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Frontiers in Digital Interpretation

Unpublished Keynote: Frontiers in Digital Interpretation," *Digital Interpretation: To See the Unseen History*, Falun, 7-9 April 2002.

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1. Introduction

An attempt to survey the frontiers of digital interpretation can scarcely hope to be more than impressionistic. The Internet is growing with enormous speed. It is claimed that there are over seven million new pages per day. A search for virtual or digital culture yields over one million sites. There are over a million sites for the virtual past,¹ virtual present and virtual future respectively. There are sites on cyber-studies,² cybersociology³ and cyberanthropology⁴ with essays on culture in a virtual world.⁵ There are major sites on archaeology⁶ and new versions of old disciplines such as digital philosophy⁷ and digital communication.⁸ Almost every major discipline has thousands and in some cases millions of sites under the prefixes virtual, digital, or cyber.

The Oxford English Dictionary (OED, 1971 edition)⁹ claims that digital in the sense of finger goes back to 1656 and that interpretation goes back to 1392 (based on an Old French term of 1292).¹⁰ Interpretation in the sense of exegesis goes back to the time of Moses.¹¹ The Oxford English Dictionary, Webster and Dictionary.com¹² list no entries for the term *digital interpretation*. Under this term the Internet search engine Altavista lists 143,249 entries; Hotbot lists 250,200, Lycos lists 359,800; Google lists 571,000 entries.¹³ There are considerably less sites, which use virtual and digital exegesis (figure 1).

The problem of interpretation is a long-standing one in the realm of culture. The topic occupied my teacher, the late Sir Ernst Gombrich.¹⁴ It was a major concern of the philosopher, Gadamer.¹⁵ In literature, interpretation or literary criticism is a vast field.¹⁶ In the field of film, there is a literature¹⁷ and there are many courses¹⁸ on interpretation. The University of California at Santa Barbara (UCSB) has a list of sites concerning interpretation with respect to anthropology on film.¹⁹ By contrast the problem of digital interpretation is relatively new. The first item in the Google list under digital interpretation is the Centrum för Digital Interpretation (CDI) in Falun.²⁰

| | | | |
|--|-----------|-----------------------------|-----------|
| Virtual Culture | 1,030,000 | Digital Culture | 1,240,000 |
| Virtual History | 1,580,000 | Digital history | 2,040,000 |
| Virtual Archaeology | 92,600 | Digital Archaeology | 108,000 |
| Virtual Philosophy | 459,000 | Digital Philosophy | 620,000 |
| Virtual Interpretation | 370,000 | Digital Interpretation | 571,000 |
| Virtual Exegesis | 3,860 | Digital Exegesis | 7,090 |
| Virtual Object | 946,000 | Digital Object | 1,600,000 |
| Virtual Interactive Object ²¹ | 336,000 | Digital Interactive Object | 366,000 |
| Virtual Cultural Objects | 106,000 | Digital Cultural Objects | 128,000 |
| Virtual Buildings | 414,000 | Digital Buildings | 593,000 |
| Virtual Monument | 86,900 | Digital Monument | 69,800 |
| Virtual Museum | 670,000 | Digital Museum | 644,000 |
| Virtual Church | 430,000 | Digital Church | 599,000 |
| Virtual Temple | 230,000 | Digital Temple | 226,000 |
| Virtual Sites | 1,980,000 | Digital Sites | 2,680,000 |
| Virtual Landscape | 323,000 | Digital Landscape | 553,000 |
| Virtual Cultural Landscapes | 90,400 | Digital Cultural Landscapes | 26,300 |
| Virtual Tours | 802,200 | Digital Tours | 352,000 |
| Virtual Visits | 329,000 | Digital Visits | 418,000 |
| Virtual Cities | 842,000 | Digital Cities | 904,000 |
| Virtual Countries | 984,000 | Digital Countries | 1,330,000 |

Figure 1. Virtual and digital disciplines and topics and number of sites listed by Google.²²

Manual Interpretation

- Traditional: intuitive.
- Simple, inexpensive equipment.
- Uses brightness and Spatial content of the image.
- Usually single channel data or three channels at most.
- Subjective, concrete, qualitative.

