NETWORK OF KNOWLEDGE IN A VIRTUAL LANDSCAPE

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An examination of virtual worlds exemplifies the role of complexity in visual systems. When comparing the composition of a photograph to that of a scene taken from a 3D computer game, reliance upon different mechanisms enables one to translate specific information into a visual image. A photograph is taken from reality, while the screenshot of the computer game is grasped from a virtual environment. Both images result from manipulating material; in one instance, photosensitive material of the negative film and the photographic paper, in another, manipulation of countless electrical switches. The photographer's job is to frame the objects in the picture according to his/her perspective, allowing for the rules of the physical world. Different scientific disciplines examine the rules that organise the world around us. In the case of a computer game, the player can influence, how the elements in the picture are organised, if the image is grabbed from a scenario in level two in the middle of a battle. However, the rules by which the player can organise the picture elements are set by a programmed engine, which includes algorithms set up by the programmers. Especially in computer games, programmers try their best to copy photographic rules in order to most closely replicate reality.

Although the photographer is familiar with the rules of the physical world, he may not be able to consider their effect on his daily life, or adapt them to manipulate his world. Yet, the person playing the computer game is not only becoming familiar with the effect of the preprogrammed rules while playing the game, he is able to manipulate the scene. In the case of the computer game, all the rules of the scenario result from a complex algorithmic process within the computer that no human could perform. Perhaps, the photographer is not even aware of the complexity, nor is the player of the game conscious either for that matter. It is only the poor programmer who must consider complex physical relationships needed, for example, to make waves reflect shiny iron surfaces under various weather conditions. The virtual world is *not* a magic alternative to the real world, but *is* a real system dealing with complex rules supported by the high processing capacity of computer chips.

The vast amount of digitalised knowledge and information requires solutions, which allow easy and comprehensive handling of data. In this paper, I will examine some of the requirements of a virtual data space that makes browsing and localisation as intuitive as possible. I will examine models from different scientific disciplines dealing with knowledge and how it is arranged. Network-like arrangement plays a significant role in all models; thus, necessitating the examination of networks.

Once I have derived basic insights into how knowledge is arranged, I will outline a draft plan for visualising knowledge and information in a virtual space. I will use the metaphor of a virtual landscape to highlight the importance of intuitive browsing in virtual space.

The research of knowledge is based on several scientific subdisciplines within information processing, for instance, cognition, notions and networks. In this paper, I will examine the spatial aspects of information processing and knowledge arrangement by considering navigation and orientation in a virtual space.

Network of Abstract Concepts

Barsalou examines the network-like function of abstract concepts and notions in the environment of the neural network. He suggests that neural records of the brain arise during perception, meaning that knowledge is essentially perceptual. ›Mental image‹ in this sense is rather a topological constellation in the brain's nervous system then a picture stored in it.

Whenever we see an object, feature maps will be activated in the proper (relevant) sensory or motor parts of the brain. During the visual processing of a chair for example, some neurons fire for edges, vertices, and planar surfaces, whereas others fire for colour, orientation, and direction of movement.[1] The object of visual perception is represented in this hierarchically arranged system. Audition, touch, and motor reenactment work in an analogous manner to vision.

According to Barsalou representations in feature maps connected to vision are topographically the same as the object observed,maps connected to vision is topographically often

1 Barsalou, Lawrence W.: Abstraction as Dynamic Interpretation in Perceptual Symbol Systems. In: http://www.service.emory.edu/~barsalou/Papers/Abstraction/abstraction_02.pdf, p. 10.

the same as the observed object, even though he states that the functioning of the perceptional symbol system is independent from this topological analogy.

If specific patterns are activated on a feature map, they are captured by conjunctive neurons in the association areas – convergence zones – and saved for later reenactment. Association areas near to the visual system of the brain react on the activations in the visual system, while the ones near the motor system capture the patterns related to action.

The information stored in different convergence zones creates the multi-modal representation of our categories. The conceptual content related to the category CAR includes information about look, as well as auditory and olfactory information, but also somatosensory information about driving skill and emotional information about how it feels driving with a speed of 195 km/h on the motorway. Barsalou calls this arborescent, modality-dependent system – responsible for conceptual contents – simulators.

