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Pictorially simplified images as machine vision design tool: semiotics approach

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Department of Semiotics, University of Tartu, Estonia

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PUBLICATIONS INCLUDED IN THE DISSERTATION

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INTRODUCTION

As intent for writing this work, an original interactive experiment, organized by the Worldwide society of blind people and people with partial loss of sight, came to attention in 2008.

The essence of experiment consists in the following: the group of 6 participants was offered to pass number of rooms in absolute darkness, being guided only by a guide's voice, and the tactile sensations. The guide was a blind person, familiar with spatial patterns of an experimental interior through his preliminary repetitive guidance experience, while all participants possessed normal sight. Thus, potential participants appeared in a situation of a literal translation of "visual touch" into "manual vision" (Kravtchenko 2001), i. e. a process of visual search as one of the information-communicative ways causing identification of surrounding subject matters, has been broken and replaced by tactile receptors. Such practice may be considered as a common and natural process, as human being has an ability and need to translate formally "foreign" messages into familiar and an appropriate language. If this translation and interpretation ability exists, the communication process is also possible (Torop 1995). However, besides loss of vector orientation in space, participants have collided with partial or full inability to identify objects, located in rooms, by manual recognition. Thus, the process of the object identification, in natural conditions caused by work of visual receptors, has been distorted by means of variation of a different coding arrangement, and, accordingly, has led to misinterpretation and, finally, an irrelevance of message understanding.

Considering the experiment above, it's quite logical to point out the problem of finding adequate replacements for distorted or completely missing natural mechanisms for transmitting visual signals via artificial optical, mechanical and other means of communication and language constructs – in other words, the search for solutions in artificial and machine vision, based on visual semiotic ground. Thus, the central research question of this disssetation will be focused on the analysis of special kind of visual construction, designated as pictorially reduced images, and search for principles of their structural elements semantization, along with so-called minimal visual trigger signification as the principal interpretation key for the specified images.

1. TITLE AND STRUCTIRE OF DISSERTATION

This Thesis consists of an Introduction, 4 published articles on the topic of Thesis, a brief review of articles, conclusion and two Appendices. The key terms and the general problems of the issue are discoursed below.

2. GENERAL TERMS REVIEW

2.1. On Pictorial Reduced Images

Before moving on directly to concepts, it makes sense to briefly review the concept of reduced image in general, as well as its types, used for computer vision development. The term *reduced image* in infographics mainly refers to a visual structure having a simplified shape of an object, but not of the meaning of its designatum – the difference is quite dramatic, for instance, in the semantic unambiguity of a pictogram and the polysemy of a logo. A pictogram itself "is a stylized figurative drawing that is used to convey information of an analogical or figurative nature directly to indicate an object or to express an idea" (Baechler et al. 2015). The function of a pictogram is to express as accurately as possible the essence of the information unit, encoded in the image. Therefore, pictograms are practically not used for abstract categories representation. The impediments to conveying peculiarities of abstract notions via reduced images are created both by the limitations of the representational means in infographics and the representative specifics of the visual language itself. Thus,

> *The point is that a language provides an unbounded repertoire of evidence of the speakers meaning, evidence that can be as nuanced, as complex, as richly structured as the speaker likes. Nonverbal kinds of evidence are much more limited.* (Sperber, Wilson 2012)

The situation is slightly different when it comes to logotypes. While typologically being a simplified image – similarly to a pictogram – a logo doesn't necessarily have to be a signal sign or even an iconic sign, because a logo can adequately reflect not only things or actions, related to certain activities, but abstract concepts as well. In the case of such communication, message decoder faces the so called "logotype paradox", consisting in ambiguity of interpretation at obvious simplification of the representative form, based on fact of a signifier de-complexity as the result of certain reduction mechanisms. Technically, being a multy-semantic informational construction, complex simplified image may be considered as at the most approached entity of transfer of multi-leveled information in a shell of one pictorial unit. Here, under simplification we designate a signifier transformation only, i. e. the spatial changes aside basic visual forms, whereas the substantial (content) side remains constant or even can absorb an additional meanings and values. Thus, instead of simplification, the term of *reduced pictorial architecture* (RPA) may be suggested as more pertinently to apply and will be analyzed further on.

In turn, visually simply constructed images do not just represent basic visual structures of integrated images since the latter may be viewed as a sum of plain geometrical forms, but everything in the world follows the law of simplicity to some extent, as a sort of Occam's razor. This can be traced in the recipient's tendency to reduce complex visual images to simplified forms, because a simple form stands out from its surroundings and thus facilitates the most adequate

decoding of the object (Arnheim 1969). This principle echoes with Vygotsky's ideas about the power saving (the saving role) as applied to visual arts, which is supposed to focus the viewer's psychological and perceptual efforts on the utmost understanding the meaning at a minimal formal expense. This principle is widely utilized in logo and brand design, as well as in the making of other informative visual products, such as pictograms or icons, because some of the main requirements for this type of images are simplicity, perspicuity (i. e. adequate interpretability) and accuracy of conveying the meaning through visual forms. In fact, reduction of iconicity makes visual construct more universal and understandable in the cultural and communicative context. Images, let alone reduced images, rarely appear outside of such contexts. They inherently pursue informative goals and are meant to clarify communication channel (apart from the so-called droodles, picture-puzzles where reduced iconicity represents a tool for concealing of the signifier). Reduced images also help achieve perceptual regularity, because human perception operates more effectively with regular stimuli, which form a paradigm of fixed meanings because of frequent repetitions. In turn, these fixed meanings create mechanisms of preliminary guessing of the meanings of reduced images, which then activate those very affordances (Gibson 1979), integrated in the visual content. In other words, the recipient generates the missing content of pictographic unit in his mind and further only correlates his own interpretation with that which is suggested. To problems of reduced images are devoted chapters of the dissertation, which include articles: *On Hermeneutics in Infographics* and *Reduced Pictorial Architecture: On Droodles and Simplified Images.* The direct analysis of selective reduced images based on interviews is given in Appendices 1 and 2. During the interviews, to the audience were shown numeral reduced images specially designed for the dissertation, as well as existing commercial design examples, to determine the so-called Minimal semantic trigger, that is necessary for such images interpretation. The question of reduction concerns, of course, not only pictographic texts, but also texts in a broad sense, for example, the verbal one and a possible links between former and the latter. One of highly common psycholinguistic methodologies of its time was so-called Additional technique, also called Methodologies of Completion (Close procedure). First, it was used by american researcher William Taylor (Taylor 1953). The essence of methodologies consists in verbal messages deformation and subsequent subject presentation for restoration of the message.

The basis for the restoration lies in the principle of text redundancy, which can be understood even with deliberately incorporated noise in the form of omissions. Here the term Close is formed from the word Closure (principal Gestalt term) (Belyanin 2003), which refers to one of the direct methods of research, used in this work. The problematic of text truncation was also apportioned by Lotman, introducing minus-device term. The article included in this thesis – *On Visual Minus-Device* is devoted to problem of visual and pictorial texts interpolation on examples of pictorial constructs. Correspondingly, Lotman addressed the issue of text compression (compaction of infor-

mation) in his work “People and Signs” (Lotman 2000), proposing to consider works of art not only from aesthetic side, but as carriers of compressed invariants of several design parameters conceivable for information transmission. Later studies, native to this field, suggested the term nanotextology as content recursion (Hampson 2007), based on the systemic analysis of verbal information compression and an option of using certain linguistic micro-integral structures. Later Scolari suggests analyzing the transmedian space in terms of expansion / compression of the narrative strategy (Scolari 2013) in traditional rhetorical categories.

2.2. On Machine vision term and general focus

At this point, it is important to define the terms and substantial distinctions between them. All too often the terms *artificial vision*, *computer vision* and *machine vision* are viewed as the same exact process, with similar objectives and solutions. While the interchangeable use of the two latter terms could be justified, since in the modern language computer is often referred to as a *machine*, the objectives and vectors in the artificial vision research are clearly distinct. Thus, the main goal of artificial vision research is development of an optical and mechanical surrogate for the biological organ of vision (eye) and further processing of any received visual information by human brain. Neurobiology and perceptual mechanics based on the 7 levels of perception play the key role in this quest:

1. Optical contact with an object (introduction of visual information to the eye/lens)
2. Fragmentation of optically transmitted object (image) into component parts.
3. Discovery of semantically significant ties between the components.
4. Primary interpretation of the integrated image
5. Identification of the most significant details
6. Extraction of holistic meaning from the integrated image
7. Expressive or logical reaction to the processed image.

The pattern was proposed in the beginning of the 1990s by David Courtney Marr (Marr 1982), who was studying human vision and split perception and processing of information into two main blocks:

Perception:

1. Image conversion
2. Banding
3. Detection of geometrical structure
4. Defining relative structure and semantics

Processing:

1. Bottom level. Noice filtering
2. Mean level. Banding
3. Higher level. Linking specific objects to the picture of the world.

As it can be clearly seen from the pattern above, all the stages equally pertain both to the natural vision and mechanical perception and processing of visual information. The fundamental difference, however, is that naturally visual information is processed by an individual's brain, whereas interpretation of optical data by a machine results from its matrix algorithm, created and supervised by an operator. Therefore, perceptual process of machine vision first and foremost employs natural intelligence, which plays a primary role in processing of optical data up to this day. For the same reason, the main goal and purpose of the evolution of machine vision – besides its purely technical aspects – is pretty often accented as to gradually reduce the operator's role in encoding of interpretation matrices and to eventually "teach" the machines to produce visual interpretation algorithms independently. Such aim began to gain momentum in the last two decades due to increasing role of different disciplines in the development of artificial intelligence, while at the same time giving to a purely technical evolution the role of secondary instruments. Indeed, when the original basic tasks of machine vision were (and still remained unchanged by demand in many areas of several industries) the recognition of objects spatial position and transfer of coordinates to the controller, measuring physical parameters of the object, inspecting certain properties and finding defects, identification of codes (barcodes, QR codes), today, as a result of neurobiology, biosemiotics and other disciplines development, the problems of machine vision evolution have multiplied and re-focused. For instance, one of the study directions involves development of bipolar machine "vision", i. e. directly connected with the mechanism of human perception as visual reality reflection to stereometric coordinates (Davies 2012). Other authors (Dickmans, Graefe 1988) go even further and offer so-called 4D dynamic machine vision, designed to improve an accuracy and flexibility of information, extracted from dynamic images. Here the main idea is also lies in human eye ability to fix selected "frames" of the sequence, thus only the last image of the sequence needs to be evaluated, thereby alleviating the real-time image sequence processing task.

3. ACTUALITY

The actuality of work is duly for the following reason. Factually, on one hand there is an overwhelming corpus of existing conventional language systems, formed to serve communicative sphere (Arika Orkent mentions 500 languages (Orkent 2010)) and the list of International Auxiliary Languages by Aleksandr Dulichenko totals 1973 numbers (Dulichenko 1995), including pictorial languages, i. e. languages, which coding system is constructed on functioning of

pictorial elements. However, all such languages were and continued to progress as some sort of "substitutional" communication systems and platforms, aimed to replace the whole verbal language, rather than to function as narrow visual instrument, intended to help certain industrial purpose. Sure, not mentioning environmental classics around, such as street, pictograms and other widely disseminated communicative pictorial examples. All such visual resources have a countless number of purposeful works and researches, devoted to the definite visual systems, developed for selected communicative objectives, such as traffic regulations, various types of semaphores, the international sets of pictograms, used worldwide, visual interface elements, etc. However, in rapidly changing informative environment it is critical to realize the status, stressed by Scollons:

> *Mankind is now so burdened with information that the chance of increasing the possibilities of verbal communication is steadily diminishing.*
>
> *In the changed, mobilized, accelerated pace of life we need to seek possibilities for information transmission that can be best adapted to these new circumstances, and in this respect, non-verbal communication has especially good endowments.* (Scollons 2003)

Without any doubt, such industrial discipline as machine vision, for not one decade was considered as a perspective and intense area of research. However, visual semiotics directly, oddly enough, was not included in the arsenal of scientists and developers of the discipline, mentioned above. There may be several reasons. Firstly, and paradoxically, normal poly-semantics of the formally simplified image is perceived as a pictorial construction, not carrying of any additional or hidden meanings. This position – image as a direct copy of the object, which implies the absence of interpretation choices – held Linzbach, creating his visual language (Linzbach 2008). Later Neurath, working on Isotype (Neurath 1936), has developed this vision, that eventually contributed to the creation of Pictograms. All in all, such paradoxical attitude, formed by massive pictographic culture, lead to widely accepted opinion as there is no fundamental sense to refer to such images as an effective material for research. The second reason may lie in the disciplinary specificity of semiotics itself, which for the most part, not directly connected to it, is a science (and often – not even science) with a lot of uncertainties and conventions in terms of object of research, methods, abilities of application, etc. In general, the discipline associated with the study of languages in a parallel course with linguistics, thus a broad understanding of language as a system, not only verbal but rather as any other, visual for instance, not often reflected in industries, oriented to the precise science. Also, quite critical role is played here by historical traditions to associate visual semiotics, first and foremost, with works on iconography, which presuppose the analysis of works of art. Therefore, it is very important to be accurate with the choice of terminology, methods and the disciplinary specificity, using applied visual semiotics on a topic such as machine vision.

