Visual Information – From Print Physics to Art

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Abstract

The question whether information is beyond the technical definition (Shannon) a physical category (It from Bit?) is discussed. If the coding of a system is nearly the same as creating the system (in human culture and in quantum physics alike?), the linkage of meaning and coding is a fascinating task ahead. In examples like hinting in visual information (text/images), content related workflow management in print production, WYKIWYG (what you know is what you get) art interpretation and in approaches towards a pictorial score (emphatic painting and expression recognition) this situation is illustrated.

Introduction

The keyword of this keynote is information. The center term ´form´ comes from the translation of Plato´s Greek word ´eidos´ into Latin. ´Eidos´ is the basis of words like ´idea´ or ´ideal´. Information has generally two different interpretations. The one is focusing on the content or the meaning of a message like in ´personal information´ or in ´infotainment´. The second is used in ´information technology´ where processing, storing, transmitting and displaying of symbols, free of any relations to the semantics, is the business. Evidently the two connotations are closely intertwined [1]. Synonyms for the word ´information´ are arrangement, configuration, order, organization, pattern, shape, structure and relationship [2]. The central question is whether information is the third basic category in physics besides matter and energy.

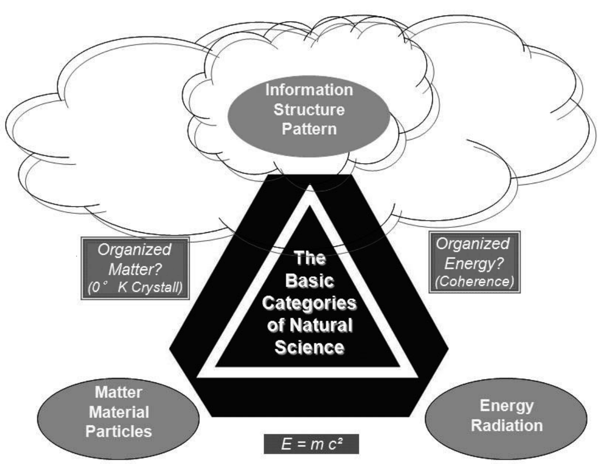

Figure 1. *Information, the third basic category?*

In very recent interpretations, the whole universe can be considered a quantum computer and reality be understood in terms of information . "Then we estimated the total power of the Universe a memory of 10 to the power of 100 bits and approximately 10 to power of 90 bits processed per second." [3]. A collection of remarkable statements might further help to encircle the word information. Information is:

- The infusion of form (von Baeyer)
- A flow of form (Paul)
- The communication of relationships (Paul)
- Electric rain pelting your receiving antenna (von Baeyer)
- Information is physical (Landau)
- We are all just bits of information. (Vedral)
- It from Bit? resp. It from Qubit? (J.A.Wheelers -list of really big questions – RBQ´s).

Information and Entropy

The scientific resp. technical approach to the information concept follows Shannons basic work of 1948. Claude Elwood Shannon (1916 – 2001), an American mathematician and electronic engineer, is known as "the father of information theory". In a simplified version, adapted to graphic arts application the following formula defines structures and enables the measurability of visual information.

$$i = n * \log^2 m \quad (1)$$

where **i** = information density (Bit/cm²), **n** = number of printed elements (e.g. dots or pixel / cm²) and **m** = number of different elements (e.g. dot sizes, character set). The technical definition of information excludes connections with the meaning or the content, it is intentionally not content orientated. In some statements, it is mentioned that only with the link to the content of the information, the right understanding is achievable. Von Baeyer uses the analogy with thermo dynamics. "The hope is that Shannon´s definition will make contact with the meaning of information before a quarter of a millennium has passed, as it did between the invention of the thermometer and the realization of just what is that a thermometer measures."

The second law of thermodynamics

$$S = k * \log W \quad (2)$$

is the inscription on Ludwig Boltzmann's tombstone in Vienna´s Zentralfriedhof. Here **S** stands for entropy, **k** = $1.3806505(24) \times 10^{-23}$ J K^{-1} is the Boltzmann constant and **W** is the number of possible microscopic states which correspond to the observed thermodynamic state. Ludwig Eduard Boltzmann (1844 – 1906) was an Austrian physicist famous for his founding contributions in the fields of statistical mechanics and statistical thermodynamics. He was one of the most important advocates for atomic theory when that scientific model was still highly controversial. The similarities between Shannon´s information entropy and the thermodynamic entropy are not only formal (Entropy > Neginformation, Information > Negentropy). For simplicity´s sake the analogy might help that the alphabet of nature is the number **W** of microscopic states (vibration, rotation, translation of molecules, electronic or nuclear quantum states, electromagnetic radiation etc.) and the package density is given by the number of elements (atoms or molecules) per volume (~ 10^{23}). Reality is the most probable arrangement of these ´letters´ (i.e. microscopic states) under given conditions. Entropy drives these ´letters´ back to the most likely configuration if they have been forced to deviate from equilibrium. As long as there are differences, entropy is busy equalizing them. This is how time is connected with entropy. After having reached the final overall equilibrium, time stops, because there is no more a before, a now or an after (hypothesis of the heat death of the universe).

