COGNITIVE PROMPTINGS FOR SEMANTIC-MIND ANALYSIS AND OBJECT-ORIENTED DATA INTEGRATION OF INFORMATION FLOWS[♥]

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ABSTRACT

An emerging area of digital data processing is the computer-based intelligent analysis of information flows. In this paper, we discuss some cognitive promptings that can lead to intelligent data (audio, images, video, mixed) analysis and synthesis. A companion paper in this book describes how to extract semantic components from unordered data sets (Gestalt problem) in visual information data (*Analysis*) and an application of our approach is illustrated with a raster-scanned color cartographic map interpretation system—*Analogical-to-Raster-to-Vector* (A2R2V).

KEY WORDS

Semantics, Information flow, Visual data, Semantic-mind analysis, Object-oriented data integration.

Think about meaning…
The words are becoming themselves.
Lewis Carroll

1. INTRODUCTION

The use of computers for data processing, storage, and transmission in a historic perspective includes the following subsequent stages [17]:

- *Data (temporal series, matrices, etc.) representation and processing using traditional mathematical models. The search for computer-oriented mathematical models in signal and image processing.*

-*Generalization of the concept of data. Software development of storage, search, and reference for texts. Development of computer programs of translation from one language into another.*

- *Development of decision-making tools and expert systems.*

- *Continuous data integration (text, audio-video) leads to the subsequent stage of software development—intelligent agents such as Data Mining, Copernicus, etc.*

This was being thought about among researchers since the early 1980s. Simon [18] wrote: "*The arrival of a third generation of machines made it possible to experiment with information (data) provided by instruments in many fields of observation: in visual images, in spoken words, in the fields of physics, medicine, economics, linguistics, etc. A new field of observation and study was transferred from philosophy to experimental sciences. This was a general and crucial phenomenon in the history of Man's efforts to understand Nature: the telescope gave birth to astronomy and metallurgical, chemical, electrical and vacuum techniques gave birth to physics. There is a certain paradox in the fact that the computer, designed for commercial accounting and scientific computation, gave birth to pattern recognition and artificial intelligence*".

For the pure mathematician, data recognition is a trivial problem that can be expressed formally as follows: Let X be a representation space, preferably a "nice" topological space, and let Ω, the interpretation space, be a finite set of names. Recognition or identification is a mapping E: $X \rightarrow \Omega$, to which certain properties are described and from which elegant theorems can be deduced.

This, however, is not where the problem lies: in practice, the question is one of constructing E, i.e., of providing operators or programs which given any x from X, enables us to decide automatically onto which ω from Ω the element is mapped.

An extended definition of E, to be held in full memory, is out of the question even for small-scale problems, because here we come up against the problem of computational complexity. In the search for usable operators, data recognition is continually confronted with problems of information complexity; so many data

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recognition problems are exponential that we are constantly obliged to adopt less than optimal, polynomial solutions. Data recognition is first and foremost a battle against complexity.

The other guiding thread appears to us to be the *semantics* of the general data recognition problem, which varies according to the question under consideration. Is there in fact a general, universally applicable method for constructing a data recognition operator?

We must therefore treat each problem in a specific manner and search for any items of information that will enable us to construct the required operators. Our view is that information is to be found in the properties of

- the representation space,
- the interpretation space, or spaces.

However, the solution of applied problems requires the bridge between the strong structure of mathematical concept of space and empirical properties of the data as input information that leads us to the following conclusion: *semantic information* is to be found in the properties of

- data representation;
- data interpretation as knowledge of subject domain.

This means that we use the following model of a recognition process: find an element from a finite set, which is equivalent to the unknown object. When the element is found, the object is attributed with its all known properties. Essentially, this is the principle of "identification by indistinguishability", first formulated by Leibnitz [19].

Information flow (IF) is binary digital data stored and processed by the computer. This is the basic element of digital technologies, i.e., Turing's (Computer) world. On the other hand, IF is data that obtain from the outer (to computer) world and that have very different representations—environmental monitoring, text, music, speech, images, etc.; thus, IF is a part of the Human's world. At present, the problem to adapt computer systems to human perception and cognition is apparent (MPEG-7), but yet not carried out. In the present work, we would like to discuss some crucial aspects (*Semantic-mind analysis* (SMA) and *Object-oriented data integration* (OODI) of IF)[1] of this problem, outline the difficulties encountered on the way to its solution, and guide the reader toward the bridge between computer and human worlds. All this can be observed within the general context of human-machine interaction as a semantic approach to computer data analysis and synthesis.