4. BRIEF HISTORY OF MACHINE VISION PROGRESS

Apparently, Marr was neither the first nor the only one to address the issue of interference of human and machine vision. The history of development of machine vision, perhaps, could be dated back to the 1950s, when in 1951 John von Neumann proposed the analysis of micrographs by means of computer comparison of allied image fields. In the 1960s, the focus of research shifted towards typescript and handwritten text recognition, and around the same time first systematic attempts at modeling artificial visual interpretation were conducted based on the studies on artificial intelligence development. The first truly successful product resulting from this research was the Perceptron machine (from "perception"), created in the laboratories of Cornell University based on IBM-740 and later, in 1960, its improved version named Mark I Perceptron, which was developed specifically for recognition of visual constructs. It was not until the 1970s that Marr proposed a scientific concept based on the study of the human visual system with the prospect of its further algorithmization. Marr emphasized the major role of nature as the core aspect of designing a visual process, and promoted the idea of identification of "shape via N", where N represented various attributes of depicted objects, such as luminosity, texture, perspective, distortion, etc. Since the real-world objects are three-dimensional per se, and computer matrix only produces their 3D models with the help of certain preset algorithms, therefore, identification of "shape via N", per Marr, calls for reconstruction of the third dimension. In this regard, Marr's "natural" concept resembles Gibson's "ecological optics" approach, which despite its discrepancies features a few potentially important aspects, for instance, the so-called affordances, which could be taken as semantic vectors for machine-operated visual interpretation. Also, regarding the key components of Gibson's "ecological optics" (Gibson 1979) and its other elements, the concept of Semantic Primes by Anna Wierzbicka (Wierzbicka 1992) is worth mentioning as a potential interpretation matrix, which consists of a set of universal elements of Natural Semantic Metalanguage. However, the detailed description of these theories does not constitute author's purpose at this stage.

The following years were marked by tangible progress in terms of matching, i. e. comparison of image fragments, identification of semantically meaningful elements inside the objects, 3D modeling, localization of simple geometrical structures, such as "dot", "edge", "spot", "straight line", "angle", etc. During the same period, one could notice an increased interest in the use of so-called "mathematical models" for solving the problems of machine vision. The idea was in random selection of one or another mathematical method and its further adjustment to possible algorithms of interpretation of visual constructs. This method helped to advance the elaboration of the mechanics of the artificial eye, but in the long run it proved ineffective in terms of expansion of capacities of interpretation matrix.

In the 1990s, many improvements in machine vision had to do with its electronic and mechanical aspects. New generation perception sensors were

created, featuring the ability to locate 2D objects and simultaneously increase the speed of microprocessors participating in data processing. A substantial breakthrough happened in the beginning of the 21st century along with the massive shift towards the merging of multiple scientific disciplines, thus introducing neurobiology, mathematical statistics and a range of disciplines related to artificial intelligence development, into the realm of machine vision. Thus, a step was taken from mere registering and processing of data to creating methods of description of images, received by the artificial "eye". In turn, the expansion of disciplinary horizons of description allowed getting closer to reading, decoding and interpretation of both 3-dimensional models and in the long term, to machine interpretation of abstract characteristics, conveyed by a visual image. Finally, as of today, the following four could be the main vectors of machine vision development:

1. Optical mechanical vector. Includes the search for technical innovations and solutions, aimed at the development of new generation devices, which should significantly enhance technical characteristics of machines with visual receptors.
2. Software matrix vector. Focuses on the enhancement of matrices' software, i. e. on creating software programs that would meet the latest machinery requirements.
3. Neurobiological vector. Research in the line of artificial intelligence, following the path of parallelism and extrapolation from natural neurobiology to the studies of artificial intelligence in general.
4. Cybernetic vector. Actual development of artificial intelligence, which includes multidisciplinary elements. Neuromechanics and neuropsychology play leading roles in the discipline. Owing to the communicative nature of semiotics, it only plays a secondary role herein, while certain aspects of visual semiotics are not at all involved and are left behind in the disputes of the 1980s.

The peripheral role of visual semiotics is quite natural. After a broad and multilateral expansion of methods of Gombrich, Panofsky, Shapiro and others, which balanced between semiotics and history of art and which, however, were widely used by semiotics scholars during many years, the focus of visual semiotics again shifted to finding new terms and new meanings for iconicity and its related concepts (mainly in Sonesson's works). In the meanwhile, the pragmatic aspect of visual semiotics remained within the framework of the classic analysis of pictorial constructions (which were often reminiscent of R. Barthes's discourse analysis of advertising). Practical use of visual semiotics as a re-considered, re-discovered discipline – let alone as applied to the current problems of science – has not been tracked in the recent years. Perhaps, the works of Scollons (Scollons 2003) or Kress (Kress 2008) could be deemed as the latest outbursts of such applications. Since then, in the last decade several attempts at

creating new auxiliary languages have been made, some of which could be typologically classified as derivatives of Isotype by Neurath, and nevertheless these attempts had no significant impact on visual semiotics in terms of pragmatic application of the discipline in the current scientific studies.

5. MACHINE VISION SPECIFICS

Modern-day artificial eye (lens) has a much higher perceptive resolution than the human organ, for which reason the issue of physical "reading" of a visual signal today is not the cornerstone of machine vision development. When it comes specifically to the development of artificial intelligence, the primary focus is not on *what* a machine receives through its external sensor or *how accurate* that perception is, but rather on how it interprets the signal and makes the correct decision, based on the signal decoding.

Today, the main decision making algorithm in artificial intelligence machines after they receive visual stimuli is based on selecting an adequate interpretation from a paradigm of options, pre-uploaded into the memory array by the programmer or operator (software developer). In practice, it means that computer's choice is not only limited by the number of variants of interpretation saved in the matrix, but, in case of deliberate distortion of meanings of a denotation, the choice may also turn out to be diametrically opposite to the logically correct one. Suppose, the lens reads an image of a triangle and per the generally accepted conventional type of geometric shapes, the machine is supposed to decode the image as the triangle. However, if the algorithm contains an accidental or deliberate error and a shape with three angles is marked as "circle", the computer, in turn, will read a triangular shape as being a circle. For a computer to be more than merely a signal decoder, but rather an active and independent interpreter (i. e. to perform as artificial intelligence), a lens need to receive a conflicting signal – a complex image that suggests the machine should carry out matrix analysis, based on the pre-set semantic variability. Multitask computers of that class have existed for a long time, such as military department computers for predicting possible scenarios of conflict, or architecture and engineering software for selecting optimal construction conditions based on the pre-loaded data. Notwithstanding, technologies for creating visual-cognitive link between the lens and the processor, allowing the machine to teach itself, are still far from perfect. A recent noteworthy breakthrough is the Deep-Q-Network (DQN) analytical system in artificial intelligence developed by DeepMind research group, headquartered in London. Certain degree of progress was achieved with regards to step-by-step processor self-teaching, based on the variation analysis of pixel matrix in the classic 1980's video games imaging. However, in this case, one cannot speak of a direct link between image, vision and interpretation, because the computer did not read the game imaging from an external optical signal, but rather received it as a set of digital data, i. e. as ready-made program codes for the game design.

In other words, the machine interpreted a sort of digital image framework, that is, digital information as opposed to visual.

Therefore, the question remains open as to the use of optical signals in artificial intelligence development, and calls for innovative approaches and non-standard solutions.

6. SELECTED MACHINE VISION PROBLEMATICS

The problem of machine vision complexity can be explicated by the fact that its rational (systemic) component is much more intricate than the traditional problems such as computer game of chess or cards, which for many years been served as a field of an "artificial intelligence" methods of application. This is, apparently, related to the intricacy of the main subject of the discipline, namely, "flat" or 2D image. The problematic of machine images recognition and interpretation considered in a general form of information retrieval task from visual data of prior indefinite scenes and objects. The solution is based on visual structural *primitives* detection and their sufficientz set of features determination.

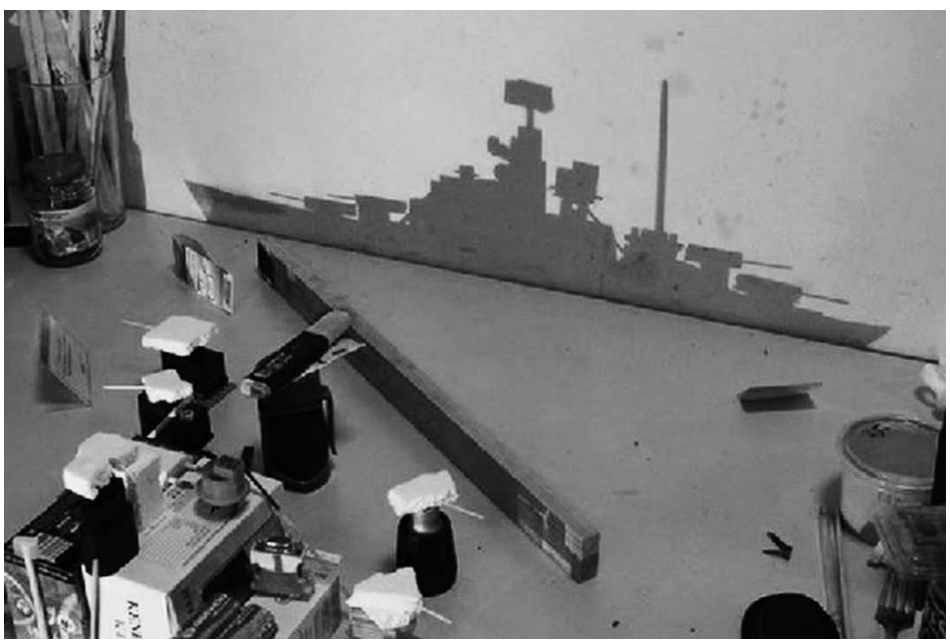

Fig. 1.

Figure 1 shows a great example of perception of 3-dimentional objects through 2D images.

A group of objects is laid out on a horizontal surface, spaced out and positioned in such a manner that if one looks at them at a certain angle and in precisely directed lighting, they cast a shadow, that forms the shape of a destroyer (ship). Formally, any objects that cast shadows can be individually viewed as geometric primitives (geons) only in very strictly defined conditions, which create an integrated planar view. In this case, a difference disappears between how a human eye and a photocell perceive integrated images, and therefore geometric figures are interpreted as identical to those programmed either in the human brain or in the machine's matrix (according to how the programmer sees them). However, while for the human eye integrated view results directly from the combination of simple forms, machine is not able to convert a set of spatially placed objects into the image of a destroyer as these things are inherently not the same. As of today, machine cannot independently compile a required integrated image from unrelated singular figures without the appropriate spatial focus. If we envision the image above (Fig. 1, Pinterest internet open source) without the ready-made shadow projection, the human brain will start seeking for a suitable point of view, at which the combined elements would form an outline of the ship. On the other hand, at the current level of technology, machines cannot perform such combinatory operations. One of the reasons is in the perception and reconstruction of such an important aspect of 3D imaging as perspective. The underlying principle of perspective is in creating a hierarchy between the elements, and in spatial terms – between the elements forming the remote context depth. It employs the mechanisms of color, lighting, scale. The history knows several types of perspective, such as classic (linear), atmospheric, isometric, anamorphic (multidirectional – M. C. Escher's works), that are used in the construction of spatial hierarchies from the percipient's point of view, and there is also reverse perspective, which besides the spatial encoding, suggests the semantic encoding of a viewpoint "from the inside" of an image. An interesting solution for machine vision research which has a problem with reading spatial depth in 2D images, could be the chiaroscuro technique. It originates from ancient Assyria and employs tonal contrasts between light and dark to convey depth. Shading (often artificial) around an object brings it forward, thus creating an illusion of spatial depth behind it.

However, human vision involves more than just perceptual spatial hierarchies while constructing 3D models, but also the so-called multicodes, i. e. multiple information channels and clusters, where besides the direct visual stimuli, additional ones are activated, such as auditory, tactile, etc. Any object with a certain shape surpasses the immediate visual experience and provides a broader integrated interpretation (Gregory 1966).

Evidently, the so-called *perceptual scheme* and *perceptual plan* play an important role here (Barabanstchikov 1997). The former defines a typical outline of an object as close as possible to the viewer's preliminary knowledge of that visual stimulus. As the perception continues, the scheme undergoes constant evolution to reach the desired level of comprehension of the object.

Perceptual plan, in turn, assigns a vector of content and interpretation, determining the main direction of the viewer's reaction to the visual stimulus. Complexity of the vector therefore depends on the complexity of the percipient's interpretational glossary. This part of the development of machine vision is closely tied to the development of the matrix itself, or artificial intelligence, and at this point it fundamentally depends on the programming tasks.

