COMPRESSION TECHNOLOGIES OF GRAPHIC INFORMATION

Nikolay Fesenko

Abstract: The classification of types of information redundancy in symbolic and graphical forms representation of information is done. The general classification of compression technologies for graphical information is presented as well. The principles of design, tasks and variants for realizations of semantic compression technology of graphical information are suggested.

Keyword: semantics, abundance, compression, graphical information, decompression, classification, ontology.

ACM Classification Keywords: A.1. Introductory and Survey; I.2. Artificial Intelligence; I.2.7 Natural Language Processing - Text analysis;

Introduction

Presentation of graphic files in the compact compressed kind is needed for comfort of storage, provision of reception and information transfer on the ducting of connection. Thus redundancy in presentation of information allows this information to squeeze, i.e. to shorten the resources expended on its presentation. When diminishing the sizes of memory, occupied by files, or at preparation of files for sending, the specialized programs are used in a compact form, accepted to talk that files are exposed to compression, or the compression [1]. Technologies of compression of files use, as a rule, programs diminishing file sizes graphic arts due to the change of method of data organization, for example, replacing repetitive elements by information that is more effective for storage. Thus graphic information compresses only on a form presentation, but not on maintenance. This appears to be actual development of semantic compression technology for graphic information. To that end we shall explore compression technologies of graphic information, on the article of application in them, approaches and methods of artificial intelligence.

Varieties of Informative Redundancy

Every form or model, different presentation actual to the same thought differs by the informative redundant - from minimum to considerable. It can be where sketch, sketching or the high-quality colored computer image is synthesized. Thus, the more adequate the chosen model, so much the better attainable degree of compression. We will consider *the types of informative redundant*, presentations of information characteristic for different organizational forms, and will execute their classification with the purpose of the determination of the possible hidden reserve for the lead through additional, deeper compression (Fig.1). The basic types of surplus [2] are near to the character and graphic forms of presentation of information. Thus for every type of redundant there are the models of compression. The design in one or another degree reflects possibility of the prediction of probability of the offensive of possible events. *On probability of reiteration*, when different events have different probabilities of appearance, takes place a distributing redundant. If a few identical events can follow friend by a friend, takes place surplus *of reiteration*. Surplus *of order* appears then, when the offensive of certain events can be predicted depending on some order of the following. Reiteration of events group results in a *group* (chainlet) redundant. Possibility for the account of probability of certain events, appearance on some positions in an events stream determines the *position* redundant. Probability of the values of closeness to the neighboring pixels of a graphic image, as well as their spatial derivative, characterizes the spatial redundant *on a form placing*: *linear, 2D, 2.5D, 3D*. *On composition* the *homogeneous* redundant is uncommon; more frequently the redundant is *mixed*. *On the redundant element* it is shown up by the *character* and *objective*.