Digital Interpretation

- Recent: requires specialized training
- Complex, expensive equip.
- Relies chiefly upon brightness and spectral content, limited spatial.
- Frequent use of data from several channels.
- Objective, abstract, quantitative.

Figure 2. Distinctions between manual and digital interpretation in Remote Sensing Lectures, Utah State University.²³

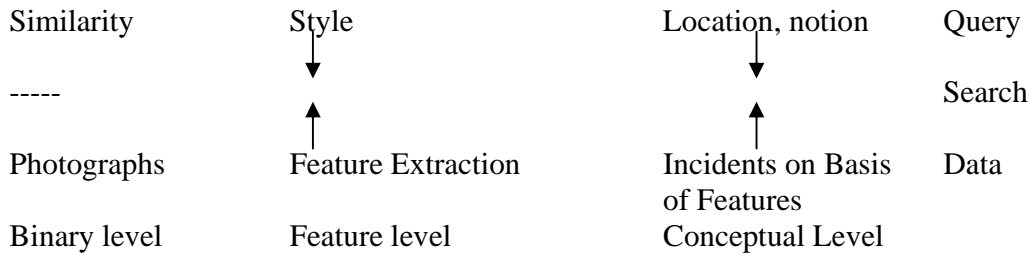


Figure 3. Digital interpretation in computer science in the SUMMER project.

Digital interpretation itself can have a number of different meanings. For the purposes of this essay we shall draw attention to five. It can refer to: 1) identification of objects in the physical world; 2) restoration of objects in the physical world (e.g. simulation before intervention); 3) reconstruction of objects in the physical world which are now in ruins or no longer exist; 4) identification of conventional subjects and 5) identification of meaning and gestalt constituting the world of symbolic values. Paradoxically those in remote sensing and computer science, who have made great advances with respect to the first two meanings, have led us to pay less attention to or to overlook entirely the importance of the last two definitions which were the domain of art history with respect to analogue sources.

2. Identification of Objects in the Physical World

In the fields of remote sensing and computer science (and more specifically computer vision) digital interpretation has a very narrow technological meaning which completely ignores the rich and complex traditions of interpretation and exegesis. In remote sensing, for instance, there is a distinction between manual and digital interpretation. It is claimed that manual interpretation is subjective, concrete, qualitative, whereas digital interpretation is supposedly objective, abstract, and quantitative (figure 2).²⁴

In computer science one finds the assumption that interpretation is a purely mechanical process of feature extraction, which can be nearly and perhaps even completely automated. For instance, projects such as the US military's *Show and Tell* assume that multimedia (digital) image interpretation is simply a question of identifying (known or readily recognizable) objects in the physical world.²⁵ Similarly, in the SUMMER project (figure 3) it is assumed that interpretation is little more than (simple) feature extraction.²⁶

Digital interpretation as it used by persons in remote sensing and computer science thus typically means the equivalent of (automatic) identification of digital images, which are based on objects existing in the physical world. This is very useful but not nearly as obvious as the technologists might wish to claim. For instance, even to recognize shapes of typical objects in digital images from satellites can be difficult. To recognize unfamiliar shapes can be very difficult.

The experts who found the lost city of Ubar in Saudia Arabia in 1992 were able to discern things, which an untrained eye would not notice.²⁷ A satellite image of an

unexplored world in outer space might very possibly contain shapes so unlikely that we would need very careful training even to consider their existence.

3. Restoration of Objects in the Physical World (Simulation before Intervention)

In the analogue world an interpretation leads a conservator or restorer to make an intervention in an original object, which usually cannot be reversed. Once one has scraped off all the layers of the *Last Supper* they cannot simply be put back. Digital interpretation introduces new possibilities. Before an intervention one can simulate the possible effects of an intervention before deciding whether or not to carry them out. One can even photograph three-dimensional objects, use stereo-lithography to create their physical equivalents and then use these to simulate the effects of intervention before trying it out on the original. This was done at the Canadian Museum of Civilization in the case of an aboriginal mask.²⁸

4. Reconstruction of Objects in the Physical World

Digital interpretation as it is used at Falun adds the dimension of time. A ruin today was once a thriving building, complex, or town. How do we learn about its original shape? In this case the archaeological evidence can serve as a basis but needs to be corroborated by archival, museum and library evidence: earlier television programmes, videos, films, photos, paintings, sketches, drawings, maps, tax records, descriptions in books, and manuscripts.

