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by

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Verbalizing Visual Data for the Blind: Towards a More Complex Graphical Ontology

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Abstract

The standard situational and picture descriptions, as produced by human professionals, are being compared to the existing proposals of a dialogue-based processing and graphical ontologies. The ontology proposed to build up verbal presentations of the graphics for sightless persons seems to be very suitable for unambiguous cases. In order to include more complex cases of the visual communication, the existing ontology should be extended. Constituent elements of the graphical ontology in a broader sense are:

- *user's perspective (user's individual features, where the user is coming from to observe the picture, what he was doing before and what he is doing now while observing it),*
- *intentional perspective of the author of the picture (picture encoding key),*
- *functional perspective concerning the graphics (framework encoding key, relationship between the pictures in the same document, or in other documents related).*

As to the third element, it is being demonstrated that the verbal expression of a picture which has been included in a document:

- *remains partially unchanged even in the new context,*
- *needs reassessment, as to the rest (due to new ties and interpretation).*

To display both information packages correctly to the user, the ontology must be complex enough to differentiate between formally identical questions and to answer them in a specific way according to the above-mentioned perspectives.

1. The articles and presentations gathered on the Web during the series of conferences known since 2002 as *Tactile Graphics* ([29], [35], [36], [37]) illustrate the complexity of the struggle for an adequate compensation of non-textual graphical information for sightless people. Generally, it is agreed that there is a complex conceptual framework at stake: real-world objects and their interactions, state of mind (in neurological and psychological sense) of both the receiver and the sender, including their experience, communication strategy, communication code (in a broad sense, therefore, with no relation to oral languages), and finally the specific properties of sensory receptors - visual, auditory, tactile, etc. At the same time, many attempts have been made to establish an ontology of visualisation [7], including the graphical ontology [21], and thus to provide blind and partially sighted Web users with a comprehensible visual information.

1.1. It is clear, regardless of which alternative receptor is chosen, that visual information cannot be communicated to persons who are not systematically educated and trained in receiving and implementing information of this type, because such information is nothing but a conventionally established demand satisfaction. Is not technically possible where there is no demand for it, in other words: where the necessary state of mind, the experience and communication code are missing. It is therefore unacceptable that visual information could be transformed by technical means to auditory or tactile code, without taking into consideration the individual psychology of the recipient. In the background of these psychologically naive ideas there is usually the vision of a visual display convention as something given *a priori*. Such a methodological error can be illustrated by a parallel in linguistics: let us imagine that a language is given *a priori*, and that an object can be attributed unique and generally understood language expression, without any linguistic competence of the recipient being examined. As a matter of fact, these supposed *a priori* are results of previous experience and training, and they depend on conventions. The question of which senses (or combinations of senses) may become an alternative vehicle for the visual information, is secondary in relation to the issue of how to create the necessary convention, or how to discover this convention, where it exists, and how to use it in communication.

1.2. In the research of this convention, Masaryk University with its more than 100 blind and partially sighted students, represents one of the largest European labora-

tories of perceptual methods of the blind, especially when considering that this is a group of people with above-average flexibility and broad intellectual interests. Let us summarize the results of several years of permanent observations connected with including sightless students into non-verbal psychological tests and providing them with literature containing graphics.

2. One of the most common requirements among orienteering service and assistance is a good situational description. The blind persons, in order to participate in common social situations, need to process the visual information available to other participants in the same situation, not necessarily in order to get oriented in space or to handle some subjects, but primarily in order to be included in intellectual activities (discussion, decision-making, motivation) dealing with such information. Just as a secondary effect, the blind person can use this information in physical activities (finding objects, moving towards a place). The interest on visual information is usually connected with the development of visual thinking and imagination, in other words, with the ability to process and use such information. This ability grows both with the intelligence, visual experience and mastering of visual code (most common among those who for a certain period of their life could benefit from sight). Let us analyse the concept of situational description for the blind.

2.1. The first stage of the visual communication, which is to be observed in order to understand the meaning of the situational description, is human nonverbal communication, without any use of recording media. The fact that nonverbal communication may be conventionalised and grammaticalised to the same extent as verbal communication, is demonstrated by natural sign languages. Within certain limits, oral and sign languages are equivalent, and the sign language is intuitively more clear than the oral one, as it uses natural elements which may not be necessarily conventionalised: objects and their interactions are taken into communication (either directly, so that the speaker handles them, or through ostension, i.e. pointing them out), in the same way as laughter, gestures of surprise, anger, simple movements, gestures of matching and consistency, of the dynamics and conflict, etc. However, a convention in using these objects and gestures develops usually very quickly, and thus the symbolic abstraction and metaphorical work with them is not spontaneous and universal, but is a matter of convention, and is linguistically diversified between regions and cultural areas.