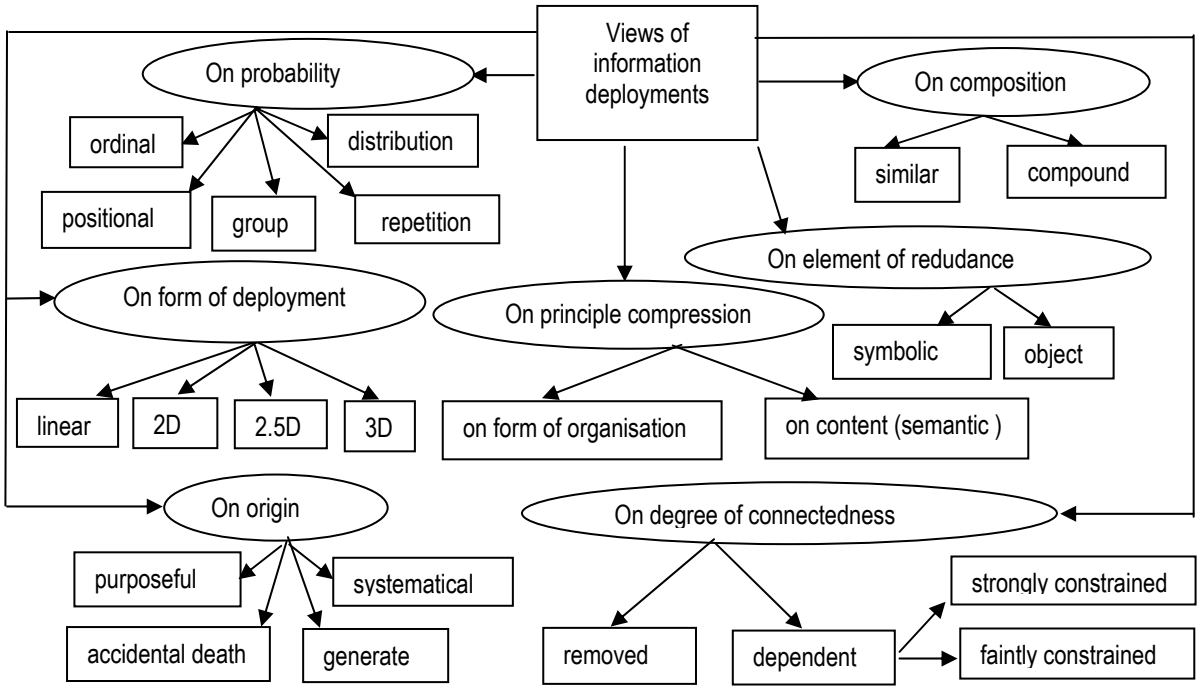

Fig.1 Classification of informative surplus

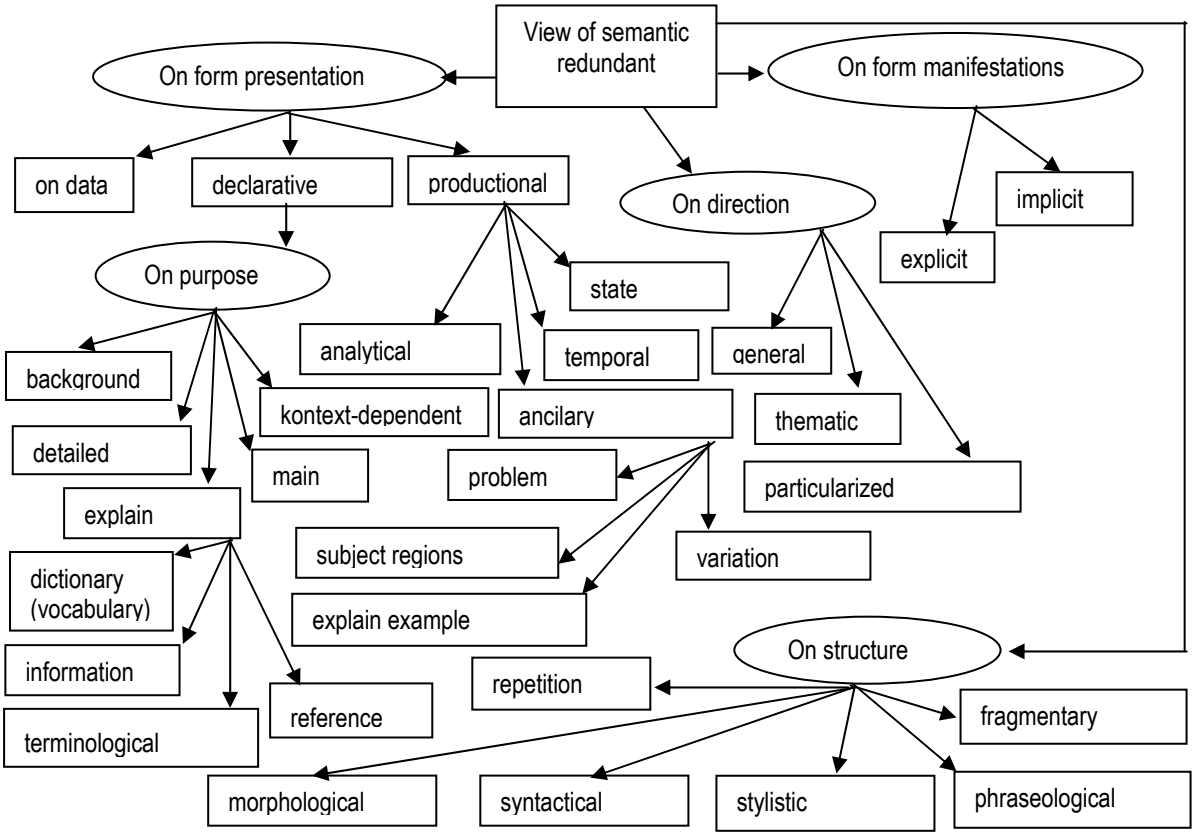

Fig.2 Classification of semantic redundant.

On the principle of compression we will distinguish the redundant *on a form organization* placing, either the locations of character or appearance, and *semantic* or semantic redundant *on maintenance*. *Originally* we will select a *purposeful*, or intentional redundant; *casual*, *originative* and *systematic*. *On the degree of compendency* we will mark the *unrelated*, or the independent redundant, and also the *dependent*, which then can be both *loosely-coupled* and *strongly*. It ensues that from the conducted analysis and classification of redundant, that less of the other semantic aspect of redundant is investigational.

Varieties of Semantic Redundant

We will conduct the analysis of types of semantic redundant and will execute their classification for determination of tasks on creation of technology of semantic compression of graphic information (Fig.2).
Semantic redundant differentiates *on a form presentation*, *on a form the display*, *to direction*, *on a structure* and *in grain settings*. *On a form presentation* we will select the redundant *from data*, *declarative* and productional to the redundant. *In grain settings* we will divide *declarative* surplus into *basic*, *base-line*, *context*, *explaining* and the redundancy *of working out in detail*. Probability of appearance of character in a context we will name *context* redundant. In same queue, *explaining* the redundant shows up as *dictionary*, *information*, *terminology* and *reference*. The productional redundant includes the *analytical*, *temporal* and the redundant *of the states* and *auxiliary*, to which we will deliver the auxiliary containers of modifiers also. *On a form the display* we will select *obvious* redundant and *non-obvious*. *General* character of the redundant, *thematic* and *specialized* shows up *to direction*. The *thematic* redundant is subdivided into *a problem*, *subject domain*, *variation* and