Semantic analysis methods usage for the implementation of systems of graphic objects content analysis

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Abstract

The solution to the problem of reducing data flows about graphic objects was carried out mainly by developing coding and compression formats. Among those methods of statistical compression considering psychovisual and psychophysical properties of human multimedia information perception are particularly effective. However, in terms of implementation, this is an extensive rather than intensive way of development solving the problem of reducing data flows between individual nodes of the system. To make decisions, the operator needs those graphic objects that provide a solution to the given task, which requires organizing the search for the necessary graphic objects among the entire set in the data store. The user compares the given fragment with the obtained search result using a graphical representation of the data, which causes additional time costs. Special complications arise graphic objects data is being processed, since information about each image can be characterized by different criteria. In addition, the constant growth of the volume of information causes a decrease in its effectiveness. It is appropriate to define criteria for data processing and retrieval and to outline approaches for evaluating the quality of retrieval. Existing methods and means of semantic description and analysis of a graphic object require the operator's participation at the pre-processing stage, so their implementation requires additional research to improve work efficiency. The analysis of existing methods shows that a significant simplification of the solution of individual storage and search problems can be achieved by structuring the description of data in repositories using a specially created semantic description for this purpose. However, now these methods are practically not used to organize information search, and their implementation in search engines requires significant time and system resources.

Keywords

graphic objects, semantic analysis, semantic significance of elements

1. Introduction

The article considers approaches of information technology creation for searching graphic data by the content of graphic objects based on their semantic analysis. Before considering the

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method, it is necessary to dwell on some conceptual provisions regarding semantics. First of all, we note that the term "semantics" is used in different works in different aspects that determine its meaning. In the theory of information, which investigates general scientific methodological problems of the development of science, information and semantics are considered as concepts that are close in essence [1, 2]. To implement semantic analysis, the concept of a semantic unit is introduced, which is compared with elements of information, determined by them and serves as a hypothetical unit of information measure [3, 4]. Such concepts replacement makes it possible to confirm to a certain extent the correctness of the known ratios that were built to describe the technical processes under study. At the same time, there was a need to carry out quantitative assessments of parameters for their description. The most popular example is the technical process associated with the transmission of digital data through communication channels. The study of this process led to the creation of ideas about information and its amount. In order to calculate the numerical values of information amount, appropriate expressions were discussed. The proposed ratios allowed a non-controversial interpretation and gained the greatest popularity thanks to the works of K. Shanon [3, 5]. Thus, the concepts of semantics and information are related and closely intertwined.

The purpose of the work is to develop and research the principles of semantic analysis implementation and the use of its capabilities in the organization of searching by the graphic object content.

2. Related works

Today, there is a fairly large number of algorithms and methods of graphic data analysis that are used in various areas of digital information processing: from the fight against spam to systems for passenger traffic tracking [6, 7].

We will dive into the most common methods of image content analysis:

- frequency-spatial display of a graphic object;
- image histograms.

Image analysis can be interpreted as its recognition, i.e. the maximum compression of the volume of information to eliminate the redundancy of processed images. Several difficulties arise in solving this problem: algorithmic and technical implementation. The compression algorithm should be sufficiently reliable and at the same time, if possible, economical. The search for effective algorithms is now carried out by researching the mechanisms of the brain, as well as the development and research of various recognition programs.

The technical complexity is caused primarily by relatively low speed and insufficient memory capacity. In addition, they are poorly adapted to the input and processing of multidimensional arrays of information, which are images.

The task of automatic analysis is reduced to finding some function that maps a set of images into a set whose elements are image classes. The process of determining such function should be carried out in three stages [8, 9, 10]:

1. Preliminary processing. A given image $f(x,y)$ will be transformed into one or more new images $\{f_1(x,y),...,f_n(x,y)\}$ by some set or sequence of certain operations.

2. Identification of signs. The image $f_i(x, y)$ is transformed with the help of $F_1,...,F_m$, functions that determine the features, as a result of which the image is coded.
3. Classification. As a result of these stages, a set of data appears, which can be considered the features of the initial image $f(x, y)$.

This set should be considered as a point in n-dimensional space. If the areas occupied by a class in this space are indicated or the probability density for each class is specified on it, then, using measures of geometric proximity and maximum likelihood, this image can be assigned to a certain class, that is, "classified."