Many of these sources are the same as would have been used in past centuries in creating an artist's impression of an ancient site or city. An artist in the 18th or 19th centuries would also have relied on earlier drawings in making their reconstruction. Yet potentially there are fundamental differences. The artists' impressions of earlier centuries were typically isolated images, which provided no record of the sources upon which they were based. An expert might recognize that a painting by Hubert Robert had drawn on earlier sources, but there was typically nothing in the painting to reveal this. Similarly an expert might recognize that one reconstruction of the Roman Forum reflected the German school whereas another reflected the French or British school. But there would be nothing in the painting other than perhaps the name to give a clue concerning this.

Many of the first digital interpretations were equally lacking in context and did not provide their sources. But this is precisely the field in which they are potentially different. A digital interpretation in the form of an electronic reconstruction can have direct links to the sources on which it is based. There can be hyperlinks to images of the original site and to images of reconstructions, which served as a point of departure. Digital interpretation thus brings with it the potential of communicating the sources and tools it used in order to reach its interpretation.

5. Identification of Conventional Subjects

The world of art is much more than a copy of the physical world. Many images are visualizations of literary texts. They often show things, which cannot even be identified without a knowledge of literature. A naked woman standing on an oversized sea shell is simply that until we have read classical literature and know that this represents the Greek Goddess Aphrodite (and Roman equivalent Venus). A man with a crown of thorns or a man on a cross can often be identified as Christ once we are familiar with the *Bible*. Without knowledge of literary versions of lives of the saints we cannot recognize their attributes. Similarly without knowledge of the Buddhist *Scriptures* it makes little sense trying to identify the specific identities of the many manifestations of Buddha and his Boddhisatvas.

In the past, such knowledge was typically limited to a few initiates in a given religion or sect and to a handful of scholars at leading institutes. Today it often seems as if the number of these initiates is dwindling rather than increasing. Nonetheless, with digital interpretation, using new versions of hyper-text and hyper-iconics it is possible to link these conventional images with the texts on which they are based or with which they are connected.

In the past any insight of a master could be passed on to a disciple orally. Alternatively the master might write down the insights in a manuscript, which might then be published. In these cases transmission was limited to persons who were able to hear the master directly or to have access to a manuscript or copy of a book to read their insights indirectly. Digital media introduce a new level of diffusion whereby anyone with access to the Internet could have access to that insight of interpretation. In January 2002 that entailed 544 million persons who had a direct connection to the Internet and many millions more who had an indirect connection using family computers or Internet cafés. This is an enormous contrast to manuscripts, which began as editions of one, and books which still often have editions of only a few hundred.

Manuscripts and books had a further limitation that only literate persons could have access to the knowledge which they contained. Digital media are different because they allow a translation from any sense and from any medium into any other sense or medium. Hence a digital text is usually based on a visual image of the original. Alternatively it could be based on an oral version by an illiterate person, which was recorded and then “translated” from audio into visual form. In like manner, once a visual text exists digitally it can be “translated” into an oral form and read out as a spoken source for a blind person, or it could be printed out as a book, as a manuscript, or even in cuneiform. Thus digital interpretation entails a new level of reversibility and inter-mediability, which removes the literate divide and thus expands enormously potential access to knowledge.

6. Identification of Meaning, Gestalt Constituting the World of Symbolic Values

We know only too well from everyday life that there is enormous difference between identification and understanding. From the television and mass media we can all identify

| Object of Interpretation | Act of Interpretation | Tools | Correction Principle for Interpretation |
|--|-----------------------|-------------------------------|---|
| Primary or Natural Subject Fact-like Expression-like | Pre-iconographic | Practical experience | Style History |
| Secondary or Conventional Subject from world of Images, Anecdotes and Allegories | Iconographic | Knowledge of Literary Sources | Type History |
| Actual Meaning or Gestalt Which constitutes the World of symbolic values | Iconological | Synthetic Intuition | History of Intellectual Symptoms or Symbols |