redundant *of explaining examples*. *On a structure* we will mark *morphological*, *syntactic*, *stylistic*, *fragmentary*, *phraseological* and the redundant *of reiteration*. The offered classification allows to give mind on the semantic redundant in the context of compression of graphic information, as its programmatic realization is practically absent for today.

Analysis and Classification of Technologies of Compression of Graphic Information

With the purpose of systematization we will conduct the analysis and general classification of technologies of compression of graphic information (Fig.3). *On a form presentation of graphic information* we will distinguish *a raster*, *vectorial*, *programmatic*, *text*, *multimedia* and *combined* forms of presentation. A *raster* form is characterized by a considerable spatial redundant. The type of redundant of *vectorial* form depends on the large number of factors and does not possess sufficient universality for creation of general formal approaches to its removal [2]. Among the formats of vector graphics we will select two: CDR (CORELDRAW) and DXF (AUTOCAD), which are standard for the proper graphic packages. Besides rasters, vectorial, texts formats, also the mixed formats or metafiles are developed. For example, the formats of ESP (Encapsulated PostScript) and CGM (Computer Graphics Metafile) allow the keeping of rasters, vectorial and text information. The universal data files of UDF (Universal Data File) engulf different data structures and can enter in the complement of the documents realized in other formats. Presentation of image stage as programmatic files both in programming languages and instructions languages of graphic packages, allows largely shortening the volume of information about the image, as such approach supposes application of other form of representation specification and assumes the use in the graphic files of programmatic procedures. A compiler, or presence of the proper graphic package, is however here obligatory. For more difficult images the complete cycle of the repeated creation of image is required.