Modality Dependence vs. Discrete Modules

The modality-dependence of Barsalou's system means that every simulator included in the system is dynamically changed by perceived new information and the other simulators included in the system.

Valerie Gray Hardcastle and C. Matthew Steward[2] also suggest a dynamic, non-discrete constellation of brain. They criticise cognitive neuroscientists for seeking discrete, physically constant »modules« when localising brain functions. The two researchers claim that neuroscientists know but ignore that any functional change in the central nervous system will lead to compensatory changes elsewhere while examining brain function in lesion studies. Xian Chen argues in support of Barsalou's theory of modality-dependence:

> Perceptual symbols are schematic fragments extracted from perceptual states via selective attention. Which perceptual symbols can be used as attributes in concept representation depends upon what the perceptual states can offer, and we can only select attributes from a list of candidates decided by the perceptual states.[3]

Chen extends the theory of modality-dependence from concepts to action, where some structural relations of the latter are temporal.

2 Hardcastle, Valerie Gray/ Stuart, C. Matthew: What Do Brain Data Really Show? In: Philosophy of Science 69 (September 2002) [Philosophy of Science Ass. 2002], p. 72.

3 Chen, Xiang: Perceptual Symbols and Taxonomy Comparison. In: Philosophy of Science 68 (Proceedings) [Philosophy of Science Ass. 2001], p. 208.

Network of Intentional States

J.R. Searle chooses a model very similar to Barsalou when describing mental and intentional states as source for action. He was interested in how rules given by the construction of the human brain affect actions. Of course he is not the first one supporting this idea, he even describes the conception published in his book *Mind, Brains and Science* as an unfinished experiment. He refers to Chomsky for instance, who presupposes the existence of an entire and complex system of universal grammar in the brain, as there are rules valid for every language determined by global characteristics of the brain. Searle slightly alters this and states that physiological structure is the limit for possible grammars.[4] In this perspective, mind is a representation of neurobiological processes. The difference between Chomsky's universal grammar and the mental states stands in the discreteness of the units.

Searle approaches the mind/body problem by applying two levels: the level of consciousness as macro level and the level of neurobiological processes as micro level.[5] These two levels are causally interconnected, yet they have different quality. Mind is a representation of neurobiological processes and it operates in both cases with a network-like arrangement.

Searle formulates the function of representation as follows: representation doesn't mean that the exact process of an action is unambiguously saved in the brain, hence an action can be carried out through different movements and a specific movement can refer to different actions. Searle sees the source of action in the network of intentions;[6] every intentional state – states of mind, which involve processing information as well – can solely function in the relationship of other intentional states. If a human being intends to execute something, this can only be realised in the context of the other aims. Intentional states have special conditions of fulfilment. The successful delivery of an action resulting from intentional states depends on the fact whether the world is adaptable to the content of the states.

4 Searle, John R.: Minds, Brains and Science. Cambridge, Mass.: Harvard UP 1985, p. 51.

5 Ibid., p. 20.

6 Ibid., p. 68.

7 Foucault, Michel: Archäologie des Wissens. Frankfurt/M.: Suhrkamp 1990, p. 50.

8 Barabási, Albert-László: Linked: The New Science of Network. Cambridge/Mass.: Perseus 2002, p. 56.

9 Maturana, Humberto R./ Valera, Francisco J.: Der Baum der Erkenntnis. Bern, München: Scherz 1987.

Relation of Discourses

Another important reason for mentioning Searle in this context is the application of the micro and macro levels in the issue. The term of ›macro- and micro-level‹ already covers a spatial quality. This enables the possibility of zooming as a technique of passage between the two levels. This means zooming in both, metaphorical and literal sense. In my view, the micro-level corresponds with the neurobiological discourse, and the macro-level with the philosophical discourse. Zooming should be understood as moving in space between locations with different resolutions. This movement can be easily imagined by thinking of a zoom lens on a camera. To apply zooming for these levels, the possibility must be created to visualise the space containing these levels. Before doing so, it is necessary to examine the notion of discourse.

Foucault's discourse theory offers a dynamic spatial constellation of things surrounding us in our world. The arrangement of things dealt by different scientific disciplines underlies different discursive rules.