Full interchangeability of both systems (verbal and sign) is possible only if speakers are using both of them systematically and translation between one and the other is a permanent practice. This is true not only for deaf users of a sign language, but also for users of the nonverbal communication code, which is an essential component of the oral communication among the hearing people. There is no doubt that parallelism of verbal and non-verbal human communication is one of the most important resources for understanding the visual code in general, and the graphic code as its specific type.

2.2. The second stage to be considered is the encoding - recording of both verbal and nonverbal communication by means of graphic conventions: writing in the case of the oral language and picture in the visual language. The relationship of a picture to the real world is similar to that of a written word and the world: it presupposes the existence of the visual concept and the visual sign, which is then recorded by means of graphics. De Saussure in his *Cours de linguistique générale* [34] presents the well known example of the dichotomy of a sign: on one side the *signifié*: the concept of a tree, on the other the *signifiant*: the word [arbor], primarily a sound, but graphically recordable in letters. In visual terms it is important, whether there is a visual concept of the tree, in other words, if pointing out an individual tree (some "default" type of it) may represent the whole semantic class and not just that particular tree which has been pointed out. If this condition is not fulfilled, a visual sign cannot be created, nor graphically recorded. If the condition is fulfilled (see fig. 1), its recording may be considered: how to build up a graphic system capable of capturing (encoding) images which represent the visual concepts (to draw a tree, see fig. 2).

2.3. A realistic photographic or video recording plays a very special role in creating graphics, as it offers some features similar to the visual work with real objects. There is usually no need to explain the graphic conventions of a photograph in order to identify an object, on condition that the recipient is used to work visually with the objects themselves (he knows the visual language). However, the visual perception of such realistic photographic images is never to be confused with the visual perception of the reality. There are always sensorial differences, but first of all, there is an interpretation issue, which in case of a photograph exists to the same extent as in drawings. A photograph has its author, and to understand his or her intentions, an interpretative key (template) is needed, like in the case of drawing a picture: selection of

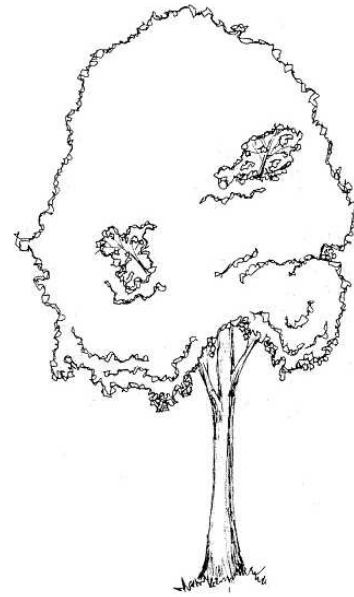
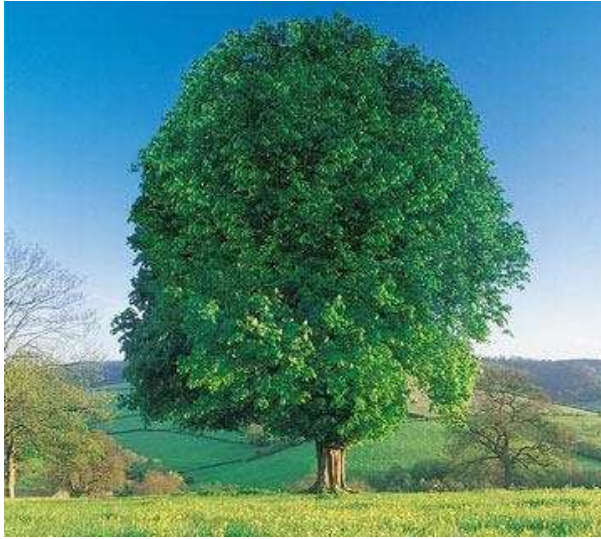


fig. 1, 2

features which the author considers important in the context, and suppression of others.

3.1. In the photograph published in fig. 1, several conventions (a visual language) are implemented, which are very often neglected if a photo is made by a nonprofessional (untrained) photographer: contrast and spatial relationships between objects, the ratio of areas at the forefront and in the background, the proportions of the object in the foreground and the image as a whole, etc. This composition allows the photograph to be attributed the interpretation "tree", and not other interpretations, in theory possible as well ("trees", "field", "landscape"), which means that a similar simplification is implemented as in the drawing published in fig. 2. It is highly probable that the recipient will attribute that interpretation ("tree") without actually studying (or having studied) the language of professional photography. Yet without understanding the language, it is not possible to take the photo (or to draw up such a picture), and there is also no guarantee that the interpretation of the picture produced by somebody else will be identical. The biggest risk in case of a different visual language is a disagreement on the level of specificity ("chestnut" > "broadleaf" > "tree" > "green" > "nature"), in the zoom ("tree / trees" > "landscape") and in the metaphoric transfer ("spring", "evening", "loneliness").

