

# THE ORIGINS OF COMPUTER METAPHORS. SURVEY AND ANALYSIS

Vladimir L. Averbukh

*Institute on Mathematics and Mechanics, Urals Branch of Russian Academy of Science & Urals State University  
Ekaterinburg, Russia*

## ABSTRACT

This theoretical paper is devoted to research of computer metaphor's sources. Metaphors are actively used in designing of modern interaction and visualization systems. The paper contains the discussion of problems of metaphor search and/or metaphor generations. One of possible hierarchy of computer metaphors is described. There are global and local interface and visualization metaphors and also metaphors of widget (or operation metaphors). Taxonomies of existing computer metaphors are considered as well as criteria for adequate selection of metaphors. One of taxonomies is based on source domains of computer metaphors (everyday life, theater, physics, astronomy, etc.). It is useful to analyze magic fairy tales, and science fiction and fantasy stories as a source of computer metaphors. Criteria of metaphor selection aid to create adequate scenarios of interaction and visualization, in particular, for end-user programming systems and virtual reality environments. On this base one can search metaphors to design virtual moving, navigation and communications in virtual spaces.

## KEYWORDS

Computer metaphors, Metaphor source domains, Metaphor analysis.

## 1. INTRODUCTION

This theoretical paper is devoted to the research of computer metaphor's sources. It continues our researches on computer metaphor's theory published in our previous works.

The subject-matter of metaphor is popular in modern literature on HCI, visualization and designing of program systems. There are hundreds interesting articles, books, technical reports and theses on metaphors in computing. In this literature there are various approaches to understanding of term "metaphor". One can differ narrow and widened understanding of this term. In the first case metaphor is considered as using of everyday life concepts to explain interface operations. The widened understanding includes in the conceptions of computer metaphor also more abstract visual ideas and even visual formalisms.

Visualization and interface metaphors are used to define user activity in end-user programming and interactive visual systems and also Virtual Reality (VR) environments. Metaphors describe user's perception of visual objects and operations above these objects. Sometimes the success or failure of system depends on successful choice of metaphors. However researchers have started to complain of rarity of interface metaphors already in early 90-s' years when development of visual interactive systems were anyway a novelty. In our opinion one may find a lot of sources of metaphors, but it is necessary to search these sources by some criteria.

Below we consider approaches to classification of metaphors basing on their sources, and also we analyze these sources to use them for designing interactive visual systems. But now let's define the concept "Computer Metaphor".

## 2. COMPUTER METAPHOR. WHAT IS IT?

In this paper we understand computer metaphors as interface metaphors and visualization metaphors though in the literature on Computer Sciences one can find other cases of using of this term. In this

connection computer metaphor is considered as the basic idea of likening between interactive visual objects and model objects of the application domain. Its role is to promote the best understanding of semantics of interaction and visualization, and also to determine the visual representation of dialog objects and a set of user manipulations with them. One can define a computer metaphor as an operator from concepts and objects of the application domain under modeling to a system of similarities and analogies generating a set of views and a set of techniques for interaction with and manipulation by visual objects. We consider the metaphoricalness of any visualization. (In our opinion there are no “metaphorless” visualizations of computer models and program entities.)

Metaphors design for the user some world frequently by means of objects, concepts or operations, not existing in a reality, creating as though “magic” opportunities (that is opportunities non existing in our real world) for the user. The logic of new reality on the one hand reflect user ideas about the interface and objects of the modeled domain, and on the other - should coincide (or to be close) with the logic of development of processes and changes of objects in source domain, including the logic of user activity. The use of metaphors should increase expressiveness of objects under investigation. To achieve it objects of target domain (with a set of structures, properties) are selected. As this takes place not all objects are chosen (and even not all their characteristic or structure elements), but only that, which are under interest most of all. Analogues for these objects (by way of structures, qualitative properties) are searched in source domain. Further the following operation takes place. Object of target domain together with object from source domain are located in metaphorical domain, or more exact in doing so the metaphorical domain is generated. In this domain the investigated object now starts to function. (It is possible to consider, that it is already a new object of a new domain.) The metaphorical domain gets autonomy from domains generated it. Many properties of its objects only mediately are connected (if at all are connected) to properties of source domain objects. There is a new logic of development metaphorical domain.

An action of computer metaphor consists of extractions of structures from target domain on the base of certain structures from source domain and transfers them in metaphor domain, which in this case has a visual nature. The concept “metaphor action” is constructed by answers to the following questions:

- How can this metaphor assist to represent the information?
- How can this metaphor assist to interact with data or to manipulate them?
- What properties of metaphorical objects (that is visual and/or dialogue objects generated by the metaphor) take place?
- What actions or ideas are arisen from the process of the user interaction (including observations of pictures) with metaphorical objects?

It is possible to construct a “formula” of metaphor actions. The metaphor “formula” includes simplified descriptions of source and target domains, an idea of likening using in the metaphor and results of metaphor actions (Averbukh V.L. et al. 2008).

