

How to map perspectives: Moving GISc to IISc

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ABSTRACT

We propose different methods to represent “time” in geographic and other perceptions of reality. One appropriate method is to show effects of the procedures which take “place” along the continuum of “time”. Similarly, perspectives on reality can be “mapped” – such is the core of geography. This presents a special opportunity for IT to develop tools for various disciplines which are then interchangeable. IT allows views on new worlds. These worlds arise by applying new perspectives to known reality. IT helps to organise the complexity of the resulting views. IT creates images of reality. IT is able to move from “Geographic Information Science” to “Interperspective Information Science”.

Key Words: Geographic Information Science (GIS), mapping, time, space, perception.

0. Let's start to think

0.1 Our world is the entirety of perceptions.
(Our world is not the entirety of facts.)

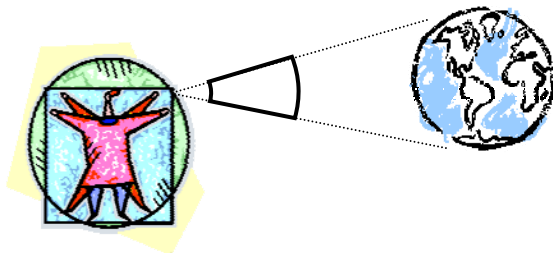


Figure 0: The human being perceives the world.

Hence, every individual lives in a different world (Fig. 0).

0.2 The “indivisible unit”, the atom ($\alpha\tau\omicron\mu\omicron\varsigma$ ¹) of reality, is equal to one (human) perspective. Our world is made up of a multitude of perceptions, not of a multitude of realities and not of a multitude of atoms (Fig. 1).

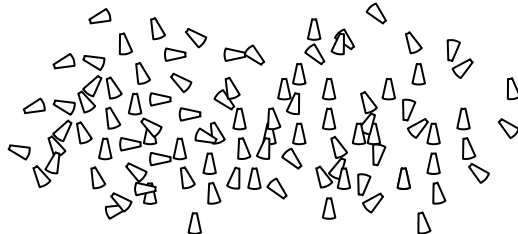


Figure 1: The “primordial soup” of living, before the advent of (social) organisms: uncoordinated perspectives, uncoordinated world views.

0.3 In order to share one's own conception with others, “writing” was invented. Similarly, complex structures, such as landscapes, are “mapped”. To *map* means to write structures.

1. Writing helps to become aware

We ask: Is it possible to map = write

1. the distribution of material facts and elements in geometric space? (physics)
2. the distribution of factual events in global time? (history)
3. the distribution of real-world objects across the Earth? (geography)
4. the distribution of elements along material properties? (chemistry)
5. the distribution of growth within surrounding living conditions²? (biology)
6. the distribution of persons acting in relationships? (sociology)
7. the distribution of individuals between advantage and disadvantage of trade? (economics)
8. the distribution of perspectives within feasible mindsets? (psychology)
9. the distribution of living constructs along selectable senses? (theology)

We see: awareness results from reflection (Fig. 2).

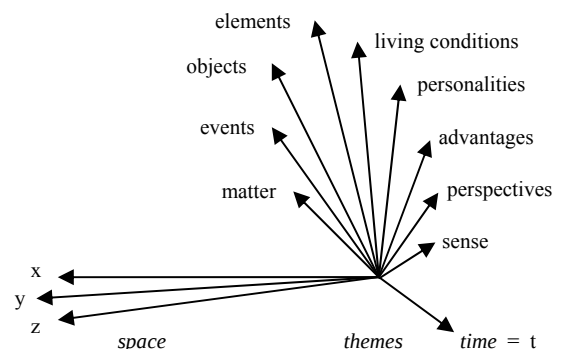


Figure 2: Fundamental dimensions, along which to coordinate individual world views when reflecting.

¹ what cannot be split any further (Greek)

² životné prostredie (Slovak): living environment

2. Time can be

1. an attribute of space (a very simple historic GISystem)
2. an independent entity (Einstein's physics)
3. the source of space (cosmology).

In terms of GIS item 2.1 is expressed as "t is one of the components of geo-data"¹ (Fig. 3).

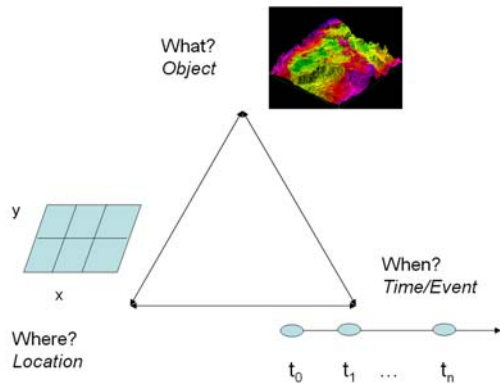


Figure 3: The where-what-when components of geo-data, also known as triad (Peuquet 2002: 203).

Time can be understood as

- establishing an ordinal scale for events
- driving changes ($= \Delta$) of realities
- something that unfortunately does not appear on paper.

A proposed solution is to map changing realities (Δ) instead of mapping time.

Time is replaced by what it produces. This is indicated in Fig. 4.

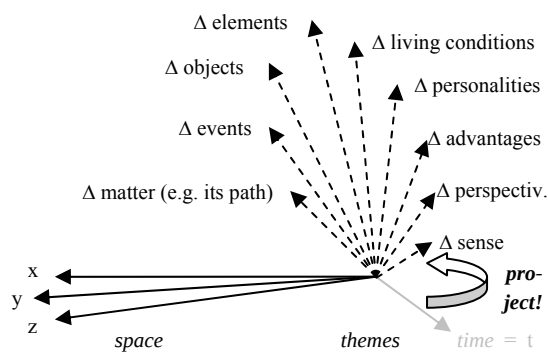


Figure 4: The projection of time (t) onto the effects of time (the changes Δ) can apply to any science.

This idea flips = projects the t axis onto one of the vertical axes. Time means then: how maps are changed by the envisaged procedures. Such procedures modify the variables along the axes, be they of physical (gravity force) or of social nature (war).

A classical example is Minard's map of Napoleon's 1812 campaign into Russia³ (Fig. 5a, b).