3.2. A specific convention (language of drawing) which makes the drawing different from a photo, narrows the field of its interpretation even further, but not to make it unequivocal. On the other hand, the more specific the language is, the more culturally

conditioned it is, which means less intuitive and more abstract. The more probable it is that the drawing will be interpreted as "broadleaves" > "tree", the more likely it is that it will not be interpreted with certainty at all. E. g., depicting a tree by means of the outer contour of its crown (as opposed to drawing of the branch lines) is a method not attested in ancient or medieval times, and probably would not have been fully comprehensible in that context. It is upon this culturally based convention, confirmed for the sighted persons through thousands of practical applications, that some other much more specific layers are developed, such as schematised children's drawings or stylised art:



fig. 3, 4

More complex than in the case of natural objects, the visual communication using objects that are socially or culturally conditioned can be illustrated by the sacred architecture:¹

¹In a further examination, the difference between interpreting visual information related to natural phenomena and socially or culturally determined ones, appears itself to be socially and culturally determined as well. A person who does not live in contact with nature tends to interpret natural objects in a rather abstract way. E.g. when observing a tree the observer makes no effort to individualise the tree and to locate it very concretely, as a living individual, whose life the observer may be familiar with and which is linked to other associations and events immediately not included in the view (individual circumstances of the birth, of history, its importance for individual persons etc.). A person with exclusively natural background, on the other hand, abstracts rather from the differences in technical culture (architecture, city planning, technical design). It has been observed that Papuan aborigines who accidentally had the opportunity to visit the Czech tourist sights, demonstrated lack of interest for religious or public architecture (and were not able to individualize the buildings), but expressed keen interest for the individual animals they could see in a zoo. Theoretically, in very specific circumstances, the tree displayed above can be interpreted as "the chestnut at the road to XY, planted by AB in the field which then belonged to his uncle, when the war was over", while the church of St. Barbara just as a "big house".

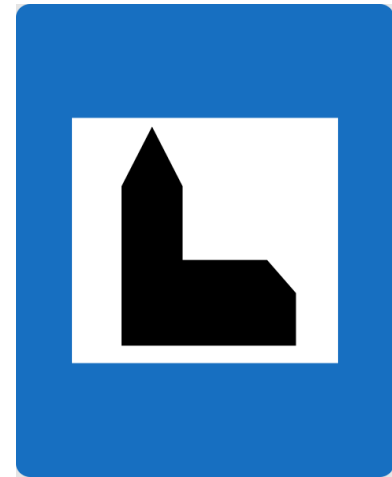


fig. 5, 6

Regarding the risk of different interpretations of pictures when using different visual languages, a disagreement in the level of specificity, in the zoom and in the metaphoric transfer has been mentioned. The religious building depicted in fig. 5, with its rich cultural ties, offers a complex range of interpretations and associations. Specificity level: "Church of St. Barbara in Kutná Hora", "city of Kutná Hora", "St. Barbora", "Gothic cathedral", "temple / church", "building", "historic monument". The zoom level: "southern facade of St. Barbara in Kutna Hora", "flying buttresses and presbytery of St. Barbara", "roof of St. Barbara", "the Church of St. Barbara", "the surroundings of St. Barbara in Kutna Hora", "southern suburb of Kutná Hora". Metaphorical transfers: "Parler masonry", "Gothic", "UNESCO monuments", "architecture", "beauty", "history", "Catholicism", "Christianity", "wealth", "majesty", "sanctity", etc. Only a good knowledge of the Central European cultural heritage, together with a good practice in local graphical conventions can ensure perspicuity of the Austrian-German traffic sign "Gottesdienst" (fig. 6), since it allows to associate the irregular octagon and the contour of a religious building with a spire.

4.1. Returning to requirements of blind persons on a good situational description which would compensate the interim visual communication of sighted people, it is clear that there is no unequivocal way to capture verbally the view presented in the picture displayed below. In the following examples different approaches to description are considered, each of them being presented - just for simplification - as a compact (one-package) information. In practice, of course, it is not only possible but also useful and necessary to build this description in different levels through a dialogue, as well as to change or combine various types of description in connection with the development of the interest or the change in strategy.