Coding and Content

For some technical and human information concepts a few examples of the variables **n** and **m** in the simplified Shannon formula (1) are listed in Table 1. In nearly all of these systems a great multiplicity of coding methods (alphabets, languages, pronunciations, slangs, grammars etc.) are in use. The binary, decimal and hexadecimal coding in computer science resp. in numeric mathematics e.g. is suitable to show the consequences in the word length if the same information is written in the different codings (Table 2).

Table 1: Information structuring examples

Discipline	n	m
System Theory	Element Number	Character Set
Telecommunication	Signal Number	Signal Levels
Computer Science	Word Length	Character Set
Print Technology	Resolution	Density Levels
Human Eye	Resolution	Density Levels
Conference Speech	Number of Words	Vocabulary

Table 2: "15" in different codings

Code / Characters	Character Set	Number	Word Length
Binary / 0,1	2	1111	4
Decimal / 0,1,2,3,4,5,6,7,8,9	10	15	2
Hexadecimal / 0,1,2,3,4,5,6,7,8,9, A,B,C,D,E,F	16	F	1

Fooling the human eye is the real skill in visual communication technologies, with a specific challenge for printing. In "traditional" printing, generally two singular coding sets are in use - 1bit in typography and 8bit in repro. In Table 3 some coding examples, typical for the graphic arts industry are listed.

Table 3: Coding examples in graphic arts etc.

Signs	Type	Example
2	Binary	Typography, Text
4	Quaternary	Life´s Gen Code
8	Octal	
10	Decimal	Arabic Numbers
16	Hexadecimal	
26		Alphabet
256	(8bit)	B&W Repro
1024	(4x8bit)	Color Repro
>20 000		Kanji

The interface protocol of the human eye is generally referenced to the standard observer. The realistic viewing conditions however are far away from a well defined lab environment. Beyond the physical parameters of the viewing situation, especially the viewing habits of a person, its aware or unaware affinity to pattern recognition or visual perception training etc. are crucial. Viewing is basically looking for content. The tables above indicate that informatively structuring a system (choosing **m**) is not only influencing the mightiness of **n** (to express a given amount of information), but it creates and casts the whole informational toolbox for the entire system communication and perception. It irreversibly eases or hinders, simplifies or complicates, includes or excludes, enables or disenables certain ways of info representation – or even of contents. This is uniquely decisive for human communication and culture, not only in the visual segment. In an extreme notation, it can be said that with the choice of **m**, a system is not only informatively and IT-wise equipped and structured, but it is basically designed and fixed for ever with all its inner and outer relations. The choice of nature for the code of life is illustrated in the following graphic from the human genome project (Fig.2).

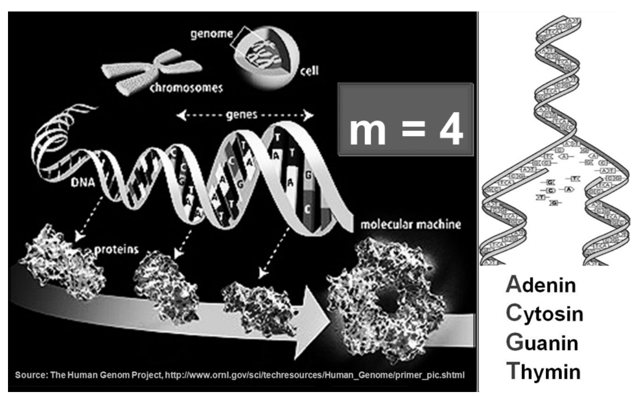

Figure 2. The Human Genome Project – DNA Structure

Content Orientation and Image Quality

Different visualization technologies strengthen or weaken certain image structures and so specific image contents. In printing e.g. a universe of highly sophisticated screening rules like AM-, FM-, hybrid, adaptive and the like are available. The screening topic generally is inclined to end in an endless "before nothing but trees see no wood" debate. In trivial FM screening, there is only one dot size (2bit coding in B/W, m=2) in adequate AM screening there are 256 dot sizes (8 bit coding, m=8).