In [1], we considered one aspect of this approach. The goal of the present work is to sketch the general frameworks of SMA (analysis) and OODI (synthesis) in different types of information flows. We apply the proposed approach for the case of the visual information flows and in particular for cartographic raster data [20].

2. DATA STRUCTURE AND INFORMATION

The concepts of data, knowledge, and information have held the steadfast attention of scientists during centuries. Although, knowledge as a research topic is one of oldest in the history of science, we have only a general philosophical understanding without a strong formal definition. Such a definition is required for knowledge-based computer systems (e.g., on-line and Internet education).

The main difficulty in formal definition of these concepts probably lies in the fact that man as an information carrier and translator has very specific structure of their representation and processing and thus cannot easily abstract and detect these concepts from a structured shell.

Known concepts of data, knowledge, and information explicitly show their direct link to the form of representation. "*A knowledge representation is a certain method in which the experience becomes structurally defined in wide-spread and common terms*" (*Marvin Minsky*).

Research concerning knowledge structuring can be divided into two lines. The first is related to the study of individual intelligence, but it does not yet systemize it. Therefore, this research does not provide an entire description of knowledge representation in the human brain. On the other hand, collective intelligence is much more accessible for research because numerous forms of knowledge representation have been constructed over the centuries.

Several examples of the social experience of mankind show a high degree of influence on the final result of man's activity with regard to the choice of one form or another of knowledge representation. A typical example in science occurs when two scientists making the same discovery cannot understand this fact because they use different forms (notations) of knowledge representation. To avoid such situations, it is important to represent any information in compact graphic form that reflects its basic essence. The representation must provide a possibility to determine certain details of information flow using as tools that are as simple as possible. We would like to highlight here that this way provides good results not only in education or knowledge popularization but also directly in practice and science. This is probably why computer science specialists prefer computer programs that provide precise details of processing to long-winded ambiguous explanations or fogware.

[1]Formal definitions of SMA and OODI will be given in §3.

Thus, research of the interrelation between information content and its structured representation is important from both theoretic and practical points of view.

2.1 INFORMATION

When investigating an object, anyone is stated (probably in an intuitive level) three questions:

- What is this?
- How is this related to something that I know?
- What are the characteristics of this object?

In other words, the human being attempts to identify the object, to order new information that corresponds to his early experience, and finally detects qualitative properties of the object. He partially obtains this information in an empirical manner by analogy with other objects in his eigensystem of representation. This is an example of the developing system of knowledge representation.

Problems of identification, ordering, and semantics appear in any research but not necessarily in this order. As a rule, these problems are repetitively applied to define (and modify) the solutions of each problem obtained in the previous step. We shall consider these three problems as follows and attempt to define their meaning within the context of structured representation of information.

2.2 IDENTIFICATION

Identification is the oldest human activity and at first glance represents sufficiently well a simple procedure of name assignment of objects, processes, and concepts. If $X^* = (x_1^*, x_2^*, ..., x_n^*)$ is a representation of original object, X is the representation space and $\Omega = (\omega_1, \omega_2, ..., \omega_p)$ the set of names, then identification is mapping ξ from the representation space to the set of names:

$$\xi : X \to \Omega.$$

Of course, the procedure of mapping should be constructive. However, in attempting to apply such a procedure we encounter several problems:

- Should we assign to any object a name? (*the problem of Leibnitz' "identification by indistinguishability"*);
- How novel and informative should a concept or process to assign it a name be? (t*he problem of label*), and
- How should new objects, concepts and processes be named for further easy use (*the problem of name structuration*)?

These three problems graphically illustrate that identification is not a mechanical procedure of name assignment (although we should perform such mechanics for pointer construction, for example). Thus, in subsequent sections we shall also discuss these three problems in relation to the concept of structure.

2.2.1 LEIBNITZ' PRINCIPLE OF IDENTIFICATION BY INDISTINGUISHABILITY

Identification is related to classification, association, analysis, and synthesis of knowledge, i.e., it is a necessary link in cognition and probably is the only link: "*A hard classification implies the hardness of words. A soft classification implies an inflexible look at things*" (*Charles Luttwidge Dodgson*).