Modern technologies of automatic images perception, that coming from "pattern recognition" methodology, implement information classification function as a predefined objects archetypes selection. Prior uncertainty of these objects, that can be distinguished and identified, may be partially removed by "manually" installed operator's standard descriptions, built on heuristically formed skins. At the same time, to solve many practical problems of machine vision, common general difficulties of "image understanding" can be reduced to much more simple and clear way of objects and categories detection and recognition via convinced pre-known description models and simplified visual constructions. Biological perception function provides monitoring of all scene components, their informational importance for the perspective behavior and management. The effectiveness of such recognition is not restricted and preestimated by number of detected objects and related categories, most of which are combined and completed during an action of visual perception and its processing. This produces new meanings. However, once again, the information efficiency of machine recognition function in this case is principally limited by parameters, specified by human operator. In this regard, the task of machine vision developing may be proposed as an attempt of signal data extraction from all observed scene objects and analyzing associated parameters such as incentives for machine's own interpretation fields creation. One of such approaches can include reconsidering the image concept in terms of its application in the aforementioned systems, i. e. the possibility of practical uses of reduced images as effective visual signals for machine vision.

Of course, this doesn't mean that the notion of image needs to be completely re-mentioned or re-defined. The concept has been the subject of an immense amount of scientific research from Aristotle up to date and constitutes the focus of fundamental works on both theory and application of image by such significant scholars as Eco, Saint-Martin, Gibson, Gregory, Arnheim, Hermerén and many others. For this reason, the range of image conceptualization is extremely wide and – judging by the researchers' discussion materials – rather controversial. Clearly, the most efficient and promising way of further work with reduced images would be through analysis of selected concepts that correlate with the specifics of achievements in the field of computer vision. At the same time, both positive and negative correlations are possible, which allows to carry out primary selection of the most appropriate concept for developing pictographic modules.

7. REDUCED PICTORIAL CONSTRUCTIONS PROBLEMATICS

The few pasigraphic systems, which today are of interest in terms of their development (hereinafter we refer exclusively to a narrow segment of the mentioned auxiliary pictorial languages (APL), the so-called pictographic modules (iConji, PICOL, UPL), employ the disputable method of open source for compiling their dictionary, whereas principles of pictographic design, that were codified into a paradigm of so-called designer principles of creation of reduced informative images during decades after they were first introduced by Neurath, are used as the primary method of construction of signifiers. Other branches of science play a very limited role, if any, in the process of development of the aforementioned APL. For instance, paradoxical as it may seem, semiotics is represented by a minimal operation not even of triad as an iconic structure, but rather of Saussure's binarity, because the interpreter's role is either not considered by the developers at all, or is implied by default without considering the cognitive, cultural, empirical and other specifics of the latter.

Authors of modules use the general principle of creation of the pictogram as their pictorial matrix, that is, an iconic or indexical sign, which requires only two components for its interpretation: the reduced form of an image and its denotation. On the one hand, this may seem exhaustive, if we're talking about a strictly codified system containing a limited set of elements (traffic signs, transport pictograms, etc.). However, the open source principle, adopted as the basis for compiling the dictionary, constantly increases not only the set of elements, but also expands the sector of significations of similar images in an undulatory manner. Of course, the problem can be solved by limiting the visual dictionary items, but this calls for a well-defined filtering mechanism to be established, which contradicts the open source principle. Another and much more important issue is that a visual module unit is treated by the developers as *image* only in its one-dimensional meaning – as an iconic representation of either physical objects or simple actions (i.e. a form of the classic pictogram). Authors use combined graphic signs as a universal pictographic means, for example, an indexical sign and an iconic sign within one signifier serve to convey the idea of both direction and movement. This practice is fully justified, taking on account Jakobson's remark:

> *The question of presence and hierarchy of those basic functions which we observe in language – fixation upon the referent, code, addresser, addressee, their contact or, finally, upon the message itself – must be applied also to the other semiotic systems. Comparative analysis of structures determined by a predominant fixation upon the message* (*artistic function*) *or, in other words, a parallel investigation of verbal, musical, pictorial, choreographic, theatrical, and filmic arts belongs to the most imperative and fruitful duties of the semiotic science.* (Jakobson 1971)

At the same time, firm attachment of sign to one of classes of the triad is far from obvious and quite flexible:

> *Peirce never divides signs into these three classes. There are three poles, three categories, and all three can be present in the same sign. He says that a symbol may have an icon and index incorporated into it. He speaks about the various bonds of signs. For him the essence of semiotics is just this interrelation, the hierarchical interrelation of these three semiotic forces*. (Jakobson 1978)

Strictly speaking, such method of evolution of APL has exhausted itself, and further development of visual modules can only progress towards quantitative growth of graphic units within the framework of one system. It is safe to say that today, the development of pictographic APL along the above-mentioned direction is not of any serious practical interest. But this doesn't mean that we must completely abandon research and developments in pasigraphy. Thus, while evolution of APL cannot be considered a preferred direction, research in the field of computer vision and artificial vision in general, constituting a segment of the large-scale development of artificial intelligence, are extremely up-to-date (Klette 2014).

8. ON RPA TERM PERSPECTIVES

As it was mentioned above, RPA may be referred to a complex structure, consisting of several significant reduced forms. The advantage of such visual structure for optical analysis is twofold: first, reduction of visual forms facilitates "readability" of meaningful image elements, i. e. the immediate optical decoding, and secondly – it transforms the degenerative sequential logical process (as A causes B) into that of various alternatives, which is necessary for the evolution of artificial intelligence development. Despite the excellence of a lens in comparison with the human eye, the former is not capable of saccadic reading, i.e. it must read an image step-by-step, as well as break the image into significant elements and subsequently decode each of them. Further computer interpretation of a pattern can be based on singling out the central couplings in the general captive map and include successive processing of elements that are meaningful for the task, such as axial binarity of poles (past – future, positive – negative etc.), random semantic and narrative pattern, and others. The primary objective in the process "...is to develop procedures that distinguish actual, functional parts from purely nominal parts that lack <psychological> reality" (Schwab, Nusbaum 1986). At the same time, phased perception of image remains the principal tool for image reading and decoding. Therefore, the architecture of reduced complex image ensures advanced splitting (degeneration) of visual signal and forms the goal of code interpretation at the same time. Undoubtedly, a polysemy and an ambiguity lowers the transparency of signified – signifier connection in the complex pictorial construction, along with the risk of an incorrect choice of the most meaningful elements of a representamen, that may complicate and even deform an interpretation. In some cases, when defining features of an object are easily

recognized, their too far arbitrary morphological combinatorix also may lead to the similar result. Nevertheless, the use of reduced images has excellent prospects even more because such images represent a formal logical stage in the ecological perceptual process, i. e. the process which includes a complex of ecological elements along with the necessary parameters and which facilitates the tendency for obvious simplification of the graphic form or concept (representamen). Therefor in the development of artificial vision, while the visual signals within the "lens-matrix" tandem will be encoded into interpretation units determined by the programmer operator, extrapolation from the mentioned process to a certain process in computer decoding of visual information appears to be more natural.

9. VECTORS OF APPROACH

Visual studies in general and visual semiotics have a broad arsenal of both theoretical and practical tools in numerous research directions. For this reason, and especially considering the pragmatic nature of this study, it's critical that we should select the most effective methods of analysis and give up the ones of secondary importance or that are ineffective for the study, despite their popularity and dissemination.

Evidently, the most widely disseminated Gombrich-Panovsky's methods in iconography that laid the classic groundwork for visual semiotics are not relevant for this study. First, iconography itself, as we mentioned before, is a study method at the junction of semiotics, cultural studies and theory of visual art, however, the latter has nothing to do with this thesis. Of course, discovery of multiple meanings of artifacts is related to a similar process of determination of the signifier in reduced images in terms of semantization, but theory of art currently plays no significant role in the process of evolution of machine vision. Likewise, methods of neurosemiotics are not applicable to this thesis, because the discipline for the most part operates within cognitive models resulting from cerebral activity in general, while the visual perceptual aspect is but a small part of it. Neurosemiotics is surely a promising direction in the development of artificial intelligence, but goes far beyond the subject of this thesis.

In general view, applicable to our research that can be observed within the diachronic concepts of classical science framework, the basis of perceptual process can be called as subject-object opposition, namely, as the determination of the subject of perception, the object of perception and the relationship between them. Thus, from the point of view of English empiricism (J. Locke, D. Hume) spatial perception is a one-way vector in the form of causal *object => subject* relationship. In other words, the surrounding reality affects human receptors, and the latter fixes his processing sensations. Thus, the process of perception unfolds within the consciousness of the subject, where the empirical merges with the Absolute Selfness (Spirit). Hume, in turn, also defined external experience as the primary one, while internal (desires, reasonings) as the

secondary. The psychological mechanism of perception and subsequent processing of information, per Hume, is built on the dominant of the external nature, which causes people to have an objective awareness of causality, and consequently the logic of B event following A. However, despite quite sufficient differences in theories of the above philosophers, they both recognize the outer sensory experience as the first and the dominant phase in the development of consciousness and perceptual logical chain. It is for this reason that we leave aside many other basic perceptual theories and directions, since the prism of sensorical origin correlates to the most degree with the basic optical-mechanical scheme of machine vision, in which the sensors are the primary stage of the process, and the integrable matrix (processor) constructed by the operator is the secondary, that interprets signals accordingly. Based on the foregoing, we find that the most relevant vectors of approach to this research based on its subject matter, are the following:

1. Formal visual communication theory
2. Pictorial theory
3. Gestalt principles

Needless to say, that we don't pursue full application of the methods of all three vectors to the subject of this study; an overview of the most explicit and effective aspects of each should suffice.

10. FORMAL THEORY

Formal theory of visual communication officially originates in the 17th century and is attributed to British philosophers, who proposed a postulate, that the knowledge of the outside world is nothing but a result of registration of external stimuli by organs of perception. This assumption inevitably led to disputes about the simultaneous work of the eye and the brain, and was formulated in the statement: the brain actively interprets what the eye registers. Later, in the 18th century, when Lessing defined spatial environment as the foundation of pictorial space, he paved the way to a deeper and more detailed perceptual and cognitive scheme, where the eye and the brain register and process not only integrated objects, but also their elements, basic and significant parts, as well as they trace qualitative characteristics of visual constructs. In the 20th century, this perceptual vector was further extended by psychologists and art scholars who relied on perception psychology, and later were joined by such artists themselves, as Kandinsky, Malevich, Mondrian and others. During this time, such formal visual elements, as dot, line, angle, etc. gained more than only compositional, but a deep semantic value, which was often extrapolated to other arts, such as music, dance, etc. Formal theory also suggests certain parallels in perception and analysis of visual constructs, regardless of the nature of thereof. Those may be natural objects, pieces of art or even images, born in someone's

imagination and having no physical embodiment. Finally, as a sort of general result of theorization, Gyorgy Kepes in his book Language of Vision (Kepes 1945) explored the idea of visual grammar, transposing it from art onto every possible visual phenomenon. That immediately brought about a dispute of the minimal unit of visual language – the dispute that settled just recently, but not because a consensus was reached, but rather due to its ongoing hopelessness. Therefore, in the 1960s William Bowman suggested a list of elements, such as dot, line, texture, etc. as units of visual dictionary, and spatial structures (plane, perspective, etc.) – as grammar. Then Bowman, similarly to Jacques Bertin in semiotics, applied these elements to information graphics.

Formal theory has often been under attack in many debates, mostly owing to the inaccuracy and vagueness of such concepts as visual language, its minimal unit, etc. For instance, there have been arguments about what could be deemed a phoneme, morpheme and lexeme of visual language by analogy with a verbal language. However, an unquestionable advantage and a promising aspect of the theory is that it granted a high semantic status to simple visual elements. Now integral image can be analyzed not only in terms of iconography, but also from the point of view of although nominal, yet official visual language, and most importantly, an integrated visual construct can be built subject to the semantic interpretation of the necessary elements. Such structure needs to be created with consideration for the specifics of how the human eye perceives shapes, because a shape, an outline of an object sets a starting point leading to the interpretation and understanding thereof. For the practical experiments and formation of new images principles of semantization of simple elements are critically important, as they are directly related to the idea of construction of reduced images with enhanced semantics. An aspect of formal theory that is sometimes referred to as "structure of feeling" and which is directly attributed to the ability of pictorial components to evoke certain emotions depending on their configuration, direction, combination, etc. might be of particular interest for us. There are such widely acknowledged visual "rules" as that a horizontal line denotes calmness and slowness, an oblique line indicates movement, etc. These factors can have a key value in the development of reduced images that are meant to convey abstract categories.