In relation to the file structure of presentation of information analyzable technologies execute the compression at once all file wholly or the compression plugged in the structure of file; and also the combined forms. Formats in which the compression is part of a file structure are less dependent at their further use. A fully compressed file is usually impossible to use until it is not be recovered to the initial state. Therefore, in future, compressed picture-size rasters by the decompression proper compatible program. The formats of compression of ZIP and RAR, which are used for the compression of both character and graphic information, are most widespread.

The Wavelet-compression of graphic information, which we will deliver to technologies by appearance transformations, consists in the compression of all images wholly to the so-called WIF-files (Wavelet Image File) with the purpose of maintenance of temporal and frequency descriptions of signals. The basic idea of lifting-transformations urgently and also the wavelet second generation, is expressed in that during every operation must change only one constituent, therefore, for example, for construction of reverse transformation it is enough to execute the mirror reflection of direct transformation and to add inverting of signal wherein it is needed. The algorithm of compression *of EZW* (Embedded Zerotree Wavelet) supposes the simple casting-out of coefficients with the values less some size. Not far the algorithm of SPIHT (Set Partitioning in Hierarchical Trees) more difficult in the calculable relation gives the much best results to the compression.

On plenitude of maintenance of coercible information we will divide compression algorithms into the executing ones of the compression *without the losses*, *with the losses* of information and *with semantic correction of coercible information*. The known technologies of compression *without the losses* practically do not execute semantic interpretation of coercible information, and at decompression aim to recover both a file and picture in full initial. Widespread technologies of compression of graphic information, executing the compression *with the losses* of information, do not take into account semantic maintenance of this information. Consequently, *lost* maybe to be exactly that part of graphic image for the sake of which it, actually, was all saved and was passed. Even half-tones distortions at the compression would carry electoral character, for example, to spread not on the image of face of portrait image, and to affect a background and clothes only.

In-process *algorithms* on the basis of *successive scan-out*, images oriented to the compression *without the losses*, it is possible to select the following phases: prediction, design of error and encoding, thus the prediction of value of next pixel is made on the basis of values of the already coded neighboring pixels. In basis of technologies of compression *on the keywords of KWE* (Key Word Encoding) principle of encoding of lexical units is fixed to, for example ordinary words, by byte groups of fixed length. The result of such encoding is placed in a special dictionary. Technology of Lempel-Ziv-Welsh (*LZW*), which is the modification of technology of Lempel-Ziv (*LZ*), is based on the search maintenance of templates into the set structure. Algorithm *of LZW* is built round the table of phrases (dictionary), which substitutes characters strings of coercible report by the codes of fixed length. The compression on this technology executes the raster format *of TIFF*, which supports plenty of algorithms of compression for the different types of images. In a raster format the *GIF* image is examined as a unidimensional sequence of pixels, which are encoded on lines with the use of algorithm *of LZC* (modification of algorithm *of LZW*). A format is counted on the images with index colors and possesses more high degree of compression, by what format *of PCX*. There are modifications of this format, which differ by the amount of the supported types of blocks of expansions, including animation. On the whole the algorithms *of KWE* execute the compression *without the losses* of information, and are most effective for text information of large volumes, but from the necessity of creation and maintenance of dictionary ineffective for the files of small sizes. In basis *of Huffman algorithm* is also productive the compression *without the losses* of information, the idea of encoding by bits groups lies.