The first problem is essentially Leibnitz' principle of identification by indistinguishability: "*Two objects are indistinguishable if all their properties are the same*" (*Gottfried Wilhelm Leibnitz*).

The problem of identification was first strongly formulated by Leibnitz in his Ph.D. thesis and led him to the concept of congruence: $\boldsymbol{ABC} \cong \boldsymbol{ABX}$. Congruence or universal characteristics according to Leibnitz mean "... *man can draw while not being an artist...*" The method consists of the rule for identifying X as a set of points, objects, and things and their properties by the name and properties of known object C. At first glance, this method provides unlimited possibilities for learning and cognition. However, anyone who frequently uses the Internet for scientific information search constantly requires conceptual identification—comparison of things searched for with known information that can be represented in different forms and languages.

Moreover, if we use Leibnitz' principle we always must take into consideration the following two limitations:

Limitation 1. Absolutely identical objects do not exist. An infinite number of properties characterize any real object. Therefore, we use only a subset of properties when comparing objects or rejecting others. A given problem or subject domain defines the choice of properties, which are essential for object comparison; hence, the same objects can be identical with respect to one subject domain and different with respect to another. Thus, the first problem is choice of identification properties, and

Limitation 2. Values of quantitative and qualitative properties can only be defined approximately, e.g., the weight is approximately1 kg, the color is blue, etc. Thus, indistinguishable objects at the crude level of computing or measurement of parameter values can be distinguishable only after re-computing and re-measuring. Thus, the second problem is exactness of representation of object properties.

Sense of the principle of identification by indistinguishability is detection of object identity by known properties. Applications of this principle are different in different subject domains: in algebra—relations of equality and identity; in geometry—relations of congruence and similarity; in linguistics—synonyms; in statistics—coefficients of correlation, etc.

2.2.2 THE PROBLEM OF LABEL

This problem is well illustrated by Di Bono: "*Having a name, the knowledge fragments become 'frozen' and 'untouchable' because the label can only be used for constant value. We must consider a world that is constructed from names such as house—from the bricks, which must be broken into parts and investigated separately to understand the whole*". This is the point! The reader encounters difficulties in understanding the main idea of a scientific paper that contains numerous abbreviations or introduces new terms for unjustifiably large number of concepts. Thus, the reader must usually break down and digest unusual concepts.

G. Zipf [10] analyzed the naming of new concepts and proposed the following law: name is a function of the frequency of use of a new concept in some limited social group; thus, professional language, dialect, slang, and other language subsets are generated. Naming is the desire to increase efficiency (velocity) of interaction in human society.

The appearance of new names inside a certain group is not sufficient for their introduction into a larger group; otherwise, the tendency to optimize transmission of messages can lead to the inverse result. For example, if each number has its own hieroglyph (digit) then number memorization and use would be difficult despite the fact that each number must be written, for example, shorter than in decimal notation.

Therefore, the problem of label should be solved taking into consideration the following two conditions[2]:

- Sufficient stability of the concept to be labelled, and
- Sufficiently frequent use of the concept so that efforts for memorizing a new name are lesser than its perception through description.

2.2.3 PROBLEM OF NAME STRUCTURATION

This problem involves the assignment of names in such a manner that their associations to objects are simplified to the fullest possible extent. Let us consider a number. By thinking, we studied to perceive quantitative information. First, we perceived one stone and two stones as objects not linked to a unified scheme; thus, counting skills were developed step-by-step. At some time, it became possible to assign different and unsystemized names to various quantities, e.g., a dozen. More complex calculations that employed a wide range of numbers rendered such an archaic method loose. A positional number system with its strong structure of number description and generation of a description of any big or small number does not yet require such types of names. Thus, we use names like a million with the same ease as when we write 10^6 or 10 to the sixth.

2.3 ORDERING

In Mathematics, the problem of structuration of object names in ways useful for applications and the problem of object ordering are solved by means of unified methods. Probably this is one of the causes of the high descriptive power of Mathematics. Although mathematical solution is quite natural, there is no similar correspondence between name and ordering in other sciences. To illustrate this thesis, let us consider computer-based numerical analysis.