The search area for comparisons and affinities and a character of used metaphors depend on the user purposes and tasks. It determines a variety in approaches to the concepts of computer metaphor and to their descriptions. There are various levels of immersing in the world created by computer, also as well as there are various levels of comprehension the fact of immersing. If the goal of human-computer interaction is to support the difficult computer model, then the metaphor should provide interaction with the program realizing this model. Other problems arise in case of support of interaction with system to change methods of data output and input. It is obvious that differences in understanding are caused by distinction in the user and developer problems, and “immersing” degree to the computer world. The analysis allows suggesting another important hierarchy of computer metaphors includes global metaphors, basic metaphors of applications, local metaphors describes a specialization of applications, metaphors for widgets and/or separate operations, and agent metaphors. Characteristic of computer metaphors lies in the fact that their use does not assume the exact conformity of a reality, but, on the contrary, demands additional, (“magic”) possibilities not existing actually. (Users already do not notice the most habitual example of a “magic” operation. This is folder opening after double “right click” on an icon.) Thus, the new world is created, world with objects, concepts and the operations which do not have full correspondence in the real, familiar to everyone world. The logic of the new world on the one hand reflects user ideas about the interface, and objects of the application (target) domain, and on the other hand - should coincide (or to be close) with logic of processes and objects changes in the source domain, including the internal logic of user activity. In many cases using of “full” and “exact” metaphors, without generation of “magic” properties and objects is unnecessary and even harmful.

### 3. RELATED WORKS

The detailed survey on computer metaphor problems is presented in our previous works. Among many papers and dissertations devoted to the analysis of computer metaphors and in particular, a desktop metaphor, one can mention such works as (Kuhn and Frank, 1991) (Kuhn, 1993) (Kuhn, 1995). Except the metaphor analysis some of these works are important what they touch upon subject of such properties of a computer metaphor as magic operations. Interest to “magic” in connection with HCI and interface metaphors was showed in early 90-s’ years. The significant attention has been given to “Magic Features” conception. This conception in the context of HCI was introduced for the first time by (Kay, 1990). “Magic Features” are considered as important for HCI. The authors of the some works emphasized especially that metaphors doesn’t preclude magic. Obviously, if to consider metaphors not only as usage everyday things and everyday entities then magic may be a part of interface metaphors. The problem of “magic” in the human-computer interface may be considered in different ways. The word “magic” is very popular as a part of metaphoric names for interface techniques – for example “magic lens”, “magic mirror”, “magic lancet”, etc. “Magic wand” in some cases may be considered as a manipulation metaphor to form an interface in systems with elements of virtual reality. (Note that in some cases the word “magic” may be used to describe rather bulky input devices.). In (Dieberger, 1994) the information system using a City Metaphor is described. In this system magic/fantastic opportunities are used on regular basis. Among these opportunities there is the “Tunneling through space” presenting the typical adoption from Science Fiction novels. Also rooms with “magic windows” may be considered as a magic (science fiction) feature. “Magic window” is an interesting expansion of a well-known Information Wall metaphor. The important (for our consideration) point of computer metaphor theory is computer taxonomy (see above). One of the approaches to this problem is presented in the works of the research team from New Zealand (for example in Pippin et al, 2005). Other approaches are described in our work and in (Poupyrev et al, 1998).

### 4. OUR APPROACH

One of the frequent question in the papers on computer metaphors is “How can we Find Metaphor Candidates?” (See the interesting example in Kuhn, 1993.) The most (on our opinion) full description of the constructive procedure of interface metaphors searching and/or generating is presented in (Dinesh, 2005). This multistage procedure provides (among other) the consideration of application domains, user tasks and user characteristics.

Well known set of metaphor relations includes base specificity, clarity, richness, abstractness, systematicity, validity, exhaustiveness, transparency, and scope (Carroll and Mack, 1985).

We suggest new approaches to problems of computer metaphor's searching and/or generating. The process of metaphor generation (metaphorization) first of all includes (may be implicit) analysis of target domain of the future metaphor. The hierarchical structure of object interrelations of target domain and their properties is revealed on a basis of the metaphor objects and its properties. At the following stage a source domain and its main object are searched. Criteria of a choice are criteria of metaphor quality. Firstly, the main object of a source domain should have the properties, similar (closed) to properties of metaphorization object. The structure of these object interrelations and its properties should be *similar* to structure of interrelations of object under metaphorization and its properties, at least on the first level of a structural tree. Secondly, a *source domain* should be **visualized**. That's mean that the nature of the source domain should be like, that its objects have dimension, extent, length, form, color or other visual characteristics. (For example - a metaphor of the railway for the functional description of operational systems.)

The person distinguishes any general logic in a picture, breaking it on the set (perhaps enclosed) of fragments, abstracting from minor elements. One can consider the structures of user's internal mental model. “Visualizeness” (in a broad sense) of source domain provides the interpretation. A process of interpretation is exactly the generation of representative cognitive structures on base of visual images. This process is inverse or more exactly dual to visualizations. Similarly to visualization principles the interpretation principles should exist. So, the metaphor's quality is connected with an opportunity of easy interpretation of the [visual] language, which is generated by this metaphor. Also the visualizeness requirement is connected with the known for a long time criterion of “good” metaphorization - habitualness, recognition of source domain

objects. (The concept of habitualness and recognition in the specialized systems of the human-computer interface should be connected mostly not with everyday realities, but with potential user activity in that sphere for which the interactive system is created).