The first two stages — image pre-processing and feature selection — are quite difficult. This is due to the redundancy of the image due to the presence of an extra background; uncertainty of position, orientation, scale; therefore, the correct choice of various methods of image filtering, normalization, obtaining invariants, etc., is of great importance.

The procedure of forming signs or parameters of the primary description, which is a transition from a two-dimensional function (image) to a system of numbers (signs), can be interpreted as a task of some functionality.

The third stage of solving the problem of analysis — classification, associated with the performance of a complex of simple arithmetic or logical operations, can be successfully solved with the use of computer technology.

Therefore, in the images analysis there are mainly difficulties associated with pre-processing and selection of features.

During analysis tasks solving, two groups of tasks can be distinguished. The first one is when the information is contained in the integral properties of the entire image (textures — cloud cover, interferograms and shadow pictures, etc.). Such tasks are solved by analysing the statistical properties of a objects set that are combined simultaneously in the field of vision, without considering the individual local properties of each of them separately. To compress the information in such images, the histograms of the informative parameters' distribution most related to image decomposition need to be used. The second group is the recognition of individual objects (or fragments) according to the given geometric parameters and their selection against the background of objects collection, their counting, which is another method of images abbreviated description.

3. Semantic analysis implementation principles for searching by the content of a graphic

The basis of any semantic analysis are the following factors:

- availability of an interpretation system;
- rules of the interpretation system usage;
- homomorphism between the rules for using the interpretation system and the rules for building and presenting the objects to be interpreted;
- semantic consistency of the description system and presentation of the graphic objects interpretation system.

First, it is needed to be noted that in this case only graphic objects will be discussed and only their semantic analysis will be investigated. The constituent parts of the interpretation system are the following components:

- semantic dictionary of the graphic objects system S_c;
- semantic environment $G(S_c)$;
- a system of environment rules, which is formally recorded in the form $\Sigma = \{\xi_1, \xi_2, ..., \xi_n\}$.

A semantic dictionary S_c — is an ordered set of attributes, primitives, and elements used to describe graphical objects. Each of the attributes, primitives and elements is defined by a certain identifier, which will be used later for formal description as the value of a certain variable. It is considered that each individual graphic object as an object from which primary attributes or graphic primitives can be isolated.

Semantic dictionary S_c is a more complex structure than a traditional language dictionary, as it is focused on solving problems related to the semantic analysis of the graphic object content. Given that the attributes and graphic primitives that we will use to describe graphic objects are a limited set, it is possible to structure a corresponding dictionary. If necessary, the dictionary will only grow due to attributes or new primitives. For example, among the dictionary elements, you can introduce a certain hierarchical dependence of the importance of the elements in the description of the subject area. This principle is widely used in various analysers and is known as the principle of determining key, or control, elements [11, 12]. Such structuring can be complicated and developed. The minimum level of S_c dictionary structure is the assignment of key elements in the dictionary, and the maximum level of S_c dictionary structure is the degeneration of the semantic dictionary into a set of fragments of graphic objects that determine the only possible forms and ways of describing graphic objects

For the full operation of the system, it is necessary to investigate the possibility of creating a system for evaluating the search engine quality based on the use of semantic analysers. In this case, the task of creating and researching search result evaluation models for a certain system arises. To create them, you can use the following approaches that make it possible to solve the problem of determining the search evaluation in graphic objects at the semantic level:

- view of the analysis of the reduction degree in the effectiveness of the system's functioning;
- system load measures;
- the strategic significance of the object and the search result.

Let us consider in more detail the approaches to the implementation of semantic search of graphic objects by content.

The first approach consists of the semantic loading implementation of the its carriers, which for a graphic object are attributes, primitives, elements, their sets, fragments and the object in general. The listed components are means that are directly placed in the graphic object and actually form this object. Mediated carriers of semantics are the means by which objects are created or analysed. These include the following components:

- semantic dictionary structure $G(S_c)$;
- a system of rules for building graphic objects $\psi = \{\psi_1, ..., \psi_n\}$;
- a system of parameters characterizing the object $P = \{P_c, ..., P_k\}$.

Lets consider a possible formal description of the semantic structure of the dictionary.