A peculiarity of numerical analysis is the numerical model: one-to-one mapping between input and output data. Nevertheless, great difficulties can appear for ill-posed problems. However, these difficulties are exceptional. In most cases, strong mathematical description of the original problem provides adequate solutions. As a rule, input and output data as well as the model's parameters are objects of the same nature and can be strongly defined. This explains the elegance of the algorithmic model in numerical analysis. Moreover, admitted operations on objects represented by numbers are known a priori. Only interpretation of the result (assuming that all definitions are correct) can result in uncertainty of the numerical model.

Information analysis does not possess a mathematics-like axiomatic base. In particular, the set of operations on objects is not defined by ordering of natural numbers as in numerical analysis.

The concept of ordering in Information Science is often used in the narrow sense as a synonym of certain temporal unfixed object relationships. For example, people in a queue can be ordered in different manners: by height; professional or sporting interests, etc. In contrast with this pragmatic approach, we understand ordering as something implied from basic object content. For example, the meaning of the word six implies that the object with the name three precedes such an object (in linear systems); the meaning of the word father implies its following location of the object, son (in hierarchical systems). Of course, other examples can show situations in which these orderings do not hold. In this case, we can use the words as temporal labels and not their usual meanings. Note that not only numbers admit such (partial) ordering. The main difficulty here is that non-numeric information expressed by words does not admit one-to-one ordering due to the multiple meanings of each word. A possible solution is multi-dimensional ordering. The Mendeleev Periodical Table is an outstanding example of this type of ordering. The Table shows how to take into consideration different properties of chemical elements and how to order each element.

[2] In the history of natural language, the problem has been solved this way.

The concept of ordered number could be established independently of its quantitative substance as the result of abstraction from qualitative differences of the equally arranged sets. Understanding independent number substances became clear only in the 19th century (*Peano*).

To express solely the number's ordering substance, we could use letters without their quantitative meaning only by using alphabetical order. In this sense, the concept of natural numbers $\aleph$ has been developed. In $\aleph$, each element is defined by its location in the series.

The French word *l'ordinateur* literally means *fixing order*, which is closer in meaning to modern computer use than the word in English, *computer*, which literally means *calculator* and mainly characterizes the prescription of computers in initial stages of the computer era.

V. Bush (Manhattan Project) was the first who noted this fact and who proposed a new approach to the order organization of concept indexing for search in the computer. In 1945, Bush published the semi-utopic work, "As We May Think", which remained during many years the most cited publication in the field of man-machine interaction. Amazingly, the work contains a description of *browser* —a system for text-graphics information search. This system, called *Memex*, included a large library of texts, photos, and drawings. Although Bush showed great forecasting talent, Memex was not a computer because it used microfilms and photo-elements. The main peculiarity of Memex system was the possibility to input relations among library elements. The corresponding mechanism was inevitably bulky but logical. If the user had two documents (each in single image) that he wanted to relate, he struck via a special relation a *name* button and this name appeared at the bottom of each image. To obtain the document related by a certain relationship to another, he simply entered its code via the same button. This we call *hypertext* at present.

Some time after D. Engelblatt (developer of the first computer mouse) developed a system that linked hypertext with newly invented devices and graphics (*multimedia*).

In contrast, the search engines of the modern Internet use the principle of search by keywords. This principle is not efficient because an engine displays a great number of vague references from different sources related to each keyword. Among methods of identification in the Internet, the most interesting principle of information search belongs to the server www.altavista.com, which shows the complete route to the site (page) where a keyword is found. However, this approach is not a semantic (or meaningful) search. ISBN (book systematization standard) uses the subject-alphabetical principle of ordering but does not provide detection and construction of semantic-meaning concepts as inter-disciplinary and inter-topic relationships (*associative pointers*). Construct associative pointers means the establishment of relationships between a given and well defined, tree-like structure of unique pointers (*subject domain*) and a set of semantically meaningful concepts (*course domain*).

Problems of semantics and meaningful search for words in IF are considered in the subsequent section.

3. SEMANTIC-MIND ANALYSIS AND OBJECT ORIENTED DATA INTEGRATION OF INFORMATION

"*Semantics—the study of the meanings of words*" [2]. Therefore, semantics is the search for cognitive, associative object identification in IF. Keywords in text, sound-shapes in audio flows, segments in image flows (*data invariants*), etc., are the object-oriented data of IF.