As mentioned above, specificity level (building, the Czech public architecture of the 70s, public institution, MU building, MU Faculty of Informatics), zoom level (park, road, parking, entrance, stairs, exterior, beige ceramic lining, metal sculpture; five-storey building) and the metaphorical transfer (school, study, University of Science) are at stake. The choice of a level is determined by situational context. For a blind person walking with a cane and speaking of his or her route, an adequate description may be: "30 meters straight along the curb, 10 meters diagonally across the road with a sharp angle on the left, then 8 stairs into the building, cars parked on the left, railing on the right, sound unit above the entrance" (1), a surprising formulation and not fully clear for a sighted person. For the guided blind person discussing aesthetic qualities of a building, the same view may be correctly described: "complex of buildings on 3 separate wings; common ground with steel and glass structure, in the middle, two entrance doors with a common staircase; wings facades furrowed vertically, beige ceramic lining; the central wing without windows, with a metal sculpture in the front, the side wings with continuous rows of tip-out windows"(2). With higher degree of mutual empathy, the same view may be summarized in the following way: "socialist modernism of the 1970s, typical research institute, all beige tiles, glass and steel" (3), totally incomprehensible, however, for a blind person without visual experience of architecture. For the sightless person with good knowledge of local conditions an adequate description of the same view may be: "The Faculty of Informatics 50 meters ahead, coming from Botanická bus stop" (4).

Another photograph of the same place a few years later suggests a completely different point of view, and makes it clear how different the description could be, if offered, for example, to a blind person responsible for accessibility of the university



fig. 7

premises: "Faculty of Informatics, entrance with an elevated ground; double entrance door, the right one automatically sliding, sound unit over it, 8 steps to the entrance, missing access for the wheelchair, possible location of the stair-lift both on the left and right, parking lot in front of the staircase, no artificial guiding lines through the parking lot" (5).



fig. 8

4.2. Another basic requirement of blinds persons relates to the description of graphics, both printed and published electronically. As mentioned above, the interpretation of a graphic record, even of photographs, must not be confused with the

visual interpretation of the real world, regardless of how much the two phenomena may be connected. The picture, unlike reality, has its author and the description must reckon with his or her intention (the language, interpretative key, etc.). Another difference comes with sensory limitations in pictures (sharpness, contrast, colors, lack of secondary information like sound and smell background etc.) and especially with the missing time information (no *hic et nunc*). Therefore, the descriptions (1) and (4) are excluded as being based on *hic et nunc*, in the other ones, time information should be added: characteristics like "socialist modernism of the 1970s" imply a forty-year period in which the picture may have been taken, while in the picture there are some visual features referring to a more specific time. These may be expressed verbally in descriptions like: "design of the parked cars: 1090s, no students traffic at the entrance, just 2 students sitting on the stairs". For cultural reasons mentioned above, the picture with a wheelchair user manipulating with a platform offers a wide range of visual elements that make an exact time indication possible: design of the platform and the wheelchair, the physical age of the captured people, their dress, hairstyle...

4.3. The question of whether or not the time should be included into the verbal description is, once again, determined by the context. In most typical situations, this is not just the context given by the observer's strategy or by the author of the picture. Another factor to be considered here is the author of the framework document (printed or electronic text with illustrations, web page or web site), provided the two authors are not identical. In learning and study material, the author typically uses a picture as a stimulation for an interpretive work: identify the object, specify the period... Verbal description which would contain such questions answered would preclude any interpretation and the picture would lose its sense. On the other hand, there is a logical requirement that the description offer all the data needed to draw the conclusions expected by the author of the document in connection with the illustration (the features identifying the object, or specifying the period). Very often, there is an unsolvable contradiction, due to the fact that visual and verbal information are not functionally equivalent. An observer can determine the time according to the design of a technical equipment while having no clear idea about what equipment it is or how exactly describe the element attributed to a certain period. The verbal description may contain names of the models of passenger cars on a photo which imply the time of their production, but to determine the time of a product according to the name of a company

is psychologically a completely different work than to determine it according to the design; one and the same person is usually not capable of both. With special devices, such as a wheelchair lift or the wheelchair itself, the technical specification is unlikely to suggest the time of the production, however it is theoretically possible. Where the author's intention is an individual selection of visual data according to given criteria or on the basis of certain experience (what impression you get... what would you say about the man in the picture?) then the verbal description is nearly impossible, as it automatically suggests a specific point of view. Whenever the purpose of a picture is to exclude verbal thinking (for example, in psychological tests), any verbalisation is virtually impossible.