Assigning a key value attribute x_i from the S_c dictionary means the value of its semantic significance for the entire environment of the subject area. It is obvious that the degree of such significance can be different for different attributes and primitives. This means that the S_c dictionary can be partitioned into subsets that combine sets of attributes or primitives with equal or close values of semantic significance. Such subsets are independent of the specific interpretation of a particular set of elements $I(x_i)$. Therefore, it is possible to formally represent the simplest structure of the S_c dictionary in the form of a $D(S_c)$ tree. Semantic criticality k_i of an attribute x_i of a $x_i(k_i)$ set can have a certain level in the given context of using other attributes and primitives with lower levels of criticality, for which $k_j < k_i$ is a critical element in S_c if $x_i(k_i)$. Such element will be called a key. We will assume that critical dependence on the context can be developed only at one level of the hierarchy of the degree of significance of the elements of the context. Further measures of significance, although they exist in other attributes or primitives, are not contextually determined for key or critical elements. This is because the measure of semantic element criticality is that it has the maximum value of its own semantic expressiveness or semantic value. In this case, the structure of the dictionary can be formally represented in the form of some hierarchical tree, which will be analytically written as follows:

$$G(S_c) = \left[S_{ik}\left(x_{ik,1}, ..., x_{ik,m}\right) \rightarrow S_{jz}\left(x_{jz,1}, ..., x_{jz,m}\right)\right] \& S_{iz}(z_1) \& ... \& S_{iz}(z_m), \quad (1)$$

where S_{ik} – set of key elements $x_{ik,j}$;

S_{jz} – a set of contextually determined elements $x_{jz,i}$;

$S_{iz}(z_i)$ – sets with different levels of semantic significance of the elements listed in the dictionary S_c.

3.1. Semantic significance of dictionary

Consider the relationship between the semantic significance x_i of an element with key elements $x_i(k_i)$ and the interpretation of the corresponding element $I(x_i)$. To ensure the effectiveness of this approach, we will assume that the interpretation $I(x_i)$ depends on the amount of semantic significance for key elements $x_i(k_i)$ and for other elements $x_i(z_i)$ equally in relation to their semantic significance. For this, we will assume that the value determined by the interpretation $I(x_i)$ depends on the number of attributes or primitives used to describe this element. For example, a dictionary element S_c can be the following structure:

$$n := < x_i > \to < x_{i1}, ..., x^*_{ik}, ..., x_{in}, \quad (2)$$

where n – numeric or any other identifier of the S_c dictionary element x_i; x^*_{ik} – an element that belongs to the subject area described by the S_c dictionary and has its own $I(x_{ik})$ interpretation.

It can be seen from the given expression that the S_c dictionary should not contain all the elements that exist in the description of the graphic object. The S_c dictionary contains only the terminological base of the elements of the description of the object used in the format chosen to represent such a graphic object. The number of elements implementing the $I(x_i)$ interpretation is not only the number of elements of one line of $I(x_i)$ interpretation but is also summed up with the number of elements of the $I(x_{ik})$ interpretation extension for the element x_{ik} from the S_c dictionary. It can be written like this:

$$\pi\left[x_i(k_i)\right] = \pi\left[I(x_i)\right] = \left[x_{i1} + x_{i2} + ... + x_{i,k-1} + ... + x_{in} + \left(x_{k1} + ... + x_{km}\right)\right], \quad (3)$$

where π – the function of counting the number of the interpretive description elements x_i and x_{ik} – elements of the interpretive description of the element x^*_{ik}, which has its own $I(x_{ik})$ interpretation within the S_c dictionary.

Thanks to this definition of the interpretive $I(x_i)$ description it is possible to determine the degree of semantic significance of individual elements of the S_c dictionary. It is obvious that for $S_{ik}(x_{ik1}, ..., x_{ikm})$ does not necessarily hold for $\pi(x_{ik1}) = \pi(x_{ik2}) = ... = \pi(x_{ikm})$ equality. The value or the semantic significance of an $x_i(k_i)$ element in a S_{ik} set can be specified by a certain interval of numerical values or $\pi\left[x_i(k_i)\right] = [m, n]$. Similarly, values of semantic significance are calculated for other elements that are not included in the set of S_{ik} key elements, which will be equal to $\pi\left[x_i(z_i)\right]$. Ranges of S_{iz} values are also specified for such $\pi_i(x_{iz})$ sets, which determine whether each x_{iz} of them belongs to one or another S_{iz} set. Such a structure of the semantic dictionary will be written in the form of a relation:

$$S_{ik}\left[\pi_i\left(x_i\left(k_i\right)\right)\right]\rightarrow\left\{S_j\left[\pi_j\left(x_j\left(z_j\right)\right)\right]\oplus...\oplus S_m\left[\pi_m\left(x_m\left(z_m\right)\right)\right]\right\}, \qquad (4)$$

where $\oplus$ — the symbol of the logical function is the sum modulo two. Let's consider the following statement.