The analysis of a source domain is carried out at the next stage of metaphorization process. On the basis of the interrelations analysis and dependences in the context of a source domain, as well as on the basis of analogies with them, both the metaphorization the analysis of the object and its properties is carried out. Objects dependences in the context of target domain are revealed. It is necessary for a source domain to have the deeper structure of interrelations than target domain in order to search for new dependences in the target domain. It's one of the factors of a "successful" metaphor.

The metaphor's success is connected first of all with interrelations concepts structure of a source domain and with a possibility to obtain on its base the new understanding of dependences in the target domain that was of interest to us initially.

The duality of interpretation and visualization processes (or any other form of representation) is shown here through a metaphor. Sign process in visual interactive systems (or more exact part of this process connected with the interface interpretation) is supported through metaphor action. Metaphor action and, in particular, the user reaction to properties and dependences carried out at objects of metaphorization are connected with imposing of rich structures of interrelations concepts of a source domain on a target domain.

One can conclude that the combination on the one hand the formalized techniques (for example criteria of metaphor selection, the analysis of application domain, and user tasks), and on another hand the use of interesting analogies and heuristics is fruitful. We have developed a set of specialized systems for example for the mathematicians and for health professionals. Our experience shows that here developer intuition and user knowledge play the very important role. Frequently many ideas prove rejected by the user until the developer finally offers a suitable metaphor.

## 5. DISCUSSION

Our researches on theory of a computer metaphor and practice of designing specialized visualization systems results us to a number of the conclusions. The constraints of metaphor habitualness and completeness are brought forth. Our approach to computer metaphor in some aspect does not comply not only traditional for philology understanding of a metaphor, as ornaments of speech and increase its informativeness due to bright comparisons, but also understanding of metaphors as an application of everyday experience for abstract conceptions as it is usual in theory and practice of HCI. Interface and visualization metaphors may be considered as a special case of scientific metaphor used for generation of new or additional senses for understanding of the new facts and the phenomena. Interface and visualization metaphors are not completely identical to the metaphors investigated in other disciplines. Practical use of metaphors frequently does not submit to the criteria chosen at the previous stage of development of discipline. On our opinion to form the qualitative and constructive theory of interface and visualization metaphors it is necessary to update and to supplement the existing theory. Then practice applications of metaphor can base on stronger basis. A metaphor generates some "metaphorical" domain constructed on basis of realities of source and target domains. Just in this domain the metaphorical objects exist, act and interact and just its logic determines their behavior and relations. Another function of the metaphor is to specify a context for better interpretation of elements of the given interaction and visualization language. The computer metaphor helps to understand entities of the application domain that are being modeled, as well as to create new entities based on the internal logic of the metaphor. The components of the metaphor are the imagery (and/or a set of dialog objects) it generates and actions it dictates for updating visual images and manipulating visual objects. The conception of "metaphor action" is important for the theory of computer metaphor. This conception has formed a basis for the analysis actions of concrete interface and visualization metaphors. Techniques of data representation generated by means the given metaphor, property of metaphorical objects and results of their interpretations by users are the subject of the analysis.

The successful HCI and visualization are constructed on base of "good" metaphors, and they should be supported on the already existing user model of phenomena and/or processes (representative cognitive structures). It is necessary *to depict entities under visualization, but not to describe them*. The metaphor has to generate integral and systematic interface and/or visualization systems. As we mentioned above, it means

an undesirability of the interface based on several fine metaphors describing details and components of dialog. This requirement means also necessity to conform as to others already existing computer metaphors, and to general ideas of global metaphors. Reduction of interpretation complexity is considered as a condition of “good” metaphor. Therefore direct interpretation of images is required, but decoding and interpretation of complex [visual] texts is considered as a source of failures. A set of the criteria, imposed on initial and target domains in a process of metaphor generation includes: similarity of object properties in source and target domains; ability to visual presentation for object in the source domain; habitualness (recognition) of objects in the source domain; rich set of interrelations between objects in the source domain.

We know how metaphors are structured and how they are generated. We are able to find new metaphors and to evaluate their properties and opportunities. We have an experience in design and developing of specialized interactive visual systems which are based on these metaphors. But in some cases the question arises of whether it is possible to design a metaphor? Or may be there is only “insight” approach to its searching. Really. Constructive procedures of metaphor generation, described in (Dieberger, 1994) or (Pippin, 2003), are not safe against failures. It may be possible that the analysis of the application domain has some negative results. Waiting for insight may be long and also may end with nothing. Where can one find new metaphors? As we have noted in (Averbukh, 2008) the magic fairy tales and fantasy stories is one of sources for metaphor searching. But systemness is necessary both in a choice of metaphors and in a choice of “correct” magic.

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