In a discourse statements (*énoncés*) and occurrences are dispersed in continuously changing space.[7] Statements come about according to rules of discourses whenever there is a possibility of linking to each other. In that way a specific pattern is unfold in the discoursive field.

Hence there are different scientific disciplines, there are also different discourses. Foucault points to the fact, that a discourse can have the function of a statement in an other discourse. This would mean, that elements of a network can play different roles in different scales. The question arises, how rule systems of each discourse can be collated with each other. Can the issue of scaling contribute to this problem?

According to Searle, neurobiological processes are examined in biological discourse while mental states in philosophical discourse. The option of zooming between these two discourses is given if we assume the correlation of discoursive rules in both discourses, i.e. the arrangement of linked neurons and the arrangement of linked mental states follows compatible rules.

Albert-László Barabási examines phenomena and rules occurring in different networks of different scientific disciplines. Hub – or connector – is one of these phenomena:

> Connectors – nodes with an anomalously large number of links – are present in very diverse complex systems, ranging from the economy to the cell. They are a fundamental property of most networks, a fact that intrigues scientists from disciplines as disparate as biology, computer science and ecology.[8]

The same network characteristics appearing in different discourses are a basic precondition of examining the arrangement of knowledge. Using experiences from other complex systems makes it possible to import rules of information arrangement in virtual space.

Consequently one perceives the transduction between different fields of discourse when changing the scale. By observing an individual in a social sense, one has to make a step backwards. Form distance the social field becomes visible containing other individuals and their interconnections. By observing an individual in biological sense, one has to make a large step forward. By doing so, the resolution becomes bigger, and it is possible to examine the network of cells in the individual's body. This is what the two Chilean neurobiologists Humberto R. Maturana and Francisco J. Valera[9] are doing by defining humans as networks as well, describing the genesis of humans starting with it's smallest component, the network of molecules communicating with each other, then a network of cells and finally a network of humans. They state, the term of behaviour for example makes sense if one observes the functioning of the network from the outside. But considering that there is no »outside position« what happens is, the position of the observer is in an other discoursive field than that of the network.

Being in the same scale all the time does not make any sense without approaching from other scales. The meaning of processes and situations is given by distance.

How Can the Relevance of Documents Be Considered?

I would like to demonstrate how elements of networks are organised topologically to indicate relevance on the example of an intelligent internet search engine. I have to admit that the intelligence of the system indeed is the result of all user's activity.
A common text search engine is looking for keywords typed in by the user in documents it has indexed or registered. After finding documents it ranges them in the search result according to the density of the keywords included in the documents. Indeed it doesn't show the relation between documents ranged in the search list, so the user can only estimate the relevance of documents according to the density of key words.

To show the relation of documents with reference to the number of links connecting them, or on the basis of the fuzziness resulting from the density of keywords, respectively combining both aspects, the search engine has to visualise the network of related documents in a multidimensional space. The user moving in the space created by the dispersed documents is not only able to reach a document linked to the given document, but as he sees the documents around – seeming to be relevant – which are two or three steps away, he can choose a shorter path as well.

The spatial arrangement of the network's elements opens up the structure of the virtual landscape. Distance between the network's elements is the indicator of relevance. For proper distance calculation in the software of the search engine we have to define programming algorithms converted from other scientific disciplines. This is the guarantee for a structure of the landscape which correlates with the human scale in its proportions.

As the system is able to store the route followed by users, and to recognise the common paths (common sense) and takes these into account while visualising the network, we get a dynamically changing landscape. This system puts the documents connected with a more common path topologically nearer to each other as the ones with less evident connections.

The authorship of such a dynamic map is shared by all users of the system, as they are the ones to define the system of connections between the documents; altogether they create the virtual landscape of knowledge included in the system. The arrangement of knowledge is realised in the virtual communication space connecting users in this case. I consider it to be an interesting question, if we can discover any similarity that alludes to an anthropomorphic arrangement of digitalised knowledge in the space of computerised communication. To examine this, it is advisable to compare the structure of knowledge constructed in the mentioned virtual space with universal network rules suggested by Barabási. The database built up by the search engine contains – independent of visualisation of the landscape – information on links between documents, which can correlate with these universal network rules according to Barabási's thesis. Visualisation is the tool which provides for an easy handling of this database for users not competent in interpreting database information. Furthermore it enables the exploration of the structure of our knowledge.