Statement. For a set of key elements $S_{ik}\left(x_i\right)$, such a set of semantically significant elements $S_{jz}\left(x_j\right)$ will be contextually conditioned, for which the relation holds:

$$\pi_j\left(x_j\left(z_j\right)\right)=\max\left\{\pi_1\left(x_1\left(z_1\right)\right),\ldots,\pi_n\left(x_n\left(z_n\right)\right)\right\}. \qquad (5)$$

Assume that the statement is not correct or that condition (2) will not hold. In this case, it can be specified that $S_{ik}\left(x_i\left(k_i\right)\right)\rightarrow S_{jz}\left(x_j\left(z_j\right)\right)$ and there is a relation:

$$\pi\left(x_j\left(z_j\right)\right)\neq\max\left\{\pi_1\left(x_1\left(z_1\right)\right),\ldots,\pi_m\left(x_m\left(z_m\right)\right)\right\}, \qquad (6)$$

It means that through $S_i\left(x_i\left(z_i\right)\right)$ there is $x_j^*\left(z_j^*\right)$, for which:

$$\pi_j^*\left(x_j^*\left(z_j^*\right)\right)=\max\left\{\pi_1\left(x_1\left(z_1\right)\right),\ldots,\pi_m\left(x_m\left(z_m\right)\right)\right\}. \qquad (7)$$

As each $x_j\left(z_j\right)$ with the value $\pi_j\left[x_j\left(z_j\right)\right]$ automatically defines the range for each $x_j\left(z_j\right)$, that included in the corresponding set $S_j\left[x_j\left(z_j\right)\right]$, because for all $S_i\left(x_i\right)$ the ranges of their values are determined $\left[\alpha,\beta\right]$ in a S_c dictionary, then it can be claimed that there is $S_j\left(x_j\left(z_j\right)\right)$ in S_c for which there is a relation:

$$\begin{aligned}&\left[\pi_{j1}\left(x_{j1}\left(z_{j1}\right)\right)\right]\&\ldots\&\left[\pi_{jm}\left(x_{jm}\left(z_{jm}\right)\right)\right]=\\&=\max\left\{\begin{array}{l}\left\{\pi_{i1}\left(x_{i1}\left(z_{i1}\right)\right),\ldots,\pi_{im}\left(x_{im}\left(z_{im}\right)\right)=S_i\left(x_i\left(z_i\right)\right)\right\},\ldots,\\\left\{\pi_{n1}\left(x_{n1}\left(z_{n1}\right)\right),\ldots,\pi_{nm}\left(x_{nm}\left(z_{nm}\right)\right)=S_n\left(x_n\left(z_n\right)\right)\right\}\\\end{array}\right\}.\end{aligned} \qquad (8)$$

Then the equality holds:

$$\pi_j^*\left(x_j^*\left(z_j^*\right)\right)=\left[\pi_{j1}\left(x_{j1}\left(z_{j1}\right)\right)\right]\vee\ldots\vee\left[\pi_{jm}\left(x_{jm}\left(z_{jm}\right)\right)\right]. \qquad (9)$$

This equality indicates that the $I\left(x_i\right)$ interpretation in the S_c dictionary is formed in such a way that all x_i elements for which $\pi\left(x_i\right)$ will fall into one $\left[\alpha,\beta\right]$ range defined by $I\left(x_i\right)$ are combined into one $S_j\left(x_j\left(z_j\right)\right)$ set of semantically significant elements. Therefore, the assumption that there is no condition for statement (5) is controversial.

We will prove its sufficiency.

