with one another.

The coordinated classification operations generate logical implicative assertions. These assertions can be understood if classifications are performed as the system of coordinated operations. The classification operations are connected with understanding the operations of quantification: "not all c are a", "all b are c", "no b are c", "some c are b", "some b are not a" and so on. The violation of the coordinated classification operations implies the violation of reasoning. Piaget & Inhelder (1959) have shown that

1) Classification reasoning is a result of gradual development of a person;

2) Appearing the ability to apply formal logical operations is connected with spontaneous appearing the ability to coordinate mental operations;

3) A key problem of the development of operational classification in mind is the problem of understanding the inclusion relation. If understanding this relation is not achieved by a person, then it is impossible for him to understand both the classification and quantification operations.

3. Reasoning as Searching for the Equivalence Relationships on a Set of Expressions

In mind, we operate only on words or names (common or proper). A name can be the name of an object, the name of a class of objects and the name of a classification or collection of classes. A class of objects can contain only one object hence the name of an object is a particular case of the name of a class. Analogically, the name of a class is a particular case of the name of a classification. In the knowledge bases, names of objects and of classes of objects become names of attribute values, and names of classifications become names of attributes.

The equivalence relations on names serve as the foundation of commonsense reasoning. For example the expression "Whale is a mammal" is true because of the fact that the property C exists such that the following expressions occur simultaneously: "*Whale* $\leq$ *C*" and "*mammal* = *C*", interpreted on the set of all thinkable animals. By the law of transitivity, we have "*whale* $\leq$ *mammal*".

In the thinking, some concepts are determined via others with the aid of equivalence relations between their names, for example, "father is a man having a child" is the word representation of the dependency on classification names "(*father* = *man*) and (*to have a child*)", interpreted on the set of all thinkable men. The knowledge of equivalence relations on the names of classifications makes it possible to draw the conclusions, which would be impossible without this knowledge.

Assume that in one of the agencies the unemployed persons of young age and the unemployed women are registered. Can one infer that, in this agency, unemployed young women are registered too (in other words, whether the interpretation of expression "(*unemployed*) and (*young*) and (*women*)" is not empty set)? No, it is impossible to achieve this conclusion. But if it is known that "*unemployed* ≤ *young*", then it is possible to assert that there are "*unemployed young women*" in the agency [Laurent, & Spyratos, 1988].

With the use of the + and ° operations on names of classes, of the * and • operations on descriptions of objects we produce the expressions which are interpreted with the use of the set-theoretical operations on the set of all subsets of objects, but the mechanisms of generating expressions do not exhaust reasoning. The main point of reasoning is finding the equivalences between the expressions constructed over the names of classes or properties. Two expressions are equivalent if their interpretations are equal. Already the act itself of constructing a class requires establishing the identity between the name of the class and the expression on the object properties defining this class.

The equivalent expressions are simply the different names of the same interpretation. For example, we can meet in the crosswords the following definitions of the concepts requested: "it is the same that destiny", "the title of prince of royal dynasty in Spain and Portugal", "a fodder or food plant with fleshy root". Defining the equivalence of words (expressions) underlies not only constructing concepts and their definitions via object properties but also updating conceptual knowledge, diagnostic reasoning, supplementing imperfect descriptions of objects (classes, situations) with new properties, inferring causal dependencies between properties, and functional dependencies between classifications.

Defining a class of objects via the properties of objects is the traditional task of learning concepts from examples. The relationships between properties are implications in the form $a\ b\ c\ \rightarrow p$, where a, b, c – properties of objects or values of corresponding attributes, p – the name of class of object.

The relationships between classes are defined by the relationships between properties of object belonging to these classes. These relationships generate hierarchical structures on the names of classes coordinated with the structures of properties and the structures of appropriate sets of objects used for interpreting considered classes and properties. The inference of these relationships is also one of the machine learning problems. Moreover, this inference is basic to creating the methodology of ontology construction.

The relationships between classifications are expressed formally by functional dependencies between attributes of objects. The inference of these relationships can be considered as hierarchical knowledge integration.

The principle concept of the GTA is the concept of classification. To give a target classification of objects, we use an additional attribute *KL* not belonging to *U*. A target attribute partitions a given set of objects into disjoint classes the number of which is equal to the number of values of this attribute.

In case of inferring implicative dependencies, we have two classes: 1) the objects in description of which the target value *k* appears (positive examples); 2) all the other objects (negative examples).

Let $M = \{\cup\ \mathrm{dom}(attr),\ attr \subseteq U\}$, where dom(*attr*) is the set of all values of *attr*. Let $X \subseteq M$. Let G be the set of objects considered, $G = G_+ \cup G_-$, where G_+ and G_- the sets of positive and negative objects, respectively; let P(*X*) = {all the objects in description of which *X* appears}. We call P(*X*) the interpretation of *X* in the power set 2^G. If P(*X*) contains only positive objects and the number of these objects more than 2, then we call *X* a description of some positive objects or a test for positive objects.

We define a good test or good description for a subset of positive objects as follows.

Definition 1. A set $X \subseteq M$ of attribute values is a good test for a subset of positive objects if it is a test and no such subset $Y \subseteq M$ exists, so that $P(X) \subset P(Y) \subseteq G_+$.

In [Naidenova, 1992], it is proven that this problem is reduced to searching for causal dependencies in the form $X \rightarrow v$, $X \subseteq M$, v is the name of the given class of positive examples.

Now consider a given classification *K* and the attributes of *U* from the point of view of the partitions which are induced by the attribute values on the set *G*. The good test for a given classification is defined on the base of partition model for relations [Naidenova, 1982; 2012].