Figure 4. Erwin Panofsky, Distinctions between Iconography and Iconology.²⁹

the President of the United States and indeed many heads of state. This does not mean that we know them, understand them and can interpret correctly their intentions, and their meanings. Similarly in the domains of art and culture. It is relatively easy to recognize a nude woman on an oversize shell as the Goddess Aphrodite or as Venus Anadyomene. It is then quite simple to identify Venus with the Goddess of Love. But it remains very difficult to know exactly what was the meaning of love symbolized by this version of Aphrodite. In this case links between the image and its meanings become all the more vital.

These distinctions were well known in traditional art history. Erwin Panofsky referred to identification of primary or natural subjects as a pre-iconographic exercise. This led to style history. Identification of secondary or conventional subjects constituted the field of iconography. This led to type history or typology. Discerning the actual meaning or gestalt, which constitutes the world of symbolic values, was for him the realm of iconology (figure 4). This led to a history of intellectual symptoms or symbols, a realm for which his colleague Ernst Cassirer set out to identify the philosophical basis.³⁰

In a sense nothing has changed. To interpret something in the symbolic sense remains much more difficult than identifying the name of an object in the physical world. There are very good reasons for this. First, the worlds of the mind, the worlds of religion, literature, culture and their various expressions are infinitely larger than the physical world of nature. Second, one of the paradoxical features of culture is that it gives persons identity and sets them apart through a relatively small subset of those infinite possibilities and uses that to close off access to others. Not all cultures are about being open to everything. Indeed it is often much more comfortable to prove one's superiority by closing off knowledge about larger fields that would threaten the validity of one's rather limited terrain. Hence, a philosopher at the level of Aristotle is happy to seek evidence from all over the known world. A petty philosopher will simply deny the value of

evidence beyond their own ken. Hence some micro-cultures remain difficult to understand because their members do everything in their power to escape being understood and to avoid communication which could lead to such understanding.

In the past it was fashionable to focus on the material aspects of culture in terms of the built environment: i.e. the heritage of churches, cathedrals, palaces and monuments. This attention to material culture often included an interest in paintings, sculpture and the arts. Then it was recognized that immaterial culture also plays a significant role: language, customs of eating, drinking, and the many small things whereby persons distinguish themselves from each other. More recently we have recognized that in addition to all this there are dimensions of openness and tolerance. Some cultures welcome the presence of others. Some cultures do everything to close themselves in both directions: to keep from learning the rules of others and to keep others from learning their rules. By contrast some persons are eager to share their knowledge with others and learn from others.

In this fundamental difference of approach lies a divide which is much greater than the seeming differences between one interpretation and another interpretation. In its most radical forms this contrast leads to polarities between fundamentalists in religion, politics and/or philosophy on the one hand and humanists on the other. One side is determined to hide its sources, rules and all its values. The other side is open on all fronts.

7. From Oral Links to Self-Linking Knowledge

Awareness of these basic differences of attitudes between schools is crucial for our discussion of digital interpretation. In most cases, the new technologies cannot determine which specific interpretation is better than another, especially as we enter into the realms of iconography and iconology. On the other hand they can help us with making links, by making “transparent” as the rhetoric goes, the connections between sources, expressions and rules.

The advent of writing meant that knowledge spread far beyond the vocal reach of those who claimed to know and it also meant that their written claims could be studied in more patience than if one were limited to audiences with the oracle or their human equivalents. The advent of books went a significant step further. The introduction of footnotes/endnotes, which in retrospect are like hard-wired hyperlinks, began a process of linking claims with their sources. Serious books had footnotes and bibliographies. Less serious books assumed or even claimed that these were unnecessary.

The frontiers of digital interpretation lie less in the introduction of some radically new interpretation and more in the advent of a new stage in the linking of claims with their sources. Hyperlinks were a first stage. Hypermedia were a next stage. There are now possibilities where every word in a text can be hyperlinked. Moreover these links can theoretically be at many different levels.