4.4. Turning from descriptions of realistic records (photos, video) to drawing and painting, we are getting on a very thin ice. Technical drawings, charts and maps are very exact and objective as to their interpretation, but the volume of data to be retrieved, and the sequence in which they are to be retrieved is unknown and individual. This contradicts in many cases not only with a fixed verbal description, but also with a dialog-based data retrieval. Consequently, there are good reasons for expressing this information rather through tactile graphics (maps), or using spreadsheet data on which the graphics (charts) are based. Subjectivity in the sequence of the data retrieval in a spreadsheet is, to some extent, similar to tracking a chart. With artistic drawings, the ice gets even thinner. There are methodological objections similar to the psychological tests: in the theory, either verbal expression of the content, or technical description of the form can be provided. The artistic perception calls for artistic verbal expression of the content or of the meaning, however, these arts follow completely different expressive rules. The accuracy of the information conversion can not be higher than, for example, in music transcription of a piece of plastic art. Verbal description of the form of a picture can be applied rather as a comment attached to tactile graphics. The link between real objects and a drawing can be completely released, as evidenced in comics and cartoons, which may be illustrated here by the famous caricature of a *mad scientist*:²

²J.J. *Mad scientist* [online]. Wikipedia Commons, 3 February 2005. Dostupné z: http://commons.wikimedia.org/wiki/Image:Mad_scientist_caricature.png



fig. 9

Schematic graphics of this type can be processed very easily in a tactile form. The interpretation of such graphics, however, encounter a number of difficulties among sightless persons:

- Considering the principles of tactile perceiving, the size necessary to make this graphics traceable is at least 30×30 cm, while in the visual form, 2×2 cm is sufficient
- In spite of the clear lines, the identification is hindered by:
 - the bust conception (only a part of the body is shown);
 - the body proportions in extremely deformed stylisation (the size of the head, the size of the gloves);
 - the right hand touching the chin (an unclear empty field arises between the hand and the chin)
- Interpretative ambiguity of the internal lines:
 - finger separation, security elements on the gloves,
 - the interior contours of the nose, lips and ear,
 - the eyes depicted asymmetrically, with a spiral element in the left eye,
 - the hair and eyebrows,

- Interpretative ambiguity of partially hidden objects (tube, glasses)
- Interpretative ambiguity of the isolated parts of graphics (fumes)
- Illegibility of the general meaning of the stylisation (comicality)

All these problematic features can be overcome, in theory, by means of a verbal description attached to the tactile graphics, with the exception of the last one, which is the most crucial one: the overall comicality.

5.1. What can be deduced, out of the above-mentioned observations, for a graphical ontology? As quoted by Kopeček & Ošlejšek [22]: "In general, the ontology represents a knowledge base, which is composed of a domain and individuals. Graphical ontology describes global properties representing important visual aspects of graphical objects and contributing to the semantic description of graphical information. Basic classification divides graphical objects into classes according to the graphical type, e.g. photography, vector graphics, cartoon, map, graph, etc."

Further on, they concentrate on 3D color photography because it represents a widespread type of graphical objects, which is still inaccessible to the blind and, at the same time, complex enough to be applicable to most of the other graphical types. In their proposal, they assign the graphical objects corresponding verbal equivalent which can be browsed hierarchically, by means of a dialogue. This is perfect accordance with what we observed above as different zoom level in in the descriptions.

5.2. On the other hand, as it is apparent from the preceding observation, it is not sufficient to retrieve verbal equivalents to the visual information using just graphical ontology *sensu stricto* (the attributes of graphic objects) and to assume that the user will find, through a dialogue, contextually appropriate information. Constituent elements of the graphical ontology in a broader sense are:

- the user's perspective (user's individual features, where he is coming from to observe the picture, what he was doing before and what he is doing know while observing it)
- the author's (or authors') intentional perspective (picture encoding key)

- functional perspective of the graphics (framework encoding key, relationship between the pictures in the same document, or in other documents related)

It is clear that:

- one part of the verbal expression of a graphic remain unchanged even after the inclusion of the graphics into a document (in a new context)
- one part needs a reassessment (new ties and interpretation)

To display both packages correctly to the user, it is necessary to differentiate between formally identical questions and to answer them in a specific way according to the above-mentioned perspectives.

Conclusion

The graphic ontology proposed to build up verbal presentations of the graphics for sightless persons, when compared to similar descriptions produced by human assistants, seems to be very suitable for simplified and unambiguous cases. In order to include more complex cases in the future, it should be extended. For that purpose, several other ontologies are at stake: dialogue ontology (determining the retrieval of verbal equivalents), both text and document ontology (considering that the graphics usually exists within the framework of another verbal communication), and finally the auditive and tactile ontologies, considering that the missing visual channel is typically compensated by means of an auditive and tactile data income. A multisensory communication is, in our opinion, the only possible final solution.

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