After the lead through of frequency analysis of entrance sequence of information, that determines the arrival rate of every character, which meets in it, characters are assorted on diminishing of this frequency. A basic idea consists of the following: the more frequent the character, the less encoded are bats. The result of encoding is added to the dictionary necessary for decoding. Algorithm *of RLE* (Run-Length Encoding) is based on the exposure of repetitive sequences of information and replacement by their more simple structure the code of information and coefficient of reiteration is specified in which, therefore he gives the best effect of compression at greater length of repetitive sequence of information. Consequently, the algorithm *of RLE* is more effective at the graphic data compression (in particular case for the solid images). Encoding on the algorithm *of RLE* supports the graphic format *of PCX*.

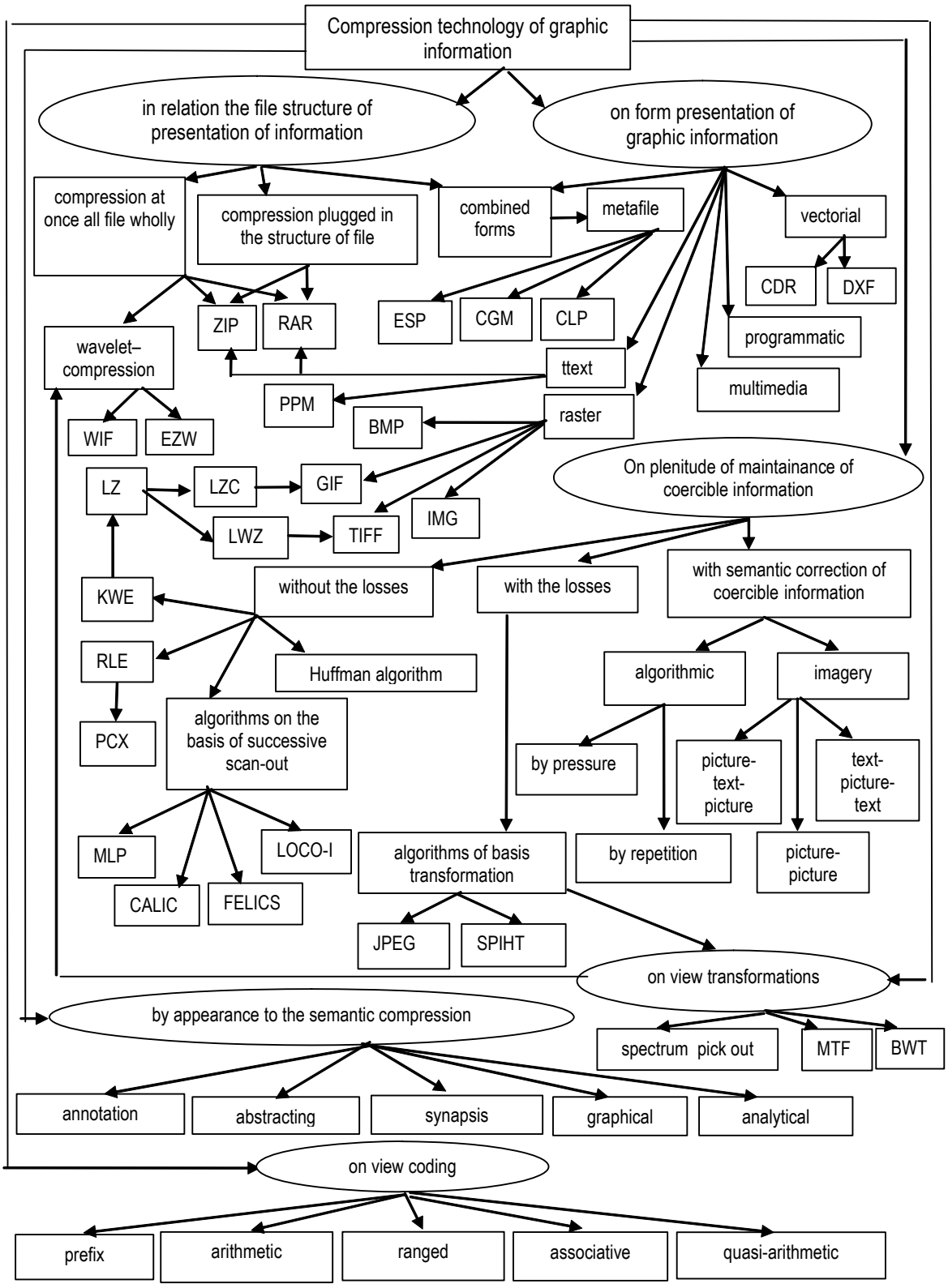

Fig.3 General classification of compression technology of graphic information

Algorithms *by appearance transformations* are intended for the compression of images *with the losses* of quality. The model chart of algorithm is such a transformation, quantisation, design of regenerate coefficients, encoding. *There* are *two approaches* to implementation of transformations. *The first* is expressed in frequent implementation of transformation separating the highest-frequency constituent of image. *The second approach* consists in implementation. Transformation of the result of which there is the spectrum of image. The high calculable complication of such transformations does not allow us to apply them for the fragments of image of largeness. Then at the compression *with the losses*, for example in the format *of JPEG*, there is the casting-out of part of information of the initial image. The features of sensitiveness of our sight are thus used on perception of changes of brightness, colour or tone. At first the image is divided into brightness and two colour constituents. A brightness constituent is major at perception of image by a human eye; it is therefore necessary to squeeze it with the best quality. Then these constituents are broken up on squares measuring 8x8 pixels, and for each of which is executed the discrete cosine-transformation of Fourier. After it the quantisation of results and encoding is made. For the encoding of coefficients *encoding of Huffman* is used with the fixed tables, as variety of the *prefix* encoding, or *arithmetic* encoding. *By appearance* we will select *encoding: prefix*, *arithmetic*, *ranged*, *associative* and *quasi-arithmetic* encoding.