11. PICTORIAL THEORY

As follows from the name, pictorial theory's focus is not on structural elements of an image, but on the image as a whole. The theory is largely aimed at discovering relationships between pictorial constructs and reality. Regarding the subject matter of the thesis, in terms of application and analysis of mechanical vision within the framework of pictorial theory, it's worthwhile to mention studies of photography, cinematography and other relative media of the 19th century, employing mechanical and optical characteristics of lenses in photocameras and motion picture cameras. As a matter of fact, it wasn't before

the invention of photo- and cinematographic instrumentation that the visual channel "object – artificial eye – brain" was first addressed directly, although lenses and optical equipment (such as spyglasses, telescopes, mirrors and camera obscura) had existed for centuries. The fundamental difference between photographic apparatus and these other devices was in the ability of the former to record an image or a visual construct, i. e. to produce a material indexical sign by means of artificial "eye". A special chapter in pictorial theory is dedicated to the *narrative*, which applies first to dynamic images or motion pictures, although static images can become narrative too, if presented in a series of pictures, such as in comic books, popular print, cartoon sequels, illustration sequels, etc. Strictly speaking, visual narrative is a series of detailed stories in the context of a larger story which, however, are not presented as a combined single 2D image, but as a sequence of several pictures. Narrative is not relevant for this paper, because studies or analyses of sequences of images are not included herein. On the other hand, a branch of pictorial theory called "reflective" (as in, reflecting real objects, i. e. where the meaning of objects lies within themselves and their reflection reveals their direct meaning) is quite important for this thesis. Even more that "reflective vector" per se has been criticized by semiotics scholars, who argued that the meaning should lie much deeper than in a mere reflection. Moreover, yet another interesting angle in this theory development can be considered the expansion of applied inter-disciplinary paradigm, and psychology in particular. Thus, Liu and Mitchell (Liu & Mitchell 2009) offer the concept of studying animated and static images, linking the latter to psychoanalysis and Freud's uncanny, finding such connection indispensable to the pictorial analysis. Although this material to its large extent reflects to biocybernetics and neurological experiments, rather than to semiotics, nevertheless a prospective combination of reflective theory and semiotics appears under indisciplinary umbrella seems to be effective in this study.

12. GESTALT PRINCIPLES

Finally, another important method of selection and creation of images within the framework of this thesis is selective Gestalt Principles (rules). Striking, that Gestalt perception method is also called The Law of Simplicity, that is significally correlates with the thesis topic, which involves the study of simplified images. In a few words, the idea of the principles goes back to early 20^{th} century, Germany, with the premise that perceptual unity of an image is fuller and more emphatic than a plain sum of visual elements, combined in an image. The history of Gestalt perception and psychology is described in detail in articles by Johan Wagemans and other scholars (Wagemans et al 2012). Through the course of half a century, the principles underwent some polishing and were minimized to a simple rule: visual elements are grouped based on their formal characteristics into larger groups, thus revealing their new attributes or

qualities. Some of the basic methods of grouping include *proximity, continuation, similarity, closure, equilibrium, etc*. This might be named as extremely interesting and promising in methodology, paralleled, firstly, with the direct methods of computer image processing, with Linked Areas Isolation, Histogram, Segmentation, Invariant, etc. Linked Areas Isolation, for instance, connects the whole raster image as an abstract object with the certain area, and at the same time, suggests this area as a potential independent object with further geometrical, logical, topological and other classification. Histogram, in turn, shows frequency of pixels of the samy brightness in one isolated image. Segmentation used for details search/classification. Technically, segmentation is the whole Image division onto areas, that are not similar upon the certain token. Such procedure presupposes that these areas are consistent to the real objects while borders represent objects boundaries. Because the Gestalt Principles have been repeatedly proven valid in visual practice, and laid a foundation for both general and commercial graphic design, the use of Gestalt laws in formation of reduced images in this thesis seems quite logical and beneficial. If we complement the basic principles with additional ones, such as contrast, rhythm and balance, playing an important role in image creation, then the use of gestalt laws becomes very productive. Therefore, step-by-step design of the reduced images, shown in Appendices, was not created based on its direct semantic meaning alone, but also based on such formal principles as similarity and proximity. Further on, several principles can be used at the same time in the process of image development, depending on the complexity of the formal structure of a image.

13. CONCLUSION

In conclusion, I'd like to make a few remarks concerning thesis application perspectives. The current stage of machine vision development roughly divided into two main directions, which can be called optico-mechanical and visual-cybernetic accordingly. The first one is interested in progress of technologies and adequate automatic images construction methods in real objects recognition systems (robotic machinery), the second – in bringing the latest achievements of cybernetics, biology, sociology and computer vision together for the development of artificial intelligence studies, based on machine learning principle.

Of course, there are no fundamental mismatches between these two areas as they both focus and depend on several similar technical and methodical factors, and in both cases, it is clearly visible a strong shift towards technologies as it is along with computing resources routine. Primarily, this is because the generally applicable image processing algorithms have become available for digital signal processors and programmable logic integrated circuits, often used together and so far, being widely installed in personal and industrial systems. Established the new level of image capturing, artificial vision has gained additional horizons of reality. At the same time, many problems of augmented reality are closely

related to information retrieval. Such problems include comparison of images, saved on machine matrix with images of unique objects, namely as architectural arrangements, sculptures, graphics, other 3D and 2D objects, and so on. As well as objects of varying degrees of generality detection and recognition (cars, animals, furniture, people's faces, etc.); the categorization of scenes (city, forest, mountains, coastline, etc). Not surprisingly that digital and optical remedies continue to be actively used by visual researchers on the leading edge of artificial vision development. Nova days so called general purpose graphics processors (GPGPU) are extremely popular.

In such situation, it will be obvious to include the results and research outcomes of this thesis into the area of "cybernetic" direction episteme, because such direction is largely operative with humanitarian disciplines, i. e. sociology, psycholinguistics, cybernetics and, accordingly, semiotics, although the latter is in its classical form, as it been said, has been pushed to the peripherals. However, studies, conducted in this thesis can be applied, in combination with to some point controversial, but rather promising discipline of cybersemiotics (S. Brier), as cybersemiotics tries to make the two interdisciplinary patterns mutually going beyond mechanical and pure constructivistic concepts to complement each other in a common context. This approach seems quite promising as one of ways for prospective programming to form artificial intellect self-learning cause-effect relationship because of visual information perceiving. Thus, one of main cybersemiotics features is "naked" naturalism, offering to reflect perception and culture solely as a part of nature and evolution. Without going into detail, it should be noted that understanding of biological and social components of visual information interpretation can be extrapolated to possible methods of machine programming and self-programming. This, in turn, will convey not only, though absolute, recognition of reality, but also an appropriate interpretation assembling as the result on visual stimuli of varying complexity. And this is not about simple and anticipated response, triggered by narrow options selection, initially preloaded to the processor matrix by operator, but rather on own artificial intelligence abilities to handle, extend and conclude intrinsic visual information values with further applicable reaction.

As the one of inclusive cybersemiotics components we can call *ecology* in its broadest sense. Reduced images, studied in this thesis, can be determined as ecological from their pictorial construction specificity. In his work "Pictorial Semiotics, Gestalt theory, and the ecology of perception", Goran Sonesson stressed the vectors of progress for semiotics in general, and for pictorial semiotics proposing so-called ecology of semiotics as one of the prospective directions for broader domains of study.

> *Such regularities of the Lifeworld, together with the laws of environmental physics, and other commonplace theories of the world, stand at the origin of an even broader domain. <...>This discipline should, among other things, lay the groundwork for all future conceptions of cultural semiotics*. (Sonesson)

Speaking about this ecology of semiotics, Sonesson suggests a cognitive transformation in the understanding of perception; a basis of this prospective process should become J. J. Gibson's ecological psychology, with an appropriate adaptation. Gibson's theory, would play the significant role of intermediating between psychology of perception and pictorial semiotics. The number of other scientists (Landwehr, Costall, Espe, Hoge, etc.), not mentioning semiotics directly, nevertheless choose as an object of the research a pictorial sign in its environmental connotation field, investigating perceptual specifics through a prism of an ecological method. Among the latter it is necessary to mention Bruce, Green and Georgeson, Goldstein, Gregory and a few other authors, whose works to some extent mention aspect of ecological visual perception. However, we have apparently managed to track some interesting functional parallels between proper ecological phenomenon and a visual perceptive aspect. This parallel consists in the so-called process of functional redundancy. The term has been introduced by Jordan S. Rosenfeld, and has been applied to the explication and analysis of mechanisms and reasons of species loss within a functional group or niche. On the other hand, considering semiotics as science studying the *functional* relatedness of different disciplines, we are able, operating with the latter, to track appropriating correlations between functional features of the behaviour of species and the mechanism of perception in development of specific visual units such as the logo (and other related units such as the icotype, pictogram, etc.) Stated above Rosenfeld's conclusion is based on observation that some species perform similar roles in communities and ecosystems, and may therefore be substitutable or lost with little impact on ecosystemic processes. Thus, under the influence of *immanent* or external components, a phenomenon of functional reduction is performed; i. e. we can observe a process of filtration and signification of the most meaningful and functionally justified elements of a system. Such process is a key technique in shaping meaningful reduced images, analyzed in this thesis.

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SUMMARY

Pictorially simplified images as machine vision design tool: semiotics approach

The present dissertation attempts to modeling plausible application of reduced pictorial nature graphics that can be called as RPA (Reduced Pictorial Architecture) on practical complications of abstract and complex categories representation through simplified visual structures. This segment of pictorial semiotics can be used as one of research and development instruments in the field of machine vision development. The choice of machine vision as a promising object of semiotics application is not accidental though. To date, the development of robotics in its broadest terms, along with artificial intelligence, in particular, is among the most advanced and promising vectors of disciplinary and multidisciplinary approaches. The development of artificial intelligence is impossible without research in the field of computer vision as one of the main channels of perception. In fact, in recent years in such studies, more consideration has been given to neuro- and bio – mechanics, as well as to other precise disciplines. Semiotics, and, above all, visual semiotics, unfortunately are not at this stage of the research, essentially important mechanisms in the field, although an applied semiotic approach to this issue seems to be very productive. In particular, as one of certain meaning-making activation tools, the reduced images proposed above, can be considered. The design strategy of such images is may be seen as a way of required formal and semantic elements combinatorics, that is reflected in articles included in the thesis. Of course, the initial steps of analysis and creation of these images are the only primary models of narrow semiotic application, requiring further numerous draughts and tests.

In the first article I suggest to reflect and analyze reduced pictorial images not from just classical and narrow graphic design and auxiliary languages contextual spheres, but rather as objects for complex investigation, combining hermeneutic principles of wholeness and parts interaction. In particular, semantic autonomy and certain inflexibility of minimal pictorial language elements along with the process of prediction, which includes aspects of creativity, will also contribute to a better understanding of the whole message denotation, because of energetic emotional and empirical background components. In other words, here we can deal with the case, when an aim to identify general language complexion should go be-yond the scope of an internal language system itself.

The second paper transfers analytic accent directly to abstract categories representation through the study of pictogram as complex hermeneutical construct and lotmanian autocommunication approach. In mnemonic autocommunication, when additional external messages are not transmitted, the viewer operates by immanent “dictionary” of codes, selecting from them the one that, according to his opinion and experience, is the most corresponding to the initial one. Reduced iconographic sign greatly complicates the task as the addresser should not

just to translate information to the specific semantic field with the aim of denotation deciphering but also, in case of an inaccurate icon pictorial expression, to recreate a visual image of transmitted symbol. Overall, for abstract concepts representation, that have no clear iconographic counterparts, a multi-stage decision is required.

In the third article I analyze types of visual trope, namely, a visual minus – device. The original term, related to verbal expression, was introduced by Juri Lotman. Despite the fact that the verbal device itself has been analyzed several times, its pictorial variation studies still remain peripheral. However, this figure of "visual silence", through its pictographic nature is typologically similar to reduced informational images on the basis of the holistic picture one or several important figurative elements exclusion. These elements of plastic language allow to classify visual minus – devices and set up markers, determining emptiness of structural elements, significant for the information transmitting.

At last, in the fourth paper I study specific drawings, called droodles and suggest a new type of a visual structure, called RPA (Reduced Pictorial Architecture). This structure might be considered as a bonus sign structure, that can be supplementary added to Pierce's signs system as the dual construction, amalgamate two types of imageries: skeleton-diagram and pictorial puzzle, composed on the principle of figure reduction to complicate interpretation, i.e. formally, for droodles the proximate term diagram can be replaced by the RPA acronym. Further on such type of reduced images with complex denotation may be used as visual matrix for artificial vision perception studies.

Both appendixes are materials of composite interviews with audience's surveys, based on the analysis of set of abridged images. These images were chosen either from ISO-coded open sources, or generated by the author selectively for each section of the interview. The first one is devoted to minimal visual trigger setting and defining. Such trigger plays a key role in correct recognition of objects, depicted by RPA. Most of these images are included in the body of the thesis papers.

SUMMARY IN ESTONIAN

Graafiliselt redutseeritud kujutised kui masinnägemise disaini vahend: semiootiline lähenemine

Käesolevas väitekirjas modelleeritakse redutseeritud arhitektuuriga graafiliste kujutiste võimalikke kasutusviise keeruliste ja abstraktsete mõisteliste kategooriate representeerimisel. Semiootiline lähenemisnurk antud probleemile võib osutuda produktiivseks masinnägemise disainimisel.