Recent advances in Optical Character Recognition (OCR) and Image Recognition (commercially represented by technologies such as Excalibur and Query by Image

Content (QBIC)), when combined with the latest wireless technologies mean that any word or image can be checked automatically using a virtual reference room. If while reading a book we encounter an unknown word, wireless technology can call up a dictionary definition, an explanation or even literature about that term. If while standing in a field or a forest we encounter an unknown plant or animal, a camera could capture its image, and a wireless computer could relay this via UMTS and satellite to a virtual reference room identify it and relay the knowledge back to our location in the field, forest or wherever we happen to be. The cameras in airports which recognize individuals assumed to be terrorists as they walk through the halls are well known demonstrations of this principle.

In short, interpretation in the sense of identifying objects in the physical world can be largely automated. Moreover, the enormously improved potentials of linking knowledge mean that many aspects of iconography and even iconology can be greatly aided by the new technologies. This will be wonderful news for those who are truly committed to sharing their knowledge and are open to learning about the knowledge of others.

At the same time these advances will loom as a terrible threat to those with closed philosophies. Indeed it is a double threat. First, it would force the defenders of closed systems to reveal their sources and criteria and make these systems open for discussion at many levels. Second, it would confront them with evidence of alternatives and challenge them to explain why their own claims are superior. Hence the champions of open culture will herald the advent of digital interpretation as a new era in the sharing of knowledge. At the same time the proponents of closed knowledge will claim that the technology is opposed to a human approach and will thus overlook its potentials for a more humane approach to knowledge.

8. Conclusions

Technologists, especially those in remote sensing and computer science often assume that the frontiers of digital interpretation lie in a shift from the subjective limitations of manual interpretation to new objective, abstract, quantitative methods (figure 1). We have set out to show that the frontiers of digital interpretation lie elsewhere. They will not increase the objectivity per se. Rather, they will provide new ways of linking our interpretations with the sources on which they are based.

Herein lie enormous new possibilities for learning in the case of those favouring open sharing of knowledge. At the same, herein lie enormous threats to those defending a closed world-view, an exclusive and excluding culture. They will continue to insist on the importance of defending some theory or claim and prefer to ignore the disturbing news that the rules for establishing defence, the rules for linking with sources, the rules of the game, which is not a game but a quest for truth, have changed in favour of those who are open. That is why the shift from analogue to digital has persuaded over 500 million persons within less than a decade and will probably spread to another 500 million in less than a decade. That is why digital interpretation will change the world: it opens new links

between the world of matter and the many worlds of the mind. It gives us better access to the evidence we need to interpret in an informed way, honestly and wisely.

Maastricht Easter Weekend 2002.

Notes

¹ See: <http://137.166.132.18/~dspennem/VIRTPAST/VIRTPAST.HTM>

² See: <http://www.webring.org/hub?ring=cyberstudies&list&page=0>

³ See: <http://www.angelfire.com/ma/Socialworld/Cyberspace.html>

⁴ See: <http://www.fiu.edu/~mizrachs/cyberanthropos.html>

⁵ See: <http://www.fiu.edu/~mizrachs/virtcult.html>

⁶ See: <http://www2.ruf.uni-freiburg.de/provroem/archimin.html#Aquaedukte>

Cf. <http://odur.let.rug.nl/~arge/Themes/>

⁷ See: <http://www.digitalphilosophy.org/>

⁸ Edward Barrett, Edited collections on digital communication include: *Text, ConText*, and *HyperText* (MIT Press, 1988); *The Society of Text* (MIT Press, 1989); *Sociomedia* (MIT Press, 1992), and co-editor of *Contextual Media: Multimedia and Interpretation* (MIT Press, 1995).

⁹ 1971 Edition

¹⁰ The Miriam Webster Dictionary claims that interpretation goes back to the fourteenth century.

See: <http://www.m-w.com/cgi-bin/dictionary>

Cf. Roget: <http://www.thesaurus.com/roget/IV/522.htm>

¹¹ See: <http://www.newadvent.org/cathen/05692b.htm>.