"*Mind—the part of human being that governs thought, perception, feeling, will, memory, and imagination*" [2]. In other words, meaning is the capability to understand, to feel, to perceive, and to imagine, i.e., restoring an entire piece of knowledge by some segment or part. For example, the program Guess a Melody [3] identifies the musical piece by a few musical phrases; the-raster to-vector conversion system A2R2V [4–6] is oriented toward searching for names of the converted set of pixels, thus, object-oriented data integration to *Geographic Information System* (GIS).

On the other hand (See first paragraph of this section), semantics is the adequate, meaningful search for *words* in IF (e.g., Google search www.google.com as zero approximation), while the meaning is the extraction of the *subject domain* in IF (e.g., adaptation of a Physics textbook or articles in a specialized journal for the secondary school).

Subsequently, *Semantic-mind analysis* (SMA) of IF is the meaningful search for object names and definition of the subject domain as a set of found names (e.g., 32 letters require five bits of information by Shannon, while the same letters require fewer bits of information by Morse. The difference is that the Morse Code took into consideration frequency of use of letters in text and named letters by symbols, such as point, dash). *Object-oriented data integration* (OODI) is input into a particular computer-based application of the output of SMA. This input suggests special SMA-output data organization, compression, storage, processing, etc., which is dependent on that application. For example, vector object integration to GIS is straightforward. Moreover, it is more desirable to store that object in GIS under the corresponding name only. In the following sections, we will use the abbreviation SMA/OODI for newly introduced concepts.

Cartographic data (CD) (raster or vector) as IF are one of the most complex subjects for SMA/OODI, because they are simultaneously contain different types of information carriers, including graphics, images, texts, symbols, etc. [6] [20].

3.1 SMA/OODI: METADA AND MPEG-7

For the sake of simplicity with regard to the following explanations, let us now consider the concept of metada. Metada are aids (via HTTP, FTP, etc.) for network users to follow up information resources and optimize their primary and secondary uses (see, e.g., IEEE European Colloquiums' Multimedia Database and MPEG-7). SMA/OODI can be also seen in the context of MPEG-7 technology as a system potentially adapted to process IF as metada (*user-oriented processing*). It is motivated by the fact that at present, digital *audio-visual information* (AVI) can be accessed by anyone not only for consumption but also for yield. This converts us at least potentially into *content makers*. We can publish and transmit digital information yielded by us via the Internet. However, day-by-day more and more simple procedures of audio-visual content acquisition, processing, and transmitting constitute only one part of the problem. The other part is that access to existing data should be equally simple because of the huge amount of AVI yielded daily throughout the world. Unfortunately, identification of desired (useful) information by searching and filtering has become more and more complicated. Even if open-source resources are used for access in such specific area as GIS (open-GIS and similar), the problem remains due to data interoperability and homogenization. Thus, GIS-oriented people now refer to *the Spatial Semantic Web* [7].

Therefore, the problem of fast and efficient identification of audio-visual contents in IF is emerging. This problem has motivated the Multimedia Content Description Interface Project by MPEG, also known as MPEG-7. MPEG-7 attempts to define standards for description of different AVIs that include images, image sequences, speech, audio, graphics, 3D models, and synthesized audio independently of representation formats [3].

Our general considerations in this work are aimed to follow up this research line and hopefully lead to better understanding of this research.

3.2 THE LAW OF PROGRESSIVE SIMPLIFICATION

We visually perceive the outer world as an optical process of transmission of images to the retina and subsequently construct the scene model as the spatial-temporal structure of objects and their relationships by local analysis and synthesis. This allows for extracting image semantic relationships and advancing to the verbal level of representation of initial visual information by logical analysis [8].

Subsequent passage from visual perception to verbal (logical) cognition provides progress in many areas (Computer Science included), well illustrated in the following [9]: "*… In the history of handwriting, we observe not only the correspondence between the techniques of writing development and the form simplification but also these two tendencies are identical 'de facto' because the technical problem of writing as registrator and translator of human speech should have been also solved. This is a clear representation of the widest sphere of human language by means of maximal optimization of visual symbols, i.e., etherification is the law of progressive simplification…*"

Human reasoning, memory, and cognition as *self-substance* do not exist. On the contrary, they are simply *the names* (labels), synonyms that associatively reflect the result of the human's brain functioning as continuous cognition, i.e., the tool (processor) of etherification. The human brain's self-sufficiency is based on *the law of progressive simplification*. A particular case of etherification is *the principle of least effort* by Zipf [10] [3].