Esimeses artiklis „Hermeneutikast ja infograafikast“ (On Hermeneutics in Infographics) tehakse ettepanek vaadelda lihtsaid kujutisi, nagu piktogrammid, logotüübid jms mitte graafilise disaini klassikalise konteksti vaatenurgast ega ikonograafia kitsastest raamidest lähtuvalt, vaid kui keerulisi kompleksseid struktuure, mis funktsioneerivad terviku ja osa immanentse vastastikseose hermeneutiliste printsiipide raamistikus. Algse kujutise adekvaatsele dekodeerimisele aitavad kaasa ka graafilise keele minimaalsete segmentide semantiline autonoomia ja piisav liikuvus koostöös kujutise denotaadi „äraarvamise“ protsessiga, mis eeldab loomingulist lähenemist. Siin on oma roll ka vastuvõtja visuaalsel ja elukogemusel. Teiste sõnadega, lihtsustatud graafiliste konstruktsioonide puhul võime me rääkida kujutistest, milles teadete edastamise ja nende tõlgendamise mehhanism väljub kujutise sisese plastilise keele ja kitsa semantilise konteksti raamest.

Teine artikkel „Ideogramm: abstraktsete kategooriate representatsioonist“ (Ideogram: on Abstract Categories Representation) kannab analüütilise fookuse üle vahetult abstraktsetele mõistekategooriatele, võttes vaatluse alla nende kui komplekssete hermeneutiliste konstruktsioonide kujutamise ideogrammide abil. Oluliseks pidepunktiks on siin Juri Lotmani autokommunikatsiooni teooria, mis sätestab, et mnemoonilise kommunikatsiooni puhul, kui väljastpoolt teateid ei laeku, opereerib vaataja „sisemise“ koodide sõnastikuga, valides nende seast oma visuaalsest ja elukogemusest lähtuvalt kõige adekvaatsema.

Seejuures on paradoksaalne, et tihtilugu raskendab vaadeldav redutseeritud ikonograafiline märk (mis eeldab ühest tõlgendust kui lihtne tähendusühik) arusaamist, sest sõnumi saaja peab visuaalse pildi paigutamisel vastavale tähendusväljale taastama ka viidatava objekti või mõiste. Seda eriti siis, kui pildi teostus jätab soovida ja ei anna täpselt edasi kujutatava visuaalseid tunnuseid. Seetõttu on abstraktse mõiste, millel puudub ühemõtteline ikooniline „originaal“, edastamisel vajalik mitmeastmeline ja -plaaniline lähenemine.

Kolmandas artiklis „Visuaalsest miinusvõttest“ (On Visul Minus-Device) analüüsitakse spetsiifilise visuaalse troobi – visuaalse miinusvõtte – tüüpe. Miinusvõtte mõistet kasutas Juri Lotman mitmetes verbaalkonstruktsioone (eriti luuletekste) käsitlevates uurimustes. Kuid antud võtte esinemisjuhte visuaalmeedias ei ole veel põhjalikult vaadeldud. Selline „visuaalne vaikimine“ on oma piktograafiliselt olemuselt tüpoloogiliselt lähedane redutseeritud graafilise

arhitektuuriga kujutistele, mille aluseks on ühe või mitme tähendusliku komponendi eemaldamine tervikpildist eesmärgiga tugevdada teisi. Need plastilise keele komponendid võimaldavad klassifitseerida visuaalseid miinusvõtteid ja teha kindlaks markerid, mis määratlevad tühjust kui nähtava informatsiooni edasiandmisel olulist struktuurset visuaalset elementi.

Neljas artikkel „RGA: druudlitest ja lihtsustatud kujutistest“ (RPA: on droodles and simplified images) vaatleb nn „druudleid“ ja esitleb uut visuaalse konstruktsiooni tüüpi – redutseeritud graafilise arhitektuuriga kujutisi (RGA). Seda tüüpi võib vaadelda täiendusena Peirce'i märgisüsteemile kui struktuuri, mis sulandab kaks kujutise tüüpi: diagrammi ja peitepildi, mille loomisel lihtsustatakse kujutise vormi eesmärgiga raskendada äratundmist. Seega võib druudlite puhul olemasoleva märgitüübi *diagramm* asendada tüübiga RGA. Just seda märgitüüpi saaks kasutada tulevastes tehisnägemisega seotud uurimustes. Töö lisadeks on kaks kompleksintervjuud, mis analüüsivad vastuvõtja reageeringut redutseeritud graafilise vormiga kujutistele. Näited on valitud vabakasutuses olevatest infopankadest või loodud töö autori enda poolt. Esimese intervjuu käigus määratleb auditoorium nn minimaalse visuaalse käivitaja (*trigger*), millel on võtmeroll RGA poolt edastatava objekti või mõiste õiges tuvastamises. Enamik küsitlustes kasutatud kujutistest on ära toodud väitekirja artiklites.

SUMMARY IN RUSSIAN

Графически редуцированные изображения как семиотический инструмент дизайна машинного зрения

В данной диссертации делается попытка смоделировать возможные пути приложения графических изображений с редуцированной графической архитектурой (РГА) к репрезентации сложных и абстрактных смысловых категорий через упрощенные изобразительные конструкции. Выбор именно машинного зрения в качестве перспективного объекта аппликации не случаен. На сегодняшний день разработка робототехники в ее самом широком плане и, искуственного интеллекта, в частности, являются одними из самых передовых и многообещающих векторов дисциплинарного и междисциплинарного подходов. Разработка искуственного интеллекта невозможна без исследований в области компьтерного зрения как одного из основных каналов перцепции. В последнее время в таких исследованиях все больше места уделяется нейро- и био – механике, а также другим точным дисциплинам. Семиотика, и, в первую очередь, визуальная семиотика, к сожалению не являются на данном этапе принципиально важными механизмами исследования в указанной области, хотя именно прагматический семиотический подход к этому вопросу может оказаться продуктивным. В частности, одним из инструментов активации интерпретационных полей могут стать предложенные выше редуцированные изображения. Создание таких изображеий представляет собой путь комбинаторики необходимых формальных и семантических элементов, чему и посвящены включенные в диссертацию статьи. Конечно, предлагаемые в работе шаги по анализу и созданию подобных изображений – лишь первичные пробы такой семиотической аппликации, требующие многочисленных проверок и анализов.

В своей первой статье диссертации я предлагаю рассматривать упрощенные изобразительные конструкции, наиболее часто встречающиеся в виде пиктограмм, логотипов и т.д., не только с классических контекстульных точек зрения графического дизайна и узких законов инфографики, но как сложные комплексные структуры, функционирующие по герменевтическим принципам имманентной взаимосвязи частей и целого. При этом семантическая автономия и достаточная подвижность минимальных сегментов графического языка в совокупности с процессом «угадывания» денотата изображения, предполагающим элемент творчества, также способствуют более точному декодированию исходного изобразительного сообщения. Здесь также играют роль личный визуальный и жизненный опыт реципиента. Другими словами, в случае с упрощенными графическими конструкциями мы вправе говорить об изображениях, в которых механизм передачи сообщений и их интерпретации выходит за рамки внутреннего пластического языка изображения и узкого семантического контекста.

Вторая статья переносит аналитический фокус непосредственно на абстрактные смысловые категории, их изображение посредством идеограмм как комплексных герменевтических конструкций и через призму автокоммуникации по Лотману. Согласно последнему, при мнемонической коммуникации, когда сообщения извне не поступают, зритель оперирует внутренним словарем кодов, выбирая из них тот, который, согласно визуальному и жизненному опыту смотрящего, наиболее адекватен исходному. Парадоксально, но часто редуцированный иконографический знак, предполагающий однозначность интерпретации как простая смысловая единица, значительно усложняет понимание, поскольку получатель должен не только перевести зрительный образ в соответствующее смысловое поле, но и восстановить изначальный изображаемый объект или понятие – особенно, если картинка не аккуратна или не точно передает визуальные характеристики изображаемого. Поэтому, для передачи абстрактного концепта, не имеющего однозначного иконического «оригинала», требуется многоступенчатый и многоплановый подход.

В третьей статье анализируются типы специфического визуального тропа, а именно – визуального минус–приема. Перво-начальный термин был введен Ю.М. Лотманом и относился к вербальным конструкциям, в контексте которых он неоднократно и рассматривался. Однако его визуальная ипостась до сих пор оставалась на периферии изучения. Тем не менее, это «визуальное молчание» по своей пиктографической природе типологически близко изображениям с редуцированной графической архитектурой, в основе которой лежит изъятие одного или нескольких значимых компонентов из целостной картинки с целью усиления других. Эти компоненты пластического языка позволяют классифицировать образцы визуальных минус-приемов и установить маркеры, определяющие пустоту как структурный визуальный элемент, важный для передачи зрительной информации.

Наконец, четвертая статья анализирует т.н. друдлы и предлагает новый тип визуальной конструкции, называемой изображениями с редуцированной графической архитектурой (РГА). Этот тип может рассматриваться дополнительным элементом в знаковой системе Пирса как структура, амальгамирующая два вида изображений: диаграмму и картинку-головоломку, созданную по принципу упрощения формы с целью усложнения интерпретации. Таким образом, для друдлов имеющийся знаковый тип *диаграмма* может быть заменен типом РГА. Именно этот тип знака может быть использован для будущих исследований в области искусственного зрения. Оба приложения – материалы комплексных интервью, базирующиеся на анализе аудиторией изображений с редуцированным графической формой.

Изображения отбирались либо из открытых публичных источников, либо создавались самим автором. В первом интервью аудитория определяет т.н. минимальный визуальный триггер, играющий ключевую роль в правильном понимании объекта или понятия, передаваемого РГА. Большинство из этих изображений вошли в главный корпус статей диссертации.

PUBLICATIONS

ARTICLES OVERVIEW

The main body of this thesis is composed of four articles, published between 2012 and 2016, and two appendixes. The first article is generally connecting the problematics of infographics as such with wider field of pictorial studies and discourses the plausibility of applying hermeneutic analysis to the informational graphics units. The second offers initial steps of abstract categories representation through so called simplified images and suggests some vectors of problems solving. The third one is devoted to visual language trope, called visual minus – device, termed after J. Lotman verbal figure. In this article several types of visual minus-devices are analyzed and categorized. Finally, number four is contributing to the system of existing signs classification with additional pictorial construction that can be abbreviated as RPA. Both appendixes are complex interviews materials, dedicated to the main theme of the thesis on use of reduced images to represent different categories. All texts contain fundamental theoretical elements along with practical research results that designed to explicate the necessary and required arguments and evidences in the field of pictorial semiotics studies.

1. On Hermeneutics in Infographics. The paper explains that hermeneutics has long been known as one of the most effective methods of analysis of visual structures, which includes an extensive range of analytical works written by a wide spectrum of authors. Nevertheless, despite such a lengthy body of work and developed methodology of analysis, a whole range of visual material remains nearly out of hermeneutical study focus: the so-called in-formative graphics or infographics. The latter includes a variety of reduced visual form image classes, such as pictograms, ideograms, etc. Indeed, due to a number of epistemological reasons, genres of fine art still remain the dominant hermeneutical study objects, whereas infographics, especially since the post-modern turn toward signifier reduction, has been analyzed from the standpoint of graphic design, sometimes semiotics or visual perception. This article discourses the plausibility of applying hermeneutic analysis to the informational graphics units.

2. Ideogram: on abstract categories representation. The paper suggests that in the process of pasigraphic systems developing an abstract categories representation still remains very important and not solved problem. Indeed, while many iconic graphically reduced signs are widely used and more or less adequately convey they stand for objects or actions, abstract categories representation is mostly skipped at all or accompanied by a syntactic marker that often only complicates the process of interpretation. Practice shows that the problem ca not be solved solely by means of a graphic design or in the framework of the basic principles of infographics. Obviously, changes in this area should take place when changing methodologies and, above all, in the use of

interdisciplinary, synthetic approach, which includes many tactics and disciplines, and visual semiotics in particular.

3. On visual minus – device. The paper analyses creative instrument, determined by J. Lotman in 1964 as minus-device in its visual forms. Some fundamental and trans-disciplinary tools and concepts at the same time had been left behind in-depth research, while maintaining its important languages and textual inner and inter-structures. Hence, minus-device as one of the most important concepts of Tartu-Moscow school toolkit, has never been reasoned in terms of its application to visual language or functional combination of visual and verbal languages as a complement of each other, while visual minimalism and visual minus-device are often treated as the same expressive mode.

4. RPA. On simplified Images and Droodles. The paper suggests that in info-graphics and related fields images of reduced form are commonly used. Those types of images, with rare exceptions, usually called simple or simplified. Such widely disseminated reduction of the term often brings confusion to the research and misunderstanding in materials, related to pictorial and visual theme. Below we will try to improve the situation with the terminology, examined the specificity of such visual phenomenon as droodles and offering yet another term, seems to be more suitable for the images, noted above.

APPENDIX 1

Complex Interview 1.