The division *by appearance to the semantic compression* allows to select *annotating*, *abstracting*, *summarizing*, or exposition, as different on the degree of compression and generalization universal forms of retelling of maintenance, and also *graphic*, or vivid, and *analytical* (formalization) forms of presentation of maintenance. Thus two last forms execute the function of compression of graphic information only in the system of some limitations.

Semantic Compression of Graphic Information

A picture, as the most simple from the possible and widespread forms of presentation of information, can be intended to expel the text description, or vice versa. Therefore we will analyze *three charts*: *text-picture-text, picture–text-picture* and *picture-picture*. *The first chart* is expedient for subject domains with the developed system of compression of graphic information. Excelling the algorithms of compression of texts naturally linguistic or programmatic structural descriptions. *The second chart* is applicable for the case of subject domain, in which compression of naturally linguistic texts and programmatic formalities is executed well, than the compression of graphic presentations of informative material. *The third chart* supposes the semantic compression directly linked to graphic images without intermediate auxiliary texts forms. The task of understanding of graphic languages joins to the same chart: pictures, drafts, illustrations, photos and other such *charts* assume a few variants of realization. In the data computer center of Russian academy of science, [3] the system of TEKRIS is built, are generations of pictures on the basis of texts, using a chart: the analysis of text is the synthesis of graphic appearance.

We suggest to make the process of compression of graphic information on the basis of semantic interpretation. Introduction is the successful decision to technology of compression of graphic information of ontological approaches. One of variants of practical realization of such approach is text description of pictures and application to the description of methods of semantic reduction, to which we will deliver summarizing of naturally linguistic texts, in particular, on the basis of growing pyramidal networks.