Let $\left\{S_{ik}\left[x_i\left(k_i\right)\right]\rightarrow S_j\left[x_j\left(z_j\right)\right]\right\}\&\left\{S_{ik}\left[x_i\left(k_i\right)\right]\rightarrow S_r\left[x_r\left(z_r\right)\right]\right\}$, then $x_i\left(k_i\right)$ з $S_{ik}\left[x_i\left(k_i\right)\right]$ allows an ambiguous interpretation:

$$I_i^*\left(x_i\left(k_i\right)\right)=I_{i1}\left(x_i\left(k_i\right)\right)\&I_{i2}\left(x_i\left(k_i\right)\right). \tag{10}$$

But, according to the statement, the following relations must hold for $\pi_j\left[x_j\left(z_j\right)\right]\in\pi_j\left[S_j\left(x_j\right)\right]$ and for components $\pi_r\left[x_r\left(z_r\right)\right]\in\pi_r\left[S_r\left(x_r\right)\right]$:

$$\pi_j\left[x_j\left(z_j\right)\right]=\max\left\{\left[\pi_1\left(x_1\left(z_1\right)\right)\right],\ldots,\left[\pi_n\left(x_n\left(z_n\right)\right)\right]\right\}$$
$$\pi_r\left[x_r\left(z_r\right)\right]=\max\left\{\left[\pi_1\left(x_1\left(z_1\right)\right)\right],\ldots,\left[\pi_n\left(x_n\left(z_n\right)\right)\right]\right\},$$

where the maximum is taken for all elements of S_c, except for the $S_{ik}\left(x_{ik}\right)$ set, which means also for all $S_j\left(x_j\left(z_j\right)\right)$. Then the ranges for $\pi_j\left(x_j\left(z_j\right)\right)$ and for $\pi_r\left(x_r\left(z_r\right)\right)$ intersect or:

$$\left\{\pi_j\left(x_j\left(z_j\right)\right)\in\left[\alpha_j,\beta_j\right]\right\}\cap\left\{\pi_r\left(x_r\left(z_r\right)\right)\subset\left[\alpha_r,\beta_r\right]\right\}\neq 0. \tag{11}$$

And this is impossible according to the $S_j\left(x_j\left(z_j\right)\right)$ structure within the S_c limits, which are put in accordance with the $I_i\left(x_i\left(z_i\right)\right)$ interpretation for all $S_j\left(x_j\left(z_j\right)\right)\in S_c$, which proves the statement about the condition of the existence of a contextually conditioned set for a set $S_{ik}\left(x_i\left(k_i\right)\right)$.

3.2. Semantic dictionary structure

The structure of the S_c dictionary can change in the direction of increasing individual components, and, accordingly, the number of components can change during the transition from one structure to another. We will call the structure that operates on S_c dictionary elements or $G\left(S_c\right)$, the lowest structure in the hierarchy, by which we will distinguish them. We take the name of the lowest structure since it operates with dictionary elements, which are the smallest elements of the accepted set, which is used to describe graphic objects from the point of view of their value as the minimum possible element that defines semantics as such [13, 14].

The next structure in the hierarchy is the structure that operates on sets of elements. An element set is a collection of semantically defined attributes or primitives. Formally, a set of elements can be written in the form of such a ratio:

$$V = \{v_1(x_{i1}),\ldots,v_m(x_{im})\}, \text{ where } v_j(x_{ij}) = \{x_{1j},\ldots,x_{kj}\}.$$

It is obvious that each element of the expression receives and conveys a certain semantic significance based on the expression that consists of these elements. It is clear that an expression is not formed from an arbitrary set of elements, and the rules for forming a set of elements are based on the rules defined by the content and on the rules of semantic admissibility. The rules of semantic admissibility are the result of the interpretation accepted in the subject area. In the case of subject areas of interpretation that are artificial and created by man, such prerequisites are quite few, and one or another semantic significance in many cases is based on generally accepted and agreed agreements. A well-known example of such arrangements are standards or formats. Of course, any agreement about the semantic significance of a certain element or a set of elements is justified by the nature of the object, which is defined by the corresponding definitions, but the basis of such justification is the possibility of connecting or connecting the new semantic significance with the semantic meanings of already defined objects. objects or elements [15, 16, 17].

The subject area, in relation to which graphic objects are composed, is quite narrow and quite precisely defined. This is due to the generally accepted practice of defining graphic primitives, which originates from geometry. In addition, there is a significant part of graphic objects so highly specialized that S_c dictionaries can describe such sets of elements only if they are structured at the level of sets of elements. If we are not talking about objects — the works of artists, then it can be assumed that in dictionaries structured at the level of sets of elements or $V(S_c)$, each of them has its own specific and not very large in number of elements interpretation $I(v_i) := < x_{i1} * \ldots * x >$, where the sign "*" means the function of consistency between the elements that make up the description. Obviously, such an interpretation is not sufficient for a non-specialist in the relevant field, but we will not consider these aspects. Therefore, during the formation of graphic objects, it should be possible, regardless of the specifics of the object, to use separate sets of elements contained in the S_c dictionary [18, 19].