Minimal Semantic Trigger

Date: 2011–2015
Place: London (UK), Tokyo (Japan), Tallinn, Tartu (Estonia), St.Petersburg (Russia)
Number of people interviewed: 63
Gender: F and M
Race: Caucasian, Asian
Age: 18–74
Education: High school / College / Higher Education
Occupation: services workers (12), creative specialists (18), students (23), higher education employees (10)

The survey was conducted as part of the doctoral thesis. In some ways, this survey can be considered a disciplinary continuation of models features analysis, once popular and quite effective in perceptual psychology and computer science. Features analysis is about to identify models critical elements to specify denotates and to distinguish them one from another. One of the most famous models include, for example, so called Selfridge's Pandemonium (1959). In general, an approximate analysis technique can be designated as usage of structural descriptions semantic. Per Bruce, Green and Georgeson such structural description does not explain mechanisms which may be involved in the interpretation, but rather offer one of the most essential options of representation, on which basis a construction of an adequate interpretation is plausible.

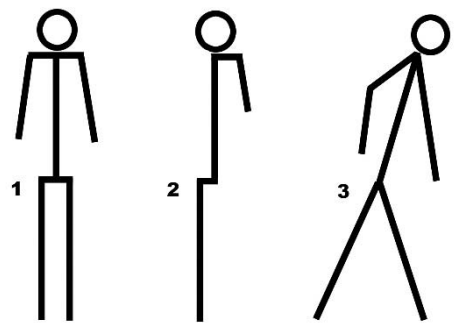
> A structural description consists of a set of propositions (which are symbolic, but not linguistic <…> about a configuration. Such propositions describe the nature of the components of a configuration and make explicit the structural arrangements of these parts. (Bruce, Green and Georgeson (2003: 272)

However, extrapolating the above-mentioned analysis on our survey, we need to do an important alteration.

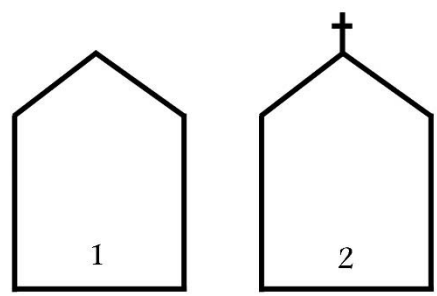
According to Perron and Danesi, the most productive elements of visual vocabulary are simple graphic forms such as a line, a spot, a point, etc. - i.e. a complex of visual units, capable to be articulated as complete images or *words* (Perron-Danesi, 2003). These elements are most flexible and their complexity is not limited for construction of meaningful structures. For instance, a construction of pasigraphy signs, which lay the basis of pasigraphy *language*, is based on these unit combinatorics. Pasygraphy, that's it, using graphemes instead of a writing system, where each constructed and often ambiguous

symbol consist of basic graphical elements and represents a concept rather than a word or sound or series of sounds in a spoken language; those symbols are combining a pasygraphy language *vocabulary*.

Indeed, first, basic graphic elements, which are not possessing non-contextual inner semantics, make possible a development of any combinations of signs and images (mentioning formal, receptive approach to the importance of these elements, leaving aside their philosophical and temporal contextual values <Kandinsky, Linzbach>). Second, it is possible, with the certain correction, to agree with Perron-Danesy statement that a point and a line are capable to be articulated as *words*, what is clearly traced on following examples:



In verbal expression, the diagram 1 is may be presented as *a human*. Simple recombination of word elements and even elimination of one of them leads to meaningless nonsense – *umnah, hmnu, anhm* etc.; quite similar procedure, performed on the diagram 2, also influence semantic value of the denotate. For verbal designation of the diagrams 3 (*walking human*) it is necessary an introduction of an additional sub-structure of verbal elements; operating of graphical units also requires an additional structural change such as spatial transformation.



Other example shows, how a word *house* (1), in it pictorial representation consisting of 5 lines, receives other meaning (*church* (2) by adding of only two the same basic graphic elements.

Thus, the aim of the survey was to determine the so-called transition element in the reduced iconic image to define the minimum boundary semantic significance of pictorial element within an icon, which can be perceived as sufficiently meaningful for the wholeness recognition/interpretation. Definition of such element allows to come to the precise information images development through "contradiction" method – i.e, the search of significant structural element can not occur through the sequential hypothetical components selection, but, on a contary, via formal reduction the wholeness of iconic sign. Existing "adding one-by-one" selection method has a substantial drawback, namely the difficulty to determine a significance of a particular pictorial element in comparison with the other components, due to simultaneous presence of several minimal elements in one analyzed icon, which significance can vary based on percipients' interpretational framework. On a contrary, with defining such boundary trigger, the paradigm of possible equivalent semantic variants reduces to a minimum. This, in turn, will prominently decrease an interpretative field of a visual signal, sent to the receiver. In this case, the hypothetical missing component will act as a significant element of the main icon structure, namely as a kind of visual "minus device". Thus, its absence will determine the value of an icon to a greater extent than presence of a number of possible image components and become a critical pictorial unit in terms of reduced visual sign signification.

As examples of reduced images several pictographic designs have been proposed, with one of the options that had been deprived of almost all iconographic referral features – i.e. with difficult or full absence of denotate recognition.

Example 1. Sitting Cat silhouette

Fig. 1

In the first icon (with an absence of a significant arch element representing a tail) cat has been recognized by 13 recipients (20.6%) only, however with an arch the result was weighty higher – 48 (76.1%).

The certain argument can be brought here that as the minimum semantic element, determining design denotation, triangular geometric shapes, which represent animal's ears, may be observed. However, most of the recipients, who interpreted image as Cat without arch-element, noted that the dominant role in design recognition been played not by these shapes but via proportion of an image. Icons itself was defined precisely as sitting pet, but not necessarily as a Cat. Some recipients have seen in given silhouette an image of Batman comix hero. Here we may observe the certain shift of emphasis towards symbolic sign, caused not only by reduced resemblance with denotate, but via cultural (in this case – mass cultural) visual phenomenon which, in turn, is a social and a cultural icon by itself. This example shows that the reduced icon, devoid of the minimum semantic trigger could easily be interpreted as a symbolic or other type of sign. In this case, the minimum visual element can not only improve or reduce the degree of iconicity, but at the same time can change the whole type of the sign.

Example 2. Owl Silhouette.

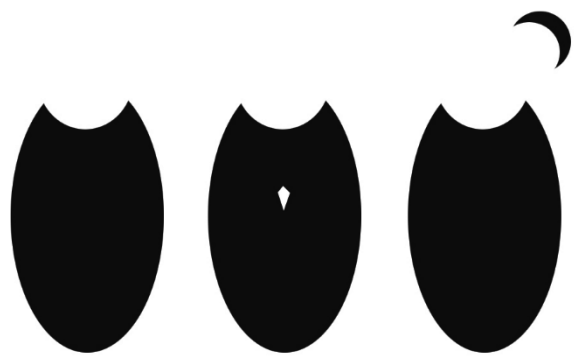


Fig. 2

Quite a similar picture may be observed with the reduced owl icon. Here the minimum unit incorporation directly into the icon has increased the percentage of recognition from 7 people (11.1%) to 21 (33%). But the addition of an external component (moon) in pictorial construct greatly increased the number of recognition up to 53 (84.1%1).

Trapezoidal element, representing the beak (a widely-used practice of eyes depicting as circles was rejected due to its obviousness) and initially added into the body of a pictorial construct, increase the degree of iconicity twice. However, quite unexpected result was conveyed through adding an external component with contextual semantic connotation while inner constructive iconic element (trapezoidal shape) was deliberately excluded. In this possibility, a

combination of a reduced iconic images is the one used in some informative pictograms, where two unrelated iconic element connected in one connote each other, increasing denotation decoding (Fig.3) or as pasigraphic language unit (iConji project for instance), where it works as RPA [Netchvolodov, 2013] representing an abstract category, in this case – heavy, useless labor (Fig.4).

Fig. 3

Fig. 4

In both cases, some interpretation aberrations are conceivable. In first case, a combination of versatile icons should have at least some aspect of functional synthesis. Otherwise, you may get a blend that does not have an established semantic trigger and exists only in author's pictorial combinatorix, such as David Gutierrez's logo (Fig. 5). When displaying this logo to the recipients not even one gave the correct answer. Here, any semantic value may be suggested per viewers' association with used iconic silhouettes, i.e. speed, fragile, wild (hare), farm (rabbit), power, force (hammer) etc. However, in such ambiguous construction without minimal semantic trigger and especially in attempt to represent any of abstract category, the whole correct denotate remain unclear.

Fig.5

In case of abstract categories depicting, pictorial sign poly-interpretative nature, based on layered and multivariate cultural matrix is activated [Nechvolodov, 2013]. Here, as the dominant and sense generating elements aren't minimal icon components, but rather cultural, social and other aspects should be designated.

Example 3. Car pictogram.

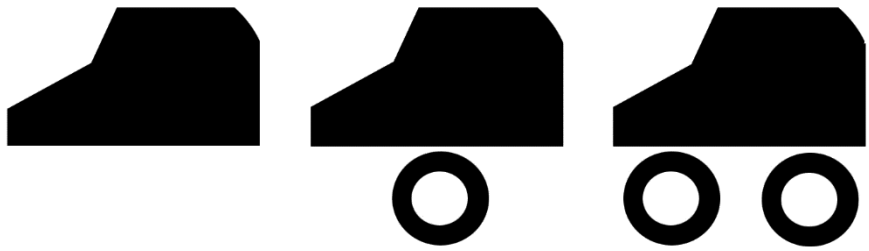


Fig. 6

Car pictogram transformation analysis helped to make many following observations. First, as the minimal semantic trigger sometimes not only the denotate's key functional component can be suggested, but also the shape of icon itself in ireduced degree of resemblance with the object. Initial image, which is a seemingly appeared as an abstract geometric shape, however caused some speculation about shape of a car body (4 people – 6.35%). It is noticeable that the "recognition" in this case was quite a coincidence, because this is too abstract geometric shape for its direct resemblance with the shape of sedan car body. At the same time, speaking of pure accident is also inappropriate. Yet Marr and Nishihara (1978) noted that the object can be identified in the framework of references given by its shape itself. In this example, plausible similarity between graphic image and the real car shape could play a role in the process of denotation recognition. Adding the circle, which represents a wheel, however, did not add a significant change into denotatate interpretation. Some percipients have suggested a vehicle (front part of the plane, for instance), but nobody mentioned a car as it is. It is obvious that in this picture the minimum trigger is a modular construct consisting of multiple repetitive elements and associated by recipients as a significant only in its complex form. Object recognition here is possible due to the general tendency of a human visual perception to isolate outline information about an object without prior knowledge of the shape of the latter (Bruce, Green and Georgeson (2003: 279). In principle, object recognition can be provided by a simple 2D shape, without reconstructing 3D structures (ibid, 282), of course, if the spectator is familiar with the object. In addition, the participants were not told in advance about what such a figure represents – either physical object or an abstract concept. Spectator' assumption that a given image depicting an iconic image of the object rather an abstract concept, most likely based on the general practice of visual informative context, consisting

habitually of iconic class pictograms. The latter, in turn, have been established as pasigraphic informative system in which the transmission of emotion or abstract categories had a peripheral value. Hence, public understanding of reduced images seated as pictures of informative iconic class representation, therefore attempts to signify abstract categories are treated as objects depiction [Nechvolodov, 2013]. To overcome this problem, and for the artificial vision development presence or absence of minimum semantic trigger is very important. It allows not only to establish a recognizability boundaries of reduced image, but to separate representation of abstract categories from objects depicting. Of course, this is impossible only by shape modulating, because abstract categories can rarely be represented through sign – icon (in this case we deal with a sign – symbol, a pictogram on electrical box or Jolly Roger for instance as a representamen of death, sorrow or danger). Anyway, it is a conventional sign, while the visual encoding of emotional categories goes far beyond conventional symbolic paradigm. The perspective solution should be sought in the related fields of visual perception, particularly in cognitive treatment of patterns with different saturation or within sensitivity of sharp and rounded contour lines and their interpretation in the plane of emotional reaction.

Example 3. Scheufelen Logo.
One of image recognition aspect is its spatial positioning. Here, as the object of analysis was suggested an existing Scheufelen paper company logo, intentionally depicting a crowned eagle and re-designed in 1989.

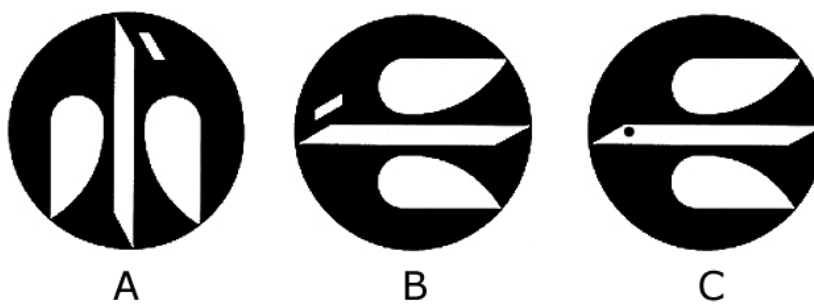


Fig. 7

As noted by Bruce, Green and Georgeson (2003: 284) the location of an object in space does not affect the identity of the object (obviously, we are talking here about isolated abstract object, otherwise the perception will be necessarily affected by secondary factors, such as light and shadow, air saturation, etc.), but it changes the audience reaction. In our survey, in turn, we sought to determine

how spatial variation within its shape affects an image recognition and how the minimal semantic trigger distresses understanding of the concept.