For a discussion of methods

See: <http://www.shef.ac.uk/uni/academic/A-C/biblst/DJACcurren/Postmodern1/Methods.html>

Cf.: http://www.digitalbible.org/article_features/methods_interpretation/methods.html

Elliott's Digital Bible identifies nine kinds of interpretation, namely:

1. Physical Realism - If you were to apply Physical Realism to the 13th chapter of Revelation above you would believe that there is going to be a beast of this description physically rising out of the Great Sea off the Coast of Israel in the natural or in this physical dimension. In other words you could get out your lawn chair and watch this creature come right out of the water in the flesh.

2. Spiritual Realism - If you were to apply Spiritual Realism to the 13th chapter of Revelation above you believe that this scripture is drawing you picture of what is actually going on in the literal sense in the spiritual dimension.

3. Bi-Dimensional Realism - If you were to apply Bi-Dimensional Realism to the 13th chapter of Revelation above you believe that this scripture is drawing you picture of what is actually going on in the spirit and the natural when this prophecy is fulfilled.

4. Physical Symbolism - If you were to apply Physical Symbolism to the 13th chapter of Revelation above you would believe that this descriptive portion of scripture would be a “Symbolic” passage of what is going to happen in the natural.

5. Spiritual Symbolism - If you were to apply Spiritual Symbolism to the 13th chapter of Revelation above you would believe that this scripture is “Symbolic” of what is going to occur in the spiritual dimension.

6. Bi-Dimensional Symbolism - If you were to apply Bi-Dimensional Symbolism to the 13th chapter of Revelation above then you would believe that this scripture is “Symbolic” to what is going to occur in the natural and the spirit.

7. Physical realism that has a correlated relationship with the spirit - If you were to apply “Physical Realism that has a correlated relationship with the spirit” to the 13th chapter of Revelation above then you would believe that this scripture is drawing you a picture of what is actually occurring in the natural yet there is a correlated relationship with this event in the spirit as well. In other words in the natural this beast is coming out of the sea but in the spirit there is an event that transpires in a correlated relationship. However the spiritual event may transpire differently in description.

8. Spiritual Realism that has a correlated relationship with the natural - If you were to apply “Spiritual Realism that has a correlated relationship with the natural” to the 13th chapter of Revelation above then you would believe that this scripture is drawing you a picture of what is actually occurring in the spirit yet there is a correlated relationship with this event in the natural as well. In other words in the spirit this beast is coming out of the sea but in the natural there is a physical event that transpires in a correlated relationship. However the physical event may transpire differently in description.

9. Allegorical or (Parables) - This method would only apply to scripture that would be considered a "story" or "fictitious", like the story of the Prodigal Son, which Jesus told us in order to learn about Gods character toward us. You could apply this method to Rev. 13 but it would mean that you would embrace that this passage of scripture is a fictional conveyance, which almost all of the body of Christ does not accept.

For a site on the bible and interpretation in the context of archaeology

See: <http://www.bibleinterp.com/purpose.htm>

¹² See: <http://www.dictionary.com/search?q=virtualSource>:

The American Heritage® Dictionary of the English Language, Fourth Edition Copyright © 2000 by Houghton Mifflin Company.

¹³ This was on 15 March 2002.

¹⁴ Sir E. H. Gombrich, "The Evidence of Image". *Interpretation: Theory and Practice*, Ed. Charles S. Singleton. Baltimore: Johns Hopkins Press, 1969.

Cf. <http://web.kyoto-inet.or.jp/people/katotk/gom.html>

¹⁵ See: <http://www.geocities.com/Athens/Parthenon/1643/gadamer.html>

Cf. <http://www.sbccc.ca.us/academic/phil/stoa/stoa1/Davidow.html>

¹⁶ E.g. I.A. Richards, *Principles of Literary Criticism*, London: Routledge and Kegan Paul, 1927; William Empson, *Seven Types of Ambiguity*, London, 1930. Reprint: Harmondsworth: Penguin, 1961. Cf. <http://www.english.cam.ac.uk/vclass/pracrit.htm>; Christopher Norris, *The Truth about Postmodernism*, Oxford: Blackwell, 1993.