As the example of realization the summarizing of naturally linguistic texts we will present the program KONSPEKT [4], which passes sense, but does not restore a source code after the conducted compression. During work of this program of phrase of source code is exposed to syntax -semantic interpretation with the purpose of selection of full-composition suggestions. After it on the basis of ontology of associations the thematic analysis of text is carried out. The dictionary of terms, in which terms are indexed by the sets of associative signs designating associations of concepts, is ontology of associations. As a result of work of the program KONSPEKT the generalized text, which on volume and to the compendency near to the folded pictures of properties of

compendia is formed. The use of a dictionary complex is other variant RUSLAN [5] as the instrument of compression of maintenance of text. A function similar on the producible effect of decompression is executed by the standard information-search systems: using the keywords and terminologies of combinations of words, which are the maximum compressed form of presentation of theme, set from outside, they find complete maintenance of text.

A graphic object can be considered certain only then, when its form is fixed for visualization, sizes are filled in and the spatial orientation and location [6] is executed. One of the first programs, which in the interactive mode could perceive the mutual location of blocks of different forms and colors and to make their description, there is the program of Vine of SHRDLU [7], however much its developers did not succeed to decide the task of abstracting. Semantic compression directly linked to graphic image also close to the semantic downscaling. The difference is only in that at the semantic compression brief information goes down or mutates, and at the semantic down-scaling it is temporally eliminated at the increase of scale, but after, at the diminishing of scale, comes back again. At decompression a semantic aspect is also possible, I.e. decompression of image with opening of the represented theme and its addition by information from a knowledge or database base, for example, in the simplest variant, by the list of literature. Rows of algorithms of computer graphics [8,9] use the generating of families of segments of lines, circumferences, ellipses, parabolas and hyperbolae, and assume application of compression and reiteration. Winning from application of method of reiterations the more than the longer generated segment and than anymore coefficient of reiteration. For every quadrant sequences, which the points most close located to the designed curve of line and a brightness is properly distributed between the basic point chosen algorithmically and auxiliary are calculated on, concern taking into account asymptotic branches and symmetry, the choice of which depends on distance relatively by a curve. Such algorithms are applicable at programs development of semantic decompression.

Basic Principles of Construction of Technology of Semantic Compression of Graphic Information

In the general context of development of existent compression technologies we will formulate basic principles of construction and task on the creation of technology of semantic compression of graphic information. *By the main principle* which determines the offered approach to the problem *of compression of graphic information on its sense*, *there* is *extraction of knowledge from the information represented in a graphic form*. General strategy of achievement of this purpose must be built on principles, which are set forth below.

The first principle is *presentation of stage of image by drawing primitives*. The tasks of analysis and synthesis of stages of graphic images are based on that such stages preliminary are described through the dictionary of drawing primitives: point, segment, line, triangle, rectangle, square, rhombus, polygon, arc, circumference, circle, ellipse, hyperbola, parabola. From them it is possible to make many other graphic objects, as lines and circumferences with the use of some receptions of interface develop the methods of quasi-general presentation of graphic objects. Basic spatial graphic objects usually consider parallelepipeds, pyramids, cylinders, and cones of rotation, sphere and torus. In the case of simple graphic object the task of his presentation consists of association of these bodies by addition or deduction and in implementation of operations of descriptive geometry, transfers, turns, sections, impositions. However, in most cases by bodies urgent analytical (i.e. in fact drawing primitives) it is impossible to describe the real mechanical objects. For this purpose it is possible to use the existent methods of determination of form of objects, based on successive adjustment.

Second principle is *formalization of presentation of stage of image* on the basis of division of stage of image on the separate graphic objects baselined in composition.

The third principle is recognition of graphic objects. Graphic object it is possible both to recognize at once and to decide this task for a few steps, and also to copy and pick up an alike object with the known analytical description. For this purpose it is possible to apply sewing together surfaces. In simplest case the circumflex

spheres of permanent radius, which provide the smooth change of tangent in transition from one sewn together surface to other, are such surfaces. The decision of tasks of recognition or distinction of objects on their images behaves functionally to machine sight. It is necessary to notice that for the surfaces of difficult form, such as: surfaces of bicurvature, surfaces of variable curvature, distorted surfaces the decision of task is begun with implementation of sequence of steps of approximation. A task consists of the mathematically exact reproducing of form of graphic object, coming the co-ordinates of the points located on-the-spot it's from. Measuring of inclinations of tangent also it can be used for this purpose, however much it does not provide achievement of exactness, and comparable with exactness of the methods based on measuring of linear co-ordinates. Thus classification of superficial forms of graphic objects comes forward to one of intermediate tasks.