If a S_c dictionary with $V(S_c)$ structure is created for the analysis of objects, then in this case, as well as for a dictionary with $G(S_c)$ structure, it is possible to form hierarchical dependencies between sets of elements, depending on their semantic meanings. In many cases, it is possible to define control sets by analogy with control elements, which are quite convenient in solving the problems of analysing the content of a graphic object.

3.3. Application of neural networks for image contour selection

The problem of extracting a graphic primitive from a graphic object can be formally presented as a classification problem. If we use the results of the wave algorithm described above for the input of the neural network, then we will get a classification problem when a certain object P is a graphic primitive based on a set of features p_i — the list of key points of the algorithm contour returns the value of the class c_i — the type of graphic primitive to which the contour refers, which is considered [20, 21].

If you create a neural network with N inputs and M outputs and train it to return C $c_i \in C$, vector at the output, when P is input, we will solve the problem of determining graphic primitives.

To solve classification problems, it is advisable to use the Kohonen network. To determine the class to which an object belongs, it is necessary to select one of the neurons of the Kohonen layer with the maximum output. This is done by an interpreter, which is either a software product that selects the neuron with the highest output, or an additional layer of neurons. So, a Kohonen network will consist of 3-4 layers of neurons, the first of which is the input layer, the next is the Kohonen layer, the additional layer and the output. In order to obtain the sum of outputs approaching unity, it is advisable to apply the Softmax function, which can be interpreted as the probability of the object belonging to a certain class.

4. Experimental study of the semantic dictionary development methods based on graphic

To build an image model and its semantic description, it is necessary to use the alphabet of conventional designations to describe graphic primitives. To do this, it is necessary to highlight their main types that can be used in the image, while the advantage of their use is that the image model built on their basis is flexible, does not depend on scaling and positioning. In addition, such a model does not depend on the colour of the primitive execution (unless special conditions are specified).

Let's consider the proposed model of presentation of a conditional alphabet or graphic primitives.

First, let's build a dictionary of graphic primitives [22, 23, 24]. For this, it is necessary to solve the problem of which graphic primitives to choose for the dictionary. Since the array of graphic data contains more graphic objects processed or created with the help of automated graphic systems, it is necessary to add those primitives used by graphic systems to the dictionary. Since the most popular graphic systems are the Adobe Photoshop, Xara Designer, CorelDRAW and 3Ds Max software complexes, the main graphic primitives used by these graphic systems were selected for the dictionary.

In addition, graphic primitives that must be used to create a semantic description of a graphic image must meet the following requirements:

- it is sufficient to fully submit the content of the graphic object;
- easy to formalize.

Therefore, the contours of the image selected from the graphic object should correspond as much as possible to a certain type of graphic primitives of the semantic dictionary. In order to maximally reduce the time of the process of identifying the contour of the image and its comparison with the elements of the semantic dictionary, it is necessary to choose such graphic primitives as the elements of the semantic dictionary, which can be formalized most simply.

To determine the set of elements of the semantic dictionary, we will classify image contours that may occur in a graphic object [25, 26, 27].

By continuity, the contour of the image can be closed and open. We consider such a contour of the image as closed, in which the wave, launched along the contour, returns to the starting point. An open loop is one in which the wave going around the loop fades out at two key points and does not return to the initialization point. According to this feature, graphic primitives are divided into lines and shapes. A line is an open contour, a shape is a closed one.

According to the presence of key points, there are contours that can have intermediate key points (except for the two points where the wave faded in the open contours) and contours without them.

After the segments connecting the key points, the contours can be with straight segments, with curved segments, and with mixed segments.

According to the given classification, the semantic dictionary should contain the following graphic primitives:

1. Graphical primitives describing open contours. We will call them graphic primitives of the second type.

- Line — an open contour with two key points connected by a line segment.
- Curve — an open contour that does not correspond to a straight line in any way.

2. Graphical primitives describing closed contours. We will call them graphic primitives of the first type. Since most of the geometric shapes that will be used to denote the first type of graphic primitives generally consist of vertices connected by straight line segments, and perfect straight lines are rarely found in a graphic object, it is necessary to introduce additional types of graphic primitives that will identify contours with segments of curves. To designate such contours, we introduce the word "almost" (fuzzy), which means that formally the figure meets all the requirements for defining the contour and the key points are connected in it by segments of curves or by a mixed type.

