STEPS TO COGNITION IN IMAGE ANALYSIS AND IN PHILOSOPHY
A COMPARISON

Hans-Peter Bähr[a] and Hans Lenk[b]

[a] Universität Karlsruhe/Germany, Institut für Photogrammetrie und Fernerkundung
Englerstr. 7, 76128 Karlsruhe, baehr@ipf.uni-karlsruhe.de
[b] Universität Karlsruhe/Germany, Institut für Philosophie
Kaiserstr. 12, 76128 Karlsruhe, ed05@rz.uni-karlsruhe.de

Commission III, WG III/6

KEYWORDS: Analysis, Comparison, Language, Modelling, Reasoning, Recognition, Vision

ABSTRACT:

The aim of the investigation is to point out common elements of reasoning in to two domains which appear to belong to very different disciplines: image analysis and philosophy. It will be shown that on the iconic, symbolic and semantic level of analysis similar or even identical tools are applied and equivalent results are elaborated. This circumstance is explained by the fact that in both cases it is the human individual who creates and controls the respective tools. Thus they emerge from the same source which unfortunately can only be classified as "unreliable" in the light of rigorous investigation.

1. HUMAN´S DIFFICULTY WITH "REALITY"

Both image analysis and philosophy set off from the same challenge: analysis and formal structuring of the "real world". This "real world" as the basic object of consideration, is beyond man´s capacity to perceive, i.e., the human is not able to wholly analise the "real world" in an absolute way . This has been repeatedly formulated by philosophy, e.g. in Platon´s allegory of the cave. In order to remind the fuzzy nature of "reality" this term as well as its composition should always be put into inverted commas.

In image analysis this problem has not yet been recognised, perhaps because image analysis was restricted up to now to the "semiotic surface" of the objects under consideration. The result of classical image analysis is the a-posteriori assignment of a-priori given terms to unknown patterns. In this relatively simple labelling procedure, the *meaning* of the terms in a given context of "reality" is not adequately taken into consideration. In Bähr, H.-P., Schwender, A., 1996 this problem was already addressed in relation to classification: What does "forest" mean ? At the end, the question is not at all trivial, it has to be seen in relation with the intention of the individual who is asking the question. W.A. Woods (1975) coined the term "intentional representations" with respect to this very high level of understanding.

2. PERCEPTION, THE INITIAL STEP ON THE WAY TO COGNITION

After "reality", the second element of common concern from image analysis and philosophy is "data acquisition" as it is called in technology, standing for physical archiving of a part from the "real world". In philosophy, this step is expressed by the term "perception" which I. Kant claimed to be the starting point of all cognition (in German: "Anschauung", after Kant,I, 1902). It very often sets off with images, i.e., reflections (transformations) of the "real world" according to the early L.Wittgenstein who claims the picture to be a "model of reality". The relation between model and "reality" is discussed by F. Rapp (1995), too. In this paper, we shall restrict perception to visual perception in order to compare image analysis and philosophy, though Kant´s term "Anschauung" reaches much beyond.

Thus, for both disciplines any kind of intellectual reasoning starts with perception. However, while the machine can rigorously separate data acquisition from data processing this is not the case for the human individual. H. Lenk (1993) shows clearly that human perception includes a selective schematisation and analysis of what is perceived. This is confirmed, too, by physiological investigations where part of man´s visual apparatus applies pre-processing to the incoming data before further processing by the brain takes place (Bestenreiter 1988). The image compression and the analysis procedure start at the retina and continues on the path to the brain.

Perception in the sense of simple viewing is, different from the human, a trivial matter in case of machine viewing: a sensor produces signals on the iconic (the physical) level, which is rigorously separated from any further analysis, in case the sensor type, the clipping of the "real world", the respective conditions of environment etc. are excluded as elements of analysis.

3. A STEP FURTHER: DATA MODELLING OR ASSIGNMENT OF CONCEPTS ("MATCHING")

The third common field of image analysis and philosophy tackles a central issue: (data) modelling. In image analysis this means the transformation of the raw ("original") data from the iconic (sensor, physical) level to a higher, symbolic (formal) level of abstraction. The objective of this step is to assign terms to the acquired data which we may call a matching process.

In philosophy, according to Kant, this process is nearly identical although it does not seem so to be at the first moment. In both fields the tasks requires the assignment and application of terms or concepts (in German: "Begriffe") to the elements perceived. Unknown features are transformed into known objects by putting a name. Images and names play a central role in any cultural environment.

In image analysis the unstructured original primitives are matched with models according to Minsky´s frames (Minsky, 1975). The procedures may be explicit or implicit. Explicit models require rigorous a-priori design, like semantic networks or production rules. Implicit procedures, on the other hand, are generally trained "on the job" by a human operator (so-called "learning systems"). Examples for implicit procedures are

multispectral classification in remote sensing or neural networks.

Explicit versus implicit models in image analysis correspond to systematic approaches versus heuristic ones in philosophy. The corresponding connectionist approach in philosophy reflects the impact of neural network research from the cognitive sciences and image analysis (D.E. Rumelhart & J.L.McClelland). Graphs or networks as in neural or semantic networks are ideally suited to formalise knowledge both in explicit and in implicit models. This is due to the fact, that the objects (terms) are in the nodes, whereas their relations are laid down in the links. The power is in the links (see H.-P. Bähr, 2001)!