The re-designed logo image with an eagle, depicted vertically (Fig.7A), has not been recognized by a single recipient. Moreover, there was no consensus in the proposed sign classification. If in the previous examples recipients could not specify the denotation meaning, they, however, always noticed hypothetical iconic sign – i.e. the audience subconsciously seen some uncompleted object in given reduced images. There were suggestions of signs - symbol, such as the key (that in case of logo is correct, but does not convey understanding of the object), and even the sign-index (an arrow pointing upward direction). Rotating logo on 90 degrees counterclockwise placed the image of an eagle horizontally (Fig.7B), which led to a qualitative leap in recognition of an object – 52 people (85.5%). Only a small spatial change of an image from vertical to horizontal position led to the object visual components correct interpretation, summarizing denotation as a bird. In turn, certain extra visual touch, designed to emphasize a crown, put the part of an audience in a deadlock. In this case, an additional semantic trigger specifying the essentials of denotation, played a negative role. Subsequent elimination of an original pictorial element and its replacement by universal visual component (point), representing an eye (Fig.7C), has led to a 100 percent recognition of the object is shown. However, the clear majority of recipients been close to correct interpretation of the image right after its spatial change. Therefore, according to this example, we can summarize with the certain confidence that in some cases of reduced images just simple spatial variation can be measured as the minimum semantic trigger, while an addition / exclusion of specific pictorial components does not play a significant role in object recognition.

Ambiguous pictorial cases.

Part of simplified images, proposed to the audience, has the formal features of minimal semantic trigger, such as White Rhino Co. logo and derby stadium pictogram (Fig. 8 and 9 accordingly).

Fig. 8

Fig. 9

However, in the first case, about half of the audience has not seen in the given picture head of a rhinoceros. In contrast, face eating peas and head of the girl depicted in the anime style were proposed, that, in this case, clearly indicates the dominance of known Gestalt principles, namely Closure and Figure/Ground complex. Here the perception of an image depends on primary activation of dark or light spots, therefore the presence or absence of minimum semantic trigger plays a peripheral role. In such images as the hypothetical trigger not an additional pictorial element can be suggested, but rather an appropriate tonal accents distribution which, in turn, will allow the viewer to decode a picture per the dominant light spot. This method is widely used on informative pictograms (strictly conventional signs), in which the light area is considered as background, whereas dark image always is a carrier of information. In cases RPA, when conventionality is absent, the importance of Gestalt principles can play a paramount importance.

In the second case, the pictogram depicts a horse's head, combined of three elements. Many respondents recognized an animal without difficulty, however most of viewers defined it as the dog's head. Here the icon – sign determination were straightforward. Meanwhile, the correct interpretation of an image was barred, first, due to the absence of a minimum semantic trigger (in this case it might be a line showing the horse's mane), and secondly - the semantic equivalence of all three shown elements. In this case, the functionality of a minimum trigger as the principal meaning – formative mechanism is decreased by semantic equivalents of other components. Recognition of these images is possible only in part, because they set just a basic interpretative marker, representing iconic sign combined of corresponding elements, which individually do not carry denotation.

Impractical trigger cases.

Part of images, such logos of Minimal Bicycle and Minttulip companies (Fig.10 and Fig.11) can be considered as samples of failed corporate identity in general as well as pictorial constructs with substantially zero trigger potential.

Fig. 10

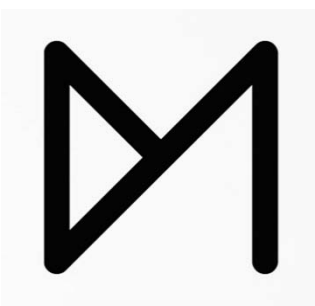


Fig. 11

In the first case, the company is engaged in sale, rental and delivery of parts for bikes, in the second – offers prompt service for Cloud technology. In both examples, the only sign that is correlated with the images of these companies is hardly recognizable stylized letter M – the first letter in the businesses names. Unfortunately, to learn more about the initial semantic roots of Minimal Bicycle was not possible due to lack of mutual communication between company and research parts, when in Minttulip logo case, the company added to the value of M a declined tulip interpretation (another allusion to the company title) along with a lying martini glass (the association is not explained). Not surprisingly, in both cases, the adequacy of denotatum interpretation by audience was an absolute zero. The main reason for the impossibility of denotation recognition was the lack of correlation between icon – sign and picture hidden meaning. Strictly speaking, the audience could not even identify the type of sign. Only two viewers suggested some resemblance with mountains and the stylized e-mail sign, respectively. Next, after revealing denotates volume, the audience has been proposed to add any pictorial data as a minimal element (trigger) into given pictorial structures that can activate an adequate interpretation. However, all the proposed variants were not a reduced graphical element, but rather completed image (a bicycle or bicycle part, the cloud in case of Minttulip, etc.), i.e. all hypothetical triggers may be acting as examples of self-contained graphic design, in which the minimal semantic trigger is not required.

APPENDIX 2

Complex Interview 2.

Abstract Categories Depicting

Date: 2014
Place: London (UK), Tallinn, Tartu (Estonia), St.Petersburg, Moscow (Russia)
Number of people involved: 31
Gender: F and M
Race: Caucasian
Age: 24–60
Education: High school / College / Higher Education
Occupation: services workers (11), creative specialists (6), students (11), higher education employees (3)

The survey was conducted as part of the doctoral thesis. The focus of the survey was to study several simplified images interpretations that represent several options of abstract categories depicting, such as *beautiful*, *affordable, nice, casual, probable*, etc. Special attention was paid to such class as *Missing* designation. Certain accuracy of these interpretations is tremendously important to determine, firstly, due to such categories signifier pictorial relevancy enlightening (which is not to be confused with pure graphemes practice) and, second, to clear up inner features of simplified images in perspective of using the latter as pictorial modules for the further artificial vision programs development. Various attempts of such pictorial solutions within numerous auxiliary language systems concluded rather in conventional composite image assemblies, abstract categories associative semantic pictorial translations or were simply relegated to the development periphery. These interpretations weren't properly analyzed, while all such pictorial constructs are conventional images with widely varying degrees of associative semantic proximity. Examples below are provided with the complexity of their interpretive intension, per survey data collection and clarification.

Example 1. Likely / Un-likely Categories

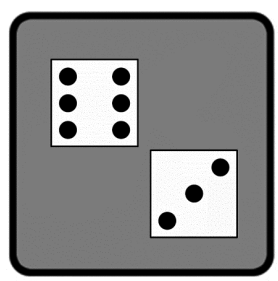


Fig. 1

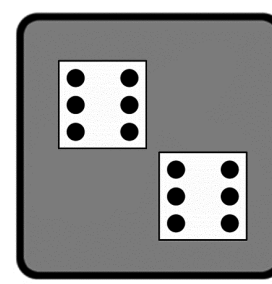


Fig. 2

In the first icon (showing dice position depicted as *Likely* due to it's common rolling chance) the correct signifoed has been recognized by 0 recipients (0.0%), however in combination with the second image the result was easily higher -5(16.13%).

Undoubtedly, a single image, regardless of its iconic resemblance with the objects, was clearly insufficient for unambiguous interpretation. Approaching the drawing inherent meaning identical interpretation become possible only in a combination of two components that allows compare two images comparison. However, for the purity of an experiment, it should be noted that there was no exact denotation given anyway. Two of the recipients identified denotation as *luck (blessing)*, the other two as a *win (bank)*, and one receiver with the closest one as *a rare case*. The rest of the audience still connected the image to conceivable gaming rules allusions. In fact, almost all the recipient even knowing about hypothetical denotation semantics, could not go beyond the associations caused by the intensity of iconic likeness. Here we have clear "illustration" case, repeatedly analyzed by a number of researchers, including Y. Tynyanov, B. Uspensky, and others.

To break Fig, 1 and Fig. 2 such strong semantic signifier – signifier association it was suggested to use another image with *Possibility* hidden denotation. In this image the role of Action determinant is played by hammer (tool) silhouette, and the ambiguity of action is signified by tilde sign used in logic for an equivalence or implication signification along with certain algebra formulas components infinity / indistinctness denotation. (Fid. 3) The goal was to translate firmly concretized audience's high iconicity associations into more abstract associative plane via high iconic signifier-to-object resemblance image with the abstract conventional sign connection.

Fig. 3

However, in this example it was realized that the combination of image with high resemblance accuracy and an abstract conventional sign not only simplified the interpretation of general abstract categories, but on the contrary makes it harder and complicated. In fact, tool silhouette has turned out to

become redundant information, since most recipients were familiar with the semantics of tilde sign. Here, the meaning of the latter, which is defined as uncertainty and variability, continued quite easily in an associative sequence as *probability -> possibility* (i.e. as an initial intrinsic image meaning). This conventionality of tilde sign is so dominant over hammer silhouette iconicity, that the elimination of the latter from this combined image "clears" associative channel towards the appropriate choice of interpretation even further. In process of this picture interpretation the audience has not faced a common pareidolia phenomenon which often happens in visual-cognitive analysis of uncertain images [Netchvolodov, 2014]. A tool silhouette forms quite firm interpretive frame along with strict tilde conventionality. Still, this does not mean that completely nonconcrete form itself is more beneficial and effective to adequately transmit the values of abstract categories. In case of tilde quite high interpretive level has been formed by strict conventionality of sign, not its plastic features. At the same time examples, displayed below, underline an ambiguity of low or non-figurative images use for abstract categories depicting.

Example 2. Sudden, Nice and Beautiful

As visual material for abstract category depicting two images with mentioned value were selected. The percentage of these designs corresponding denotate "recognition" was zero accordingly.

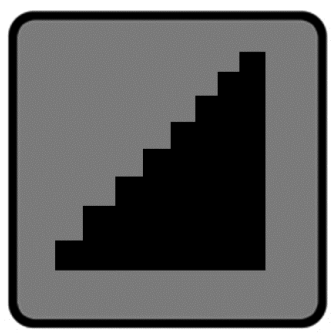


Fig. 4

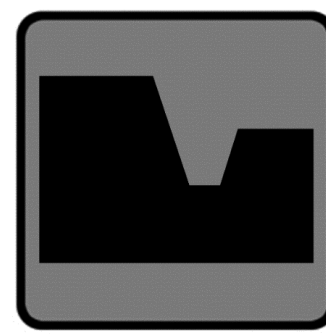


Fig. 5

Here, interpretive field of this visual design is full of random presumptions. Even though both figures be indexical signs with varying degrees of iconicity (in the first case (Fig. 4) the silhouette shows a staircase, assuming sudden ascents and descents) while the second image (Fig. 5) may be understood as a schematic abstract design, intended to depict a pit, failure etc., the audience fell into a complete stupor when tried to get closer to the correct denotate clarification. Moreover, after revealing the real value of denotation to recipients, all of them admitted that did not have the slightest conjecture aside *Sudden* meaning. Perhaps a reduced image of a pit or cliff (Fig. 5) is a derivational

extension of industrial conventional warning sign (Fig. 6), which, however, is always accompanied by verbal connotation, i.e. by visual information correct translation confirmation.

Fig. 6

In Fig. 5, reducing iconicity in sign resemblance with an object crossed the border of recognition loss, i.e. gradually faded its minimum semantic trigger. This has shifted hypothetically recognizable silhouette in a fully abstract shape that without verbal connotations acquired too broad active interpretative field. Meanwhile, ladder silhouette works the same way as hummer in Fig.3, being too concrete for abstract sensation depicting.

Similar interpretation failure may be observed with images below, aimed to represent Nice and Beautiful abstract categories (Figures 8 and 9 respectively). A more detailed analysis of Nice image can be found in *Nechvolodov. Ideogram: on abstract categories representation* [2013]. Both pictures taken from iConji open library and, while Fig. 8 is a completely abstract plastic form, an image with a value of Beautiful is a combined pictorial construct consisting of indexical sign (arrow), icon (eye) and abstract graphic element of strict rectangular shape.