- Circle — a closed contour without key points, all points of which are equidistant from the center of gravity of the contour.
- “Fuzzy" circle — a closed contour without key points, not all points of which are equidistant from the center of gravity of the contour.
- Triangle — a closed contour with three key points connected by three straight line segments.
- "Fuzzy" triangle — a closed contour with three key points connected by three curve segments or mixed segments.
- Quadrangle — a closed contour with four key points connected by four straight line segments.
- "Fuzzy" quadrilateral — a closed contour with four key points connected by four curve segments or mixed segments.
- Polygon — a closed contour with five or more key points connected by line segments.
- "Fuzzy" polygon — a closed contour with five key points or more, which are connected to each other by curve segments or mixed segments.

Primitives of the first type are the most significant elements that unambiguously characterize the content of a graphic object. Other graphics primitives are smaller and may simply be elements of primitives of the first type in the case that one of the graphics primitives is derived from another by cutting graphics.

With the help of tools of the XML language, we will present the alphabet in the following way.

Having selected graphic primitives as elements, each of them, depending on the shape, can be assigned a value and get their semantic description:

```
<Element GroupID>
    <ID>1</ID>
    <Name></Name>
    <Value></Value>
</Element>
```

If necessary, the dictionary can be expanded by entering element attributes, such as fill colour, line colour, etc. XML tools make it possible to implement any changes by changing the format of the dictionary, introducing new elements into it, and reformatting existing descriptions.

For example, after expanding to include colour, fill, and line colour attributes, the dictionary description would have the following form:

```
<Element GroupID>
    <ID>1</ID>
    <Name></Name>
    <Value></Value>
    <Attributes>
        <Attribute Name="color">
            <Value></Value>
        </Attribute>
        <Attribute Name="filling">
            <Value></Value>
        </Attribute>
    </Attributes>
</Element>
```

The dictionary will consist of a set of elements with their meanings, and, accordingly, the semantic description will consist of dictionary elements (Fig. 1).

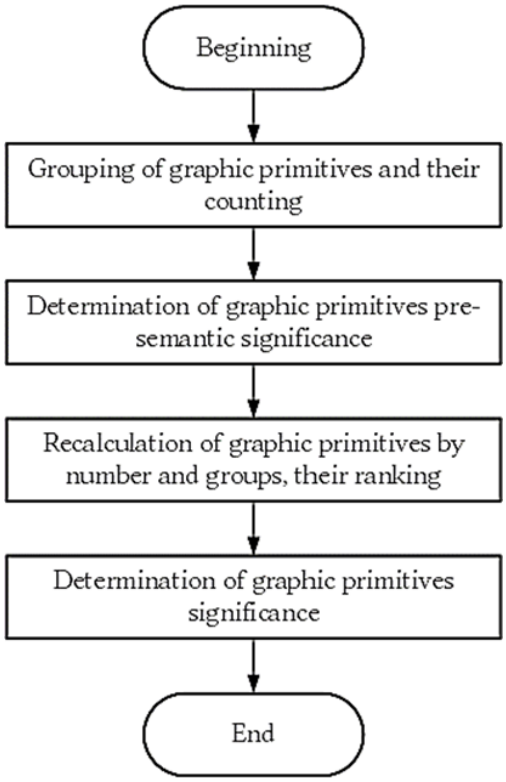

Figure 1: Determination of the semantic significance of the element

5. Conclusions and discussion

Graphical objects in their essence are most fully characterized by words of natural language, therefore it is advisable to describe them based on methods of formal grammars and semantic features.

To determine the semantic significance of graphic objects and their fragments, it is necessary to build a semantic dictionary from the subject area, which would include the main features of graphic objects, their attributes and hierarchy. In the subject area of the attributes of graphic objects, their completeness, semantic significance and consistency should be determined, which will reduce the search time and improve its quality.

The rules for forming a set of dictionary elements are based on the rules defined by the content and on the rules of semantic admissibility. The rules of semantic admissibility are the result of the interpretation accepted in the subject area. In the case of subject areas of interpretation, which are artificial and created by man, such prerequisites are quite few, and one or another semantic significance in many cases is based on generally accepted and agreed agreements. Proposed inference rules for the semantic analyser of graphic objects by the methods of formal grammars based on the consistency and completeness of the semantic dictionary.

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