¹⁷ See: <http://mentalsoup.net/jelkins/theory.shtml>

¹⁸ Cf: University of Buffalo, Department of Media Studies:

Interpretation

| | | | | |
|----------------|-------|----------|----|-----------|
| Film | | History | | I |
| Film | | History | | II |
| Film | | | | Theory |
| Film | | | | Analysis |
| Avant | Garde | (Film | | Analysis) |
| Video | | Analysis | | (303) |
| Video | | Analysis | | (304) |
| Nofiction | | | | Film |
| Socio-Cultural | | Context | of | Media* |
| DMS | | | | Elective |
| DMS | | | | Elective |
| DMS Elective | | | | |

See:

http://wings.buffalo.edu/academic/department/AandL/media_study/programs/interpretation.html

¹⁹ See: <http://www.anth.ucsb.edu/videos/>

²⁰

See:

<http://www.falun.se/www/falun/nar.nsf/wwwvanster/2DCB30B72C9C73D9C1256B26005C2949>

²¹ See: <http://www.sribascad.com/QTVR-Objects/QTVR-Objects-Menu.html>

See: <http://www.synchromedia.co.uk/objects.shtml>

²² On 20 March 2002.

²³ Remote Sensing Lecture Materials, Department of Geography and Earth Resources, College of Natural Resources, Utah State University: Logan, Utah 84322-5240, Digital Image Analysis vs. Visual Interpretation.

See: <http://www.nr.usu.edu/Geography-Department/rsgis/Remsen1/imganal/imganal.html>

An image is a rendition, or model, of target features described through the use of spectral reflectance. These reflectance values are stored in a quantitative, numerical fashion in a manner suitable for input to a computer.

See: <http://www.nr.usu.edu/Geography-Department/rsgis/Remsen1/lec3/imgnatr.html>

See:

<http://www.fes.uwaterloo.ca/crs/geog376/ImageAnalysis/DigitalImages/DigitalImage.html>

Joseph Piwowar, Geography 376. Environmental Remote Sensing

How do we interpret digital imagery?

- A. Manually
- B. Digitally

Image Processing

Image processing involves the manipulation of images to:

- extract information;
- emphasize or de-emphasize certain aspects of the information contained in an image; and/or
- perform statistical or other analyses to extract non-image information

Although certain image processing procedures are frequently used, there is no definitive "standard" set of processing steps because:

- each project requires individual attention;
- some processing decisions may simply be a matter of personal preference; and
- the quality of data varies greatly.

²⁴ See note 16 above.

Cf. Canada Centre for remote Sensing

See: <http://www.ccrs.nrcan.gc.ca/ccrs/eduref/tutorial/chap4/c4p1e.html>

For some basic reading see:

David P. Paine, *Aerial Photography and Image Interpretation for Resource Management*, Chichester: Wiley Europe, 1981.

Terry Caelli, Walter F. Bischof, *Machine Learning and Image Interpretation*, Albany NY: Plenum Press, 1997

Sergey Ablameyko and Tony Pridmore, *Machine Interpretation of Line Drawing Images*, Berlin, London: Springer-Verlag, July 2000.

Sunil K. Kopparapu, Uday B. Desai, *Bayesian Approach to Image Interpretation*, Boston: Kluwer Academic, 2001. (Book Series: The Kluwer International Series in Engineering and Computer Science, Volume 616).

²⁵ See: <http://www.cedar.buffalo.edu/ShowTell/>

²⁶ Erik Boertjes, Willem Jonker, and Jeroen Wijnands, "Multimedia Information Services Enabling: An Architectural Approach, KPN Research.

See: <http://www.acm.org/sigs/sigmm/MM2001/ep/boertjes/>.

²⁷ See: <http://www.jpl.nasa.gov/radar/sircxsar/ubar.html>

<http://www.pbs.org/wgbh/nova/ubar/zarins/>

²⁸ See: http://www.vit.iit.nrc.ca/Pages_Html/English/NRC%20M&H_tech.html

²⁹ Ikonographie und Ikonologie, " *Ikonographie und Ikonologie. Theorien-Entwicklung-Probleme*, Ekkehard Kaemmerling, ed., Cologne: Dumon, pp 207 225 esp. p.223. (Bildende Kunst als Zeichensystem 1).

³⁰ Ernst Cassirer, *The Philosophy of Symbolic Forms*, New Haven: Yale University Press, 1955- 1957, 3 vol.