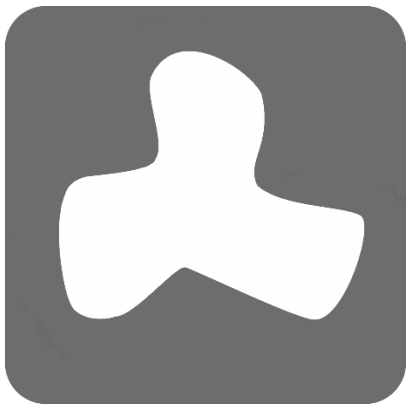


Fig. 7

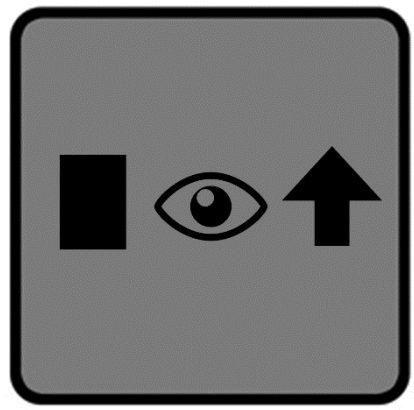


Fig. 8

As in case with *Sudden* category image above, an abstract form, representing *Nice* category firstly, deprived of minimal visual semantic visual trigger, that vectoring initial step of correct interpretation, and secondly, its random formal design has a clear iconic resemblance to fan or to a plan of a lake, for instance. No wonder such responses were given by the most of recipients. It is also quite hard to determine the pictorial idea of Beauty representation behind Fig. 8 construct. This visual example is a combination of symbols that represent Object, Eye (with a value of *Seeing*) and up-arrow accordingly. In sum, this mixture should denote something pleasing to the eye (as visual process). All recipients have noticed that even in combination of an eye and arrow the idea of sight improvement has imposed in the first place, the arbitrary rectangular shape, on a contrary, has completely disoriented the direction of interpretation. Thus, no association between the rectangle sign and analyzed from the aesthetic point of view shape did not arise. It is not difficult to presuppose that the number of correct interpretation was about zero. As Improved vision suggests an answer, look from the top (4 respondents – in this case, none of them developed the idea in arrogance), look upward, observation deck and others. Here, the obvious mistake of selecting eye as the core image of such visual structure was in attempt to merge a concept of something Beautiful (as an aesthetically pleasing process) and a concept of Pleasure as it is. The latter is not always a synonymous of beauty, neither necessarily derives from visual contact or analysis. Additional elements as an arrow and a rectangular shape, representing object in a process of visual communication, created a construct far too complicated for an appropriate and unambiguous interpretation of the original denotate. Such general abstract category understanding was reduced to a narrow explanation of the latter, with a cut-off other equally important semantic variations. Therefore, it seems logical to conclude that an attempt to depict an abstract category with initial broad interpretation through a combination of

narrowly selected reduced and abstract images oes not succeed a desired interpretive result either.

At the same time, surprisingly high number in recognition result appeared with yet another conventional-warning *Beware of purse snatching* (Fig. 9) sign. Here, 16 people (51.6%) demonstrated quite close interpretation results, when responses included the following variations: *suddenly* (6 persons), *surprisingly* (3), *without warning* (3), *insidiously* (2), *random* (1) – i.e. more or less co-inciding with the "original" denotate.

Fig. 9

One reason for such high percentage of "recognition" can be named due to image figurative (inner pictorial) specifics – namely, not a static object representation but action depicting. The latter, as verb in verbal structures can possess an expanded paradigm of values or respectively, associations, rather than a static object (noun). In favor of this cause yet another point can be detected: some of the recipients who went on his way through the incident factual (*theft, robbery, assault*) interpretation were developed their initial association via additional noun paradigm (*victim, crime, etc.*) expansion. However, those who have described the image through the verb form (action) – as *to attack, to snatch, to be frighten, to offend* – rather quickly continued their associative array with a bunch of words named above – *suddenly*, *surprisingly*, *without warning*, *insidiously*, sharply etc.

Nevertheless, as on example below, action representation is not always true choice for abstract category depicting. Thus, Fig. 10, according to iConji open library, shows *Enjoyable* concept. As one might assume, the correct interpretation of a pledged denotation in this case turned out to be zero. Per iConji resource idea, the picture shows a basketball player, throwing a ball. Thus, *Enjoyable* concept must be directly associated with the concept of Game. However, firstly, the game itself has a wide range of connotative attributes, not always positive, such as loss, fatigue, cheating etc. Secondly, the iconography of this image involves interpretation of the latter as a human figure, pointing to the moon.

Fig.10

Such interpretation has been suggested by several recipients and specified as a denotation of Night, darkness, fear (i.e. directly opposite the "original" meaning, that was clearly formed by night time archetypical connotation). In this case, action iconography and, primarily, static human figure image is not quite "transparent" that, in turn, dilutes the boundary of interpretation. It seems that direct *Game – Joy (Pleasure, Nice)* analogy cannot be suggested as matching interpretive pictorial pair, particularly when the reduced image is too neutral or blurred to depict the game specifics.

Example 2. Invisible

At last, we've analyzed yet another concept, namely, *Invisibility*, depicted by RPA. It is hard to call such a concept a pure abstract category and one can find an obvious paradox in illustrating of such an idea. When abstract category itself is full of representation complexity due to its descriptive ambiguity, then Invisibility simply cannot be shown through pictorial image. You can't directly represent something that does not physically exist, without resorting either pure fantasy transactions or attempts to portray *an absence* of the object through a spatial context. Both methods have been repeatedly used by numeral illustrators, particularly in H. G.Wells The *Invisible Man* books, as well as by numerous artists, depicting poltergeist and presence of other supernatural forces. Typically, these illustrations are quite complicated and overloaded with visual details that necessary for character emotional state transmission (e.g., during having a dialogue with an empty space) or often it is a classic mess of objects, hanging in the air. For instance, the simplest and most clichéd example of The Invisible Man illustration is an image of the latter, partly dressed. Thus, it appears as sort of, quasi – invisibility, which may be accepted as visual realm with the certain knowledge of the novel or as cultural pictorial model, previously established within certain traditional circles. Therefore, an attempt to portray *Invisibility* through a simplified graphic construct is a certain semantic

challenge by itself. Generally, an analysis of imaginary objects depicting theories (even Umberto Eco "Kant and the Platypus" book investigation would presuppose medium size academic paper) was not in objective of this interview still, two examples, provided to the audience (Figure 11 and Figure 12 below) revealed a wide range of opinions and interpretation options.

Fig. 11

Fig. 12

In both examples invisibility represented through partial property of the latter, i.e. via an ability to observe objects on a background and other spatial context through the central object (in this case the simplified object selection does not take any significant part.) It can be an anthropomorphic image (with a direct allusion to the specific cultural actor, i.e. *The Invisible Man*) as well as image of any recognizable object. In both cases, the main role in recognition was played by formal "plastic" (Greimas) feature of an object, namely by *transparency*, that was understood to a greater or lesser degree of clarity and therefore interpreted as a conceivable *invisibility*. Thus, 19 people suggested correct interpretation because of simple logic: an ability to see a few substances behind each other at the same time from one point of view can be defined as the transparency of one or more objects. Here is the only logical step to parallel Transparency with Invisibility, so this step has been done successfully by 12 of 19 respondents.

Certain easiness of such pictorial transmission and interpretation of Invisibility may be explained by steady Transparent – Invisible semantic pair, fixed in the clear majority of percipients empirically. Visual obviousness of main Invisibility feature dictates the ease of its interpretation, even in a reduced graphic form. The paradoxical difficulty of non-existing object pictorial imaging is quite easy to overcome via transfer of a similar feature (in this case through "incomplete" invisibility primary characteristic), that allows to quickly extend an initial interpretation to the correct understanding of the denotation. In turn, the presupposition on abstract categories pictorial transmission and "reading" difficulties would be named as the lack of accurate and widely conventional pictographic illustration of such categories sense. Mental image that occurs in

abstract category verbal designation, first, is very individual and often unique, as in the most cases is based on personal emotional experience; secondly, due to the lack of conventionality, images of this kind do not have a stable unambiguous functional dominant (as *transparency* in invisibility), which able to work as the semantic trigger.

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Education:
- University of Tartu: Tartu, Estoina – Faculty of Philosophy, Literature and Journalism dep., 1984–1992;
  Graduation Thesis: "Artistic principles and creative position of Pavel Kuznetsov during the period of "The Blue Rose" Group" – passed with Excellent (5); Diploma N.01824, awarded in 1992; Masters of Arts in Humanities, MA
- Georgia Institute of Technology: Atlanta, GA, USA, 1997–1998; Higher Education Program and Certificate of *Design Principles for NewMedia*, awarded February 4, 1998

Recent Employment History
Guest Tutor / Lecturer
Jan. 2010 – present **EBS Tallinn / Helsinki and University of Tartu, Institute of Semiotics**
- Effective Presentations Workshop
- Semiotics and Communication principles of Advertising course. EBS Tallinn/Helsinki / Tartu University for BA and MA students.
- Semiotics of Art course (2013, autumn semester).
- Special course "Models of Communication and Mass Media" for B.A. and M.A. Studies Program (2010–11) performed in University of Tartu.
- Selected lectures on performed course / seminar works (2012)
- Parallel translation works on public academic events (Russian-English, English-Russian – conferences, seminars, schools etc.)
- Supervising / opponent duties. University of Tartu, EBS.

General Employment:
2014– 2015 **White Bridge Group, Moscow – Tallinn**
Free-lance visual concept/communication developer.
Responsible for visual interfaces and communicative linkage design/implementation of WiqiTour web portal and mobile application.

2013–2014 **Media specialist. European College**, Tartu TU – Tallin TLU.
TradeRun Program lectures filming and montage, based on monthly performance.

2012 **Sterno Ad Monitoring Agency.** Moscow, Russia
Sony selected products web monitoring and analysis, business presentations implementation.

2010–2012 **Crypton, S-Francisco, USA**
Free-lance based design and consulting work for several mobile applications development and implementation. Analysis and monitoring of related market issues.

2008–2010 **Private Art teaching Program**, **RBR Art Center** Tokyo, Japan
Instructing and teaching private and group clients on Creativity Improvement Developing Program.
Special focus on motivation and developing self-confidence in Creative and Communication Processes.
Also worked as a free-lance author for **Weekender** Magazine, Tokyo.

2006–2008 **The Art Academy**, London, UK
Tutor of Creativity and Communicational Process – Creative Principles of Communication and Presentation skills.
Classes for adult amateurs and young art professionals.
Intranet site monthly editor-coordinator. Responsibility included selecting materials and editorial duties.

1999–2006 **Synectics**, London, UK
Free-lance Communications and design consultant.
Visualizations coordinator and communicative assistant.
Graphics and creative expertise in the area of computer design and multimedia – special "in-line" visualizations for brain-storming/ conceptualization sessions for private and corporate clients.
Developing visual connections framework between design groups and clients.

1997–1999 **Coca-Cola**, Atlanta, USA /London, UK
Head of Projects – Communications and Graphic Design Dept.
Responsibilities included developing effective strategy for international Coke communicative module and coordination the process of implementing Graphical Interfaces for various environments.
Free-lance work for **Atlanta Buckhead** weekly magazine – Cultural events reviews.

1995–1997 **Chicago Art Institute**, Chicago, Illinois, USA
Tutor/Consulting. Visual Principles and Computer Graphics software.
Instructed children, amateur adults, art and design professionals

Special program designed for understanding and developing computer skills related to Art and Art Projects.
Articles for internal Institute weekly edition.

1991–1993 **Tartu University Gymnasium**, Tartu, Estonia
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1984–1992 Tartu Ülikool, Filosoofiateaduskond, MA.

- Enam kui 20 aastat kogemust reklaamiloomejuhina juhtivates meediaasutustes, reklaamikampaaniate ja -lahenduste väljatöötamine paljudes tööstussektorites.
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- tegevuse juhtimine ning suhtlemine vabakutseliste disainerite ja muude ettevõtteväliste teenusepakkujatega;
- meediamonitooring, ettevõtte suhtluse reguleerimine;
- projekti väljatöötamine alates ideest kuni käivitamiseni;
- projekti (trükk, video, meedia jne) tehnilise poole juhtimine;
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Töökogemus:

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Ajutised lepingud:

2014–2015 **White Bridge Group, Tallinn**
Responsible for visual concepts/communication development. Interfaces management and its integration strategy implementation, *Creative Director*

2013–2014 **European College, Tartu – Tallinn**
Implemented filming and consulting upon TradeRun International Program, *Media specialist*

2012 **Sterno Ad Monitoring Agency, Moscow, Russia**
SONY products monitoring and marketing analysis, business presentations development, *Creative Consultant/analyst*

2010–2012 **Crypton, MoleskinSCell, S-Francisco, USA**
Responsible for overall mobile applications conceptualization and prototype development. Provided business presentations and collateral market issues monitoring. *Creative Director*

2008–2010 **RBR Design Centre, Tokyo, Japan**
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1999–2008 **Synectics, London, UK**
In-line brain-storming conceptualization/visualization sessions for corporate clients such as Frubes, Petits Filous, Aldi etc. Developing communication frameworks between design team and clients. Building advertising cases from idea ground up to installation, *Creative Director on Duty*

1997–1999 **Coca-Cola, Atlanta, USA**
Head of Communications and Design Department within Project Infinity structure. Responsibilities included developing effective visual strategy for international Coke communication module and graphical Interfaces implementation process coordination, *Head of Department*

Täiendkoolitus:

1998 Georgia Tech, Atlanta, USA "Multimedia Public Design Guides & Principles"

Arvutioskus

- Pikaajaline nii Mac kui PC platvormide kasutamiskogemus
- Valdan ja kasutan igapäevaselt Adobe CS, InDesign, Illustrator, Flash, MSOffice programme ja nendega seotud tarkvara
- UX ja UI kasutusoskus
- Word Press ja HTML operatsionaalne kasutusoskus.

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2014 Tartu Kunstnike Liidu liige
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1996 Best Design of Local Ethnic Edition, Chicago, USA
1992 Special Award for Book Concept and Illustrations, Denmark
1989 Riikliku karikatuurivõistluse laureaat (Tartu)

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