The assignment of terms to given patterns may not be fully matching due to the natural variance of the patterns (and of the terms, too, a fact which has not yet been adequately investigated). It follows that the matching process in the framework of data modelling, will lead to homomorphy rather than to isomorphy.

4. COGNITION: FROM TERMS TO MEANING

The final step in the common procedure from perception to cognition in both image analysis and philosophy requires data integration. Here, the findings from data modelling, the terms, are fused and merged with additional kinds of information yielding a higher level of knowledge compared to simple terms. At this step *meaning* is given to the terms.

As an example, we again may take "forest" assigned to a given pattern: this step does not yet give any meaning in a semantic domain. In order to do this, "forest" has to be put in a specific context like "part of the landuse statistics of an individual municipality" or "a class of environmental analysis" or "a landuse class in a legend of a map", or "an element of tourism" or "a component for the Agenda 21". In this way conventional image analysis gains added value by data fusion. From the philosophical point of view, for instance, the later L.Wittgenstein defines "meaning of a term as its use in the language". This again adds context to an isolated term which only by its integration (i.e. by its use) acquires a specific meaning.

Obviously, the path to cognition starts with perception, then goes to formalisation (modelling) and finishes by adding meaning from context. This 3-step procedure seems to be a common rule for any human reasoning (Bähr, H.-P., 2002). It is formulated by the genius Kant as follows:

"So fängt denn alle menschliche Erkenntnis mit Anschauung an
        geht von da zu Begriffen
        und endigt mit Ideen"
("Hence all human cognition starts from perception,
        from there it proceeds to terms
        and ends up with ideas")

(I. Kant, Kritik der reinen Vernunft, Elementarlehre, 2.T. 2.Abt.)

Meaning is semantics, and semantics requires high quality knowledge in a specific context. Therefore it is obligatory to use the term "semantics" very carefully and not just in the sense of "attributes". However, exactly this happens very often in image analysis, when all non-geometrical/topological information is trivially called "semantics".

5. CONCLUSION

Levels	Tools	Procedure	Results
physical, iconic	Sensor	viewing	Signals (Human perception)
formal, symbolic	Model	matching	Objects, Classes (Terms)
semantic	Context	analysis	Cognition Meaning (Ideas)

The table visualises the elements on the path from perception to cognition as discussed earlier. The philosophical concepts are put into brackets, according to Kant´s 3-step procedure.

The comparison of machine-based image analysis and human intellectual reasoning as done in philosophy shows very similar components. This is no surprise, since both fields are, at the end, of course created and controlled by man. The intercourse of "reality" (i.e. what the individual feels to perceive), of his thinking and of its formalisation by terms had already been investigated by B.L. Whorf in the fifties. His fundamental publication (Whorf 1956) titles the inverted sequence, starting from language and ending with "reality".

The crucial point is, after all, "reality". Image analysis, different from philosophy, has not yet encountered any problem with respect to this term. Fortunately – but in the moment when the original data base for the analysis turns to be unreliable, the results themselves are not any more acceptable as before.

6. REFERENCES

Bähr, H.-P., 2002. Stepwise Reasoning. Bildteknik/Image Science Nr. 2002 :1, pp. 123-129.

Bähr, H.-P., 2001. The Power of the Links. In: *Zeitschrift für Photogrammetrie und Fernerkundung*, 1/2001, pp. 23-31.

Bähr, H.-P., Schwender, A., 1996. Linguistic Confusion in Semantic Modelling. In K. Kraus, P. Waldhäusl (Eds.): *Proc. of the XVIII Congress of the ISPRS, Vienna. International Archive of Photogrammetry and Remote Sensing*, Vol. XXXI, Part B6, Commission VI, pp. 13-17.

Bestenreiter, F., 1988. Vom Punkt zum Bild, Entwicklung, Stand und Zukunftsaspekte der Bildtechnik. Karlsruhe: Wichmann, 317 p.

Kant, I.,1902 ff.: Gesammelte Schriften (Akademieausgabe) Berlin.

Lenk, H., 1993. Interpretationskonstrukte: Zur Kritik der interpretatorischen Vernunft. Frankfurt/M.: Suhrkamp, 698 p.

Minsky, M., 1975. The Psychology of Computer Vision, Chapt. A Framework for Representing Knowledge, Computer Science Series, McGraw-Hill.

Rapp, F., 1995. Modell und Realität. *Zeitschrift für Photogrammtrie und Fernerkundung*, 6/1995, pp. 220-223.

Whorf, B. L., 1956: Language, Thought and Reality. The M I T Press.

Wittgenstein, L., 1953. Philosophical Investigations. Basil Blackwell Oxford.

Woods, W. A., 1975: What´s in a link: Foundations for Semantic Networks. In: Representation and Understanding, Studies in Cognitive Sciences (Ed.: Bobrow, D. G. and Collins, A.). Academic Press**.**