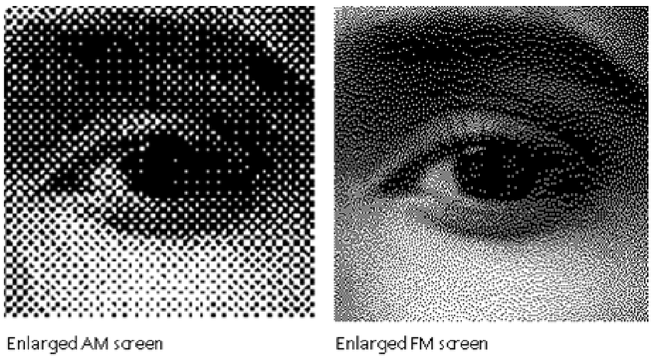

Figure 3. *AM/FM Screening.*

As in other information transferring processes (e.g. broadcasting of sounds or TV movies), the content should be sustainable over all transformation steps. A proper tool to keep the most important aspects of type fonts over all variabilites of a reproduction process is hinting. Additionally, to the bitmap, the outline spline or the vector data of the font itself, hints indicate the essentials of the type font (e.g. constant and equal line width, serifs, proportions etc.). Figure 4 depicts some principals of hinting in text.

Figure 4*. Hinting in text – e.g. constant line width.*

For the reproduction of pictures, comments or tags help to focus on the important parts of the image (typifying). In photography a comment like portrait, people, landscape, architecture, food, high key, low key etc. might indicate where compromises in processing, compression etc. are tolerable or where not. So in a portrait for example the skin tone might be more important than grey balance, in a high key or low key photo the mid tone is of minor importance etc. The comments or tags can be added by the author, in some cases they can be generated by an automatic process (pattern recognition, histogram analysis etc). (In the conference presentation here a sequence of 4 characteristic pictures and the suitable hinting for these images are discussed. In a B&W reproduction these pictures would not be very helpful, so they are not included here.) Similar to the argumentation for hinting in images is the discussion about image quality, especially if a semantic quality orientation is not excluded. The next table tries to summaries image quality management approaches in three (historic) steps.

Table 4: Quality Concepts

Level of Judgment	Concept	Quality is
Printing Process	**Control Elements**	**No Failure**
Visual Perception	**Standard Observer, Color Management**	**No Surprise**
Image Content	**Generic Coding, Hinting, Typifying**	**Positive Excitement**

In the printing industry, standardized production processes are well established. This allows in best cases the no-surprise-result. The partners along the production chain are forced to optimize on their fragmented responsibility level only, an unrestricted overall optimization is impossible. The providers of industrial equipment are in different branches (prepress suppliers, press manufacturers, paper and ink suppliers) and their businesses are built on very different rather singular profit bearing structures (software, hardware, consumables only). Innovations that cover the whole production chain and apply an unrestricted quality management communication would be structural wise too innovative and seem less desirable. In the NIP branch there is no such horizontal disintegration of competences and businesses in different companies as in the traditional printing industry.

At manroland we tried to establish a holistic concept in the DICOWEB development. The DICOWEB is a web fed offset press with seamless cylinders. The print form cylinders can be imaged and erased within the press (digital change over). The workflow management is able to include here the communication of hinting along the whole production line. The image meta data (input hinting) indicate what is more and what is less important in a sujet, what should be supported with every available image enhancement trick and what can tolerate compromises. The profiling meta data (output or production hinting) of the press or even of every roller nip indicate the strengths and weaknesses of the system resp. its components. In the ideal case, the process independent meta data of the image files and the specific profiles of the output device “negotiate” the overall optimum. In case of incompetence, the fall back line is the state of the art standardization (no failure, no surprise). In this structure, it would be much easier to technically verify a print production process independent repro and openness for innovations, even for not yet invented printing technologies.

Content Orientation and Art

WYKIWYG, what you know is what you get, was the title of a project, elaborated in the 1980ties at the Gutenberg University in Mainz, Germany [4]. The students concentrated on the "Die Kubismus Maschine" (The Cubism Machine) subtitled elaboration on the cubistic phase of Juan Gris (1887 – 1927) and Pablo Picasso (1881 – 1973), both Spanish painters and sculptors. Amongst others the question was treated whether there is something like a pictorial score in paintings, especially in cubistic paintings. Why do we have scores in music and not in visual art? The question is whether there is something like a hidden score. And of course there are detectable sets of rules (Fig.: 5).