Basic sources of information exchange and their types, and evolution of perception and thinking in the human world are shown in Table 1. If we look at this table from the point of view of computer-based systems (Turing's world), some analogs are straightforward. Let us only highlight some of them, leaving to the reader to complete others as an exercise.

Suppose that you are a computer specialist and have never heard about cognitive science or have never learned any other science. Are you familiar with concepts such as genetic algorithm, environment, sampling, learning, self-learning, knowledge, etc., from your area? Of course you are. Then look again at the table.

Computer genetic algorithms and programming involve methodologic background similar to the natural processes and laws that govern the transmission of genetic information. Thus, the concept of inherent knowledge can be spread and accepted in both worlds (Stage I).

Environment and environmental models are now commonly accepted concepts of Turing's world. They are rather the computer media (Unix, Linux, Windows, WordNet, open GIS, Spatial Semantic Web, etc.) in which computer programs are run than physical media. At present, computer experiments are common and available to nearly everyone. Moreover, newly invented computer environments encourage experiments that we call by analogy research instinct (Stage II).

Sampling is widely used in image processing and pattern recognition to imitate the characteristics and behavior of something already known from "parents", "teachers" (sample set, seeds, etc.) to acquire new or identify old information from unordered data sets (Stage III).

Learning and self-learning are represented as powerful tools of new knowledge acquisition in both worlds.

[3]In other words, we adopt here a strongly nominalist point of view. It is rather our hypothesis and model than a fact that everyone should accept. The only aim of this "sound" affirmation is to guide the reader toward the computer-oriented model as quickly as possible (§3.3).

Moreover, learning and self-learning computer systems usually oriented to tune system parameters are most efficient in automatic modelling (Stage IV).

Knowledge-based computer systems applied to digital data processing are now revisited and aimed toward development of self-consistence virtual reality similar to human's imagination (Stage V).

Stage	Source	Information process	Model	Transmission tool
I	Biological kind (Nature)	Transmission of genetic information	Inherent knowledge	Inherence, instincts of life and death
II	Environment	Self-learning	Environmental model	Research instinct
III	Parents, flock	Sampling	Behavioral model	Imitation
IV	Teachers, society	Transmission of exciting knowledge, learning	Model of life	Language
V	Cognition	Synthesis of new knowledge	Model of the world	Imagination

Table 1. Evolution of perception and thinking (levels of information exchange) ordered by rows. We aim for this to show some analogs between human and machine worlds in this evolution.

3.3 TOWARD A PROBLEM-ORIENTED SEMANTIC ENVIRONMENT

In taking up again previously mentioned promptings within the context of SMA/OODI, we should note the following.

Images or events of any nature involve *semantics*. Semantics is universal and context-interpretative in a certain finite space of meanings and events. This statement is based on the understanding (probably multi-valued) of any image or event of the outer world even if they do not yet possess a semantic context.

At present, organization of system analysis of data flows that aim to detect the interpretative in different contexts structured elements and a fast search for commonly accepted data structures experience great difficulties. This means that further significant development of data flow processing is impossible without a knowledge-based semantic-oriented analysis of data structures. The latest developments in the Internet graphically illustrate our statement. Of course, the knowledge bases themselves are not functional without special methods of preliminary analysis.

Here, correspondence of the problem-oriented environment to the level of the problem under consideration and the capacity to process meaning arises once again. For example, signal digital representation is solely based on the abstract concept of band capacity and does not take into account semantics: what is this signal—text, music, or image?

To illustrate certain principles with regard to *meaning processing*, we temporarily disregard the concept of generalized context.

If we denote something, then we assume that the meaning is understood, explicit. We do not go from sounds to images and from images to meaning: from the beginning, we are embedded in meaning, and being able to express it in sentences. Meaning prescribes possible denotations and conditions. Moreover, meaning is the object of the following sentence. If a certain name is assigned to a sentence, then clearly each name that itself denotes an object can be the object of the new name denoting its meaning: N1 addresses N2, which denotes the meaning of N1; N2 addresses N3, etc. The language for each of its names must contain some name for the meaning of this name. Such infinite multiplication of verbal essences is called a *Freguier paradox*. In the meaning-object relationship, Freguier paradox locates the place of search for the meaning and indicates the moment of appearance of so-called *context-meaning dependence*. We use Freguier paradox as a methodology of the *dynamic structures* of data relationships in the problem-oriented environment. These relationships in difference with arbitrary environment are defined by means of associatively organized identification and allow eventual, i.e., meaningful structuration [20]. This provides a new look at problems of efficient organization of the computer environment for data processing and understanding.