Fourth principle is ***drafting of ontology of graphic associations***. The mechanism of semantic compression must be stopped up in the system carrying out the automatic understanding of text representation specification. Such functions must be also taken into account at planning of in-use of dictionary of grapheme. If to unite the dictionary of graphic terms and primitives with the dictionaries of more commons concepts characterizing thematic subject domains, it is possible to make ontology of graphic associations for some their subset.

Fifth principle - ***the semantic compression can be conducted in the interactive mode with participation an expert.***

Sixth principle is ***translation of stage of graphic image in the intermediate text form of presentation.***

Seventh is ***semantic compression of text form of presentation of graphic image***. The lead through of preliminary translation of graphic image in text description and application to such form of modification of the known technologies of semantic compression of character information is not uniquely the only possible decision, because to text description it is possible to additionally apply technologies of character compression of form of presentation, for example, *PPM* or *combined* variants.

Eighth principle is ***renewal of image from the intermediate text form of presentation in graphic one.*** After the lead through of semantic reduction of text presentation of picture, we make renewal of it's image in the semantically compressed variant.

Ninth principle is ***semantic decompression of graphic information.***

Conclusions

Semantic information, which is contained in graphic presentation, can be extracted by the ontological description of the problem region, built on base drawing primitives and objects, and used after for a compression and decompression of graphic images. For the compression of maintenance of picture (images) translation of graphic arts can also serve as procedural basis in text description with the subsequent semantic compression of text through the programs of type KONSPEKT. Future intellectual technologies of semantic treatment of graphic information must develop taking into account achievements in the area of fox messages and to use the ontological constructions specialized for the graphic appendixes.

Thus, in-process real on results the analysis of types of informative surplus and systematization of technologies of compression of graphic information as their general classification *tasks*, *basic principles of construction* of technology of semantic compression of the graphic information, based on application of semantic compression to its intermediate intermediary forms of presentation, formalization and text description, are indicated, and the variants of its realization are offered.

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Author's Information

Nikolay Borysovitch Fesenko – V.M.Glushkov Institute of cybernetics NAS of Ukraine, Kiev-187 ГСП, 03680, Akademik Glushov avenue, 40,e-mail: glad@aduis.kiev.ua

AUTOMATED PROBLEM DOMAIN COGNITION PROCESS IN INFORMATION SYSTEMS DESIGN

Maxim Loginov, Alexander Mikov

Abstract: An automated cognitive approach for the design of Information Systems is presented. It is supposed to be used at the very beginning of the design process, between the stages of requirements determination and analysis, including the stage of analysis. In the context of the approach used either UML or ERD notations may be used for model representation. The approach provides the opportunity of using natural language text documents as a source of knowledge for automated problem domain model generation. It also simplifies the process of modelling by assisting the human user during the whole period of working upon the model (using UML or ERD notations).

Keywords: intellectual modeling technologies, information system development, structural analysis of loosely structured natural language documents.

ACM Classification Keywords: I.2 Artificial Intelligence: I.2.7 Natural Language Processing – Text analysis

Introduction

The term "Problem domain" is usually used when the problem of Information Systems (IS) design is discussed. This term represents the aggregation of knowledge about objects and active subjects, tied together with specific relations and pertaining to some common tasks.

Usually the scope of the problem domain is not described strictly and different problem domains intersect. Let us take two problem domains for example: a school education service and a public health service.

An information system designed for automating reporting at schools and another one designed for decision-making for health authorities of a city council can not be completely independent. There are medical consulting rooms at schools and the rate of sickness certainly depends on the school working conditions and so on. After all,