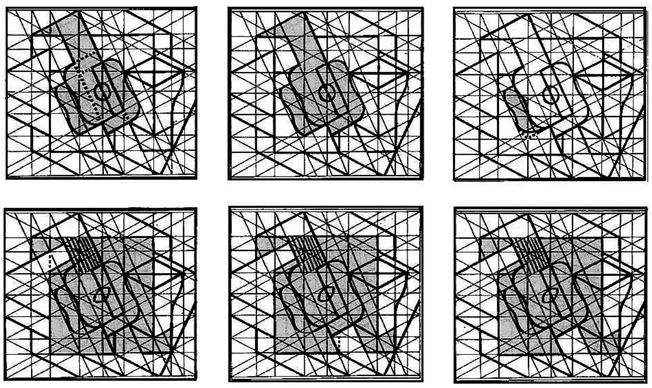

Figure 5. *Illustration of cubistic composition steps. [4].*

The authors followed the fascinating idea to let the painters continue painting with the founded rulings after they have discontinued this phase. Here the question arises whether the formal analysis of aesthetic and art is suitable to detect any content related quality aspects. The clear answer in "Nach allen Regeln der Kunst" (According to all Rules of the Art) [4] is no, even so there are significant structural differences in literature (Fig.:6), music or in visual art detectable.

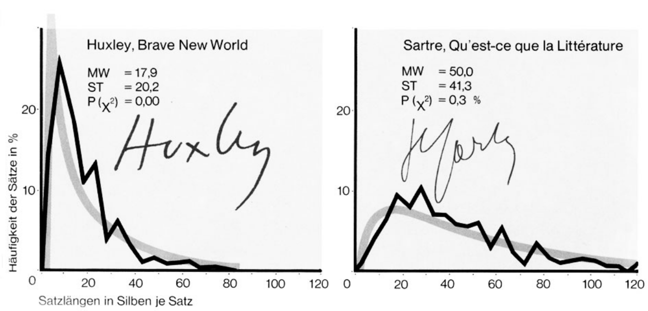

Figure 6. *Length/Frequency of sentences; Huxley´s "Brave New World", compared with Sartre´s "Qu`est-ce que la Litterature" [5]*

Recent trials to perform visual art like music are carried out in the emphatic painting project [6]. Here, the mimic of a person is analyzed by a video camera (expression recognition) and accordingly used to vary the composition and/or the colors of a painting. This is mimic "conducting", with the restriction that only variants out of a look up table or out of a parameterized "painting" algorithm can be reproduced. Figure 5 depicts three scenes of a video clip (demonstrated in the presentation) with the facial expression above and the corresponding painting underneath.

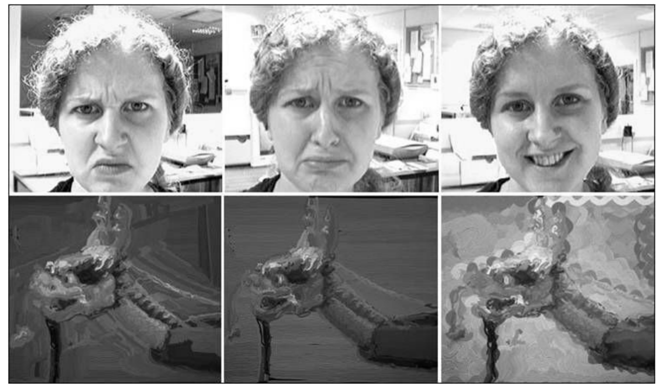

Figure *7. Emphatic Painting – Expression Recognition [6].*

Final Remark

Viewing is looking for content. The challenge of linking IT with content in image science and technology seems to be (at least to the author) one of the most attractive and promising fields of research now and for the near future. The content web or the quantum information are apparently on a somehow similar track. Nice applications are in the playgrounds of art, from pictorial scores to emphatic painting, and the like. Desirable is especially a universal (i.e. visualization- and printing-process independent, image content orientated) input hinting and an output hinting, that describes the strengths and weaknesses of an output channel in a way, that it can be used to support the content in a perfect and future proof handshake.

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Author Biography

Josef O. Schneider received his Diploma in Physics (1976) and his Dr.rer.nat. (1980) from the Technical University in Munich, Germany. Since 1980 he has worked at the FOGRA Institute (innovation consulting in printing) and since 1988 with manroland, a printing press manufacturer in Augsburg Germany (VP research / business unit digital printing). In parallel he has been a guest professor at Universities in Berlin and Wuppertal for 12 years. He is a member of IS&T since 1980, has been a member of the technical council and has received several research and industry awards, so the IS&T Fellowship (2001) and the Johann Gutenberg Price (2005).