Passage through Networks. Zooming and Browsing

If we observe the field of neurobiology and mental states visualised by the interface of this search engine mentioned above, we can zoom between the two fields as suggested in connection with Searle's issue of mental states. Although the zooming could solve the problem of shifting between different network landscapes of the different scientific disciplines (discourse) – one discipline is the micro-level for the other and vice versa – it only enables the option of moving linearly, the observer perspectives are positioned on one straight line.

The abandonment of the perceptional habit forcing the linear arrangement is one reason the necessity for visualisation of the virtual space. The psychological research of A. Paivio underpins this concept at two points: 1) the visual perception of human beings proceeds synchronously, and therefore there is no predefined order for perceiving picture elements, 2) the processing of visual information is faster than that of verbal information. This makes it easier for recipients to overview complex systems of relations.

In my opinion, the sequence of these networks is only a specific constellation in space of the network involving them, what reserves that the path between not adjacent networks leads through the others between them. I would like to modify this scenario in the way that I presume links bridging directly over different discourses.

Moving in Space instead of Zooming

This results in the network's less rigid formation in space, in which perspective and scale are playing a decisive role. The other consequence of the denser interweaving is the fading of the borders of included discourses, so the different discoursive networks, which were treated separately are in this perspective nothing else than fields with higher concentration.

The above mentioned example on zooming is applicable in a case, if somebody is examining the surrounding world from the view of the human scale. Whereas if we assume the constructability of this virtual information landscape, we can move into and through other scales than the human, i.e. biological, chemical, astrological etc.

The aim of visualising systems of connections and networks is to create a virtual landscape, in which we can use the same techniques and technologies of orientation and navigation as in the human scale.

Why Do We Need Maps in the Network?

In case of the word wide web the geographical location for storing data and information is of a completely different significance than the location of libraries or printed publication for example. Research on network has already shown that though geographical distances are not completely irrelevant, the measurement of distance is based on new units: the number of connections. If we try to measure the distance between two elements of the network, we have to look after the number of links connecting two elements directly or indirectly. In other words we have to count, how many steps it takes to get from one node to the other.

If we have to pass more than one link, the issue of finding the shortest way arises. For that we will need a map, since if we set off in the wrong direction, it may take much longer to find the desired node, and we have a good chance to learn more about the lost-in-cyberspace syndrome.

A map on the one hand provides an overview of our position in the network (the current scale), and shows us on the other hand the distance between different nodes in space. We have to keep in sight that the distance between nodes in this virtual space – exemplifying the internet, we talk about documents – shows the relation between them, and the relevance to one another in our perspective. A document containing information about the key word »horse« must not be far on our map from documents about mane and saddle, but we must be able to find documents about horsepower and the performance of cars as well. This must be granted – considering aspects of content – similarly in the hypothetical case if we wouldn't use the term »horsepower« for the performance of cars.

The function of maps described above refers to the issue of orientation. But in mapping documents or any other kind of information the relation of topology and interpretation is of higher importance. Property simulators as suggested by Barsalou were described above. But Barsalou also addresses the mechanisms of simulators to relations. Relational simulators reflect on spatial, temporal, causal, and intentional relations. By discussing relational simulators Barsalou concentrates on spatial relations as *above*, *under*, *besides* etc. Spatial relations affect the function of abstract concepts just as property simulators do, that means in the system of cognition and/or interpretation topology is a decisive factor.

According to this, topological arrangement of information data – represented as picture elements on a map – is a key to interpret connections in the system of knowledge.

Conclusion

The examination of relation systems and networks mapped by different research disciplines teach us more about structures and functions possibly adaptable into algorithms to create a global virtual space, which provides for further devices to reveal human knowledge.

The virtual landscape of knowledge includes not only descriptions of different objects, but creates the topological representation of the relations between them. So does human thinking, which is not only based on separate knowledge items but also on different kinds of relations between these items.

The structure which is able to deal with relations, is network-like. Visualisation of the network is a tool for showing relations, a dynamic virtual landscape allows to use and manipulate the network, as well as the relations in the system of knowledge accordingly.

In my further work I would like to deal with the issue of this virtual knowledge landscape and examine its epistemological potential.

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