The first problem—compact representation of information concerning complicated systems— forces the search for new structured forms of knowledge representation. From our point of view, *self-similar recursive structures* provide adequate description tools. Moreover, self-similar recursive structures not only handle information but also manage information in a similar manner as genomic programs. One more important fact is their simplicity and regularity, although the result of application does not provide such as impression [11].

Secondly, the problem of memorizing the data structuration must be solved in a flexible, manageable manner so that signs that represent information segments are ordered by values [1] [13].

The problem of development of computer knowledge-based systems is illustrated very well by Hofstadter [12]:

"*A computer does not have automatic sensitivity to the images it processes. Of course, we could not expect this. It only executes the program like an old saw. The computer does not tire by adding columns of numbers even if all numbers are equal. Men get tired. What is the difference? Obviously, the machine misses something that allows it to have unlimited patience for repeated operations. The missing detail can be described in a few words: this is the capacity for self-observation, contact with the outer world; this is the capacity to perceive an image of proper activity and carry it out at any level of abstraction. Meta-knowledge and knowledge are completely mixed between themselves in a unique flow and are mutually enriched. This renders self-observation as an automatic implication of the memory's structuration. How is this amazing flow organized in the human brain?*"

We cannot answer Hofstadter's question even approximately. Undoubtedly there is the need of hierarchical knowledge ordering, but *the hierarchy* should possess a special form that Hofstadter calls " ... *complete mixture in unique flow*" [13].

Natural organization of memory demonstrates once again the efficiency of a system approach with flexible inclusion of different tools for the problem of structuration of information. For example, Arbib [14] wrote: "*Many people have discussed the problem of whether the human brain is a sequential or a parallel computer? This is false opposition. Considering the eye's motion, we observe some sequence of operations but understand that strong parallel computing is required within each time segment*".

If we can successfully designate to machines the capacity to make decisions on an experimental basis, fully using any given insufficient data, furthering precision and extending these decisions with newly arrived additional data, then we would have a computer that does not require an explanation of *how-to-do*, but only *what-to-do*. Of course, the language of human-machine interaction should possess less logical and arithmetical depth than the internal language of the computer in this case.

4. CONCLUSION

Psychographic visual images as tool of communication appeared much earlier than language i.e., the abstract verbal form of the semantic-meaningful representation of the outer world. We attempted to highlight this fact in §3.2 by citing [9]. Development of traditional mathematical models has only led to numerical data processing. By inertia, similar approaches have been relegated to the computer data processing (e.g., a huge number of useful-less, pixel-oriented image processing approaches: the amount of data required to apply such approaches is often equivalent to the amount of the original data). There is no need to prove that recognition of the known painting requires less information than an attempt to recognize the unknown. Modern computer technologies (protocols, formats, etc) empirically demonstrate the necessity to identify different types of images, including cartographics, paintings, photos, chart-flows, etc. Morphologic classification could be useful here, but experiences great difficulties in computer analysis due to its weak formalization.

In the present work, we recall and show one possible approach to the problem: detection of semantic-meaningful components from information flows. These components can be different with regard to dependence on the problem under consideration.

In Table 1, we attempted to exhibit evolution of human processing of information flows and to put forward some analogs with machine processing. From our point of view, these analogs are quite correct because efficient human-machine interaction is the stumbling block of modern computer technologies.

The problem herein discussed is of great current interest (remember the now-popular image-processing slogan *Back to the intelligence!* www.ijcai-03.org). We conjecture that the most promising line of progress toward the solution of this problem lies in successively increasing automation of the separate links of the approach considered herein. We suggest as *the main principle* of such automation, the maximal use of data-semantic content. Indeed, semantic information can be optimally organized and effectively processed by a computer system.

The companion paper in this book [20] illustrates our approach by describing the *Analysis* system and the color cartographic map interpretation system (*A2R2V*) that encapsulate basic elements of semantic analysis and synthesis of visual data. Both systems constitute symbolic language descriptions of objects of information flows rather than the traditional programs of data treatment.

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