We shall use Kl(*A*) to denote the partition by a collection *A* of attributes on the set of objects, and we use $\mathrm{Kl}(A) \otimes \mathrm{Kl}(B)$ to denote the product of two partitions Kl(*A*) and Kl(*B*). The relation of partial order over a set of partitions is introduced in the standard way: $\mathrm{Kl}(A) \le \mathrm{Kl(B)}$ iff $\mathrm{Kl}(A) \otimes \mathrm{Kl}(B) = \mathrm{Kl}(A)$ [Ore, 1942].

Let K be an additional attributes (or a set of attributes) the values of which partition a given set of objects into disjoint classes.

Definition 2. A subset *A* of *U* is a test for a given classification *K* of a given set of objects, if the following condition is satisfied: $\mathrm{Kl}(A) \le \mathrm{Kl}(K)$ $(\mathrm{Kl}(X) \otimes \mathrm{Kl}(K) = \mathrm{Kl}(X))$.

Definition 3. A test *A* in *U* for a given classification *K* for a given set of objects is said to be good if the following condition holds: $(\forall Y \subseteq U)\ (\mathrm{Kl}(Y) \le \mathrm{Kl}(K))\ (\mathrm{Kl}(A) \le \mathrm{Kl}(Y)) \Rightarrow \mathrm{Kl}(Y) = \mathrm{Kl}(A)$.

In [Naidenova, 1982], it is proven that this problem is reduced to searching for functional dependencies in the form $A \rightarrow K$, $A \subseteq U$, $K \not\subset U$.

By constructing the all good tests for classes of objects or for classifications of objects, we obtain the expressions of two kinds: $A_1 \cup A_2 \cup \ldots \cup A_m \rightarrow K$ and $X_1 \cup X_2 \cup \ldots \cup X_m \rightarrow v$. Thus, the Good Tests Analysis allows constructing, simultaneously, the hierarchical structures of object classifications and the descriptions of object classes in terms of their properties. This knowledge can be used for realizing human commonsense reasoning.

4. Reasoning as a Special Kind of Computing

Reasoning can be reduced to solving the equations of the following types:

a) "Call things by their correct names": $y = \varphi (x)$, $x = a$, $y = ?$

b) Find the interpretation x satisfying the equality of expressions $\varphi 1$, $\varphi 2$:$\varphi 1(x) = \varphi 2(x)$ or $a = \varphi 1(x)$;

c) "Approximate φ () with the use of $\varphi 1()$,$\varphi 2()$, …, $\varphi k()$ and the set of given operations.

In these equations, x is a sub-domain of reasoning and φ is an expression on the names the interpretation of which is equal to or included in x. Given y, it is necessary to find an interpretation x satisfying the equation $y = \varphi (x)$; Given x it is necessary to find y as an expression the interpretation of which is equal to or included in x.

Example 1. y = "*an infectious children's disease * name of 5 letters * the fist letter is* "*m*" * *the last letter is* "*s*" (x)". To find x is to find the name of the concrete children's disease: x = *mumps*.

Example 2. $y = \varphi$(*voltmeter*); voltmeter belongs to a class of electric instruments, since "*voltmeter ≤ electric instrument*". Furthermore, this instrument serves for measuring tension. Thus, y = *electric instrument * measuring tension*".

Example 3. $y = \varphi$(*quilted jacket*); y = "*warm clothing *working clothing* wadded jacket *jacket without the collar*".

Example 4. "$y_1 + y_2$ * *blue* = φ(*good weather*) ". Let us define this expression so that it would not contradict with the observed true situation: "*the sun + the sky * blue*.

In resolving equations, the passages from the expressions to their interpretations and from some expressions to the others through the known dependences between them are performed.

For example, assume that the expression "*birthday in the piggery*" is given. It is necessary to find another equivalent expression, which consists of one word (this example is taken from a crosswords).

The concept "*birthday*" defines the region of reasoning or the region of interpretation "*the living beings*" ("*the living beings ≤ birthday*"). Note that the region of interpretation is expressed by using words, i., e., by using its name. Thus, we pass from the properties to the names of their interpretations. Since the discussion deals with the piggery, then the region of reasoning is "*the living beings born in the piggery*".

The contraction of the region of reasoning occurs by means of the multiplication of properties "*the living beings * born * in the piggery*".

But "*the living beings born in the piggery*" = "*piggy*", thus, we pass to the search for equivalent expression for y = "*the birthday * piggy*". It is now clear that y = "*farrow*".

Conclusion

In this chapter, we examined the classification as the system of interconnected structures of objects, properties and classes together with the operations, with the aid of which these structures are built.

We showed that the structural connections between classes and properties of objects, between different classes, and between properties of objects make it possible to build logical expressions on the names of objects, classes and properties, interpreted on the set of all subsets of conceivable objects.

The tasks of machine learning deal with mining the classification connections making it possible to establish equivalence relations between the logical expressions, utilized in the processes of commonsense reasoning.

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ОБОСНОВАНИЕ МОДЕЛИРОВАНИЯ ПРОЦЕССОВ ПРАВДОПОДОБНЫХ РАССУЖДЕНИЙ

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В статье рассматривается роль классификационных рассуждений в человеческих правдоподобных рассуждениях. Моделирование этого типа мышления является ключевой проблемой для конструирования интеллектуальных компьютерных систем.

Ключевые слова: классификационные рассуждение; правдоподобные рассуждения; машинное обучение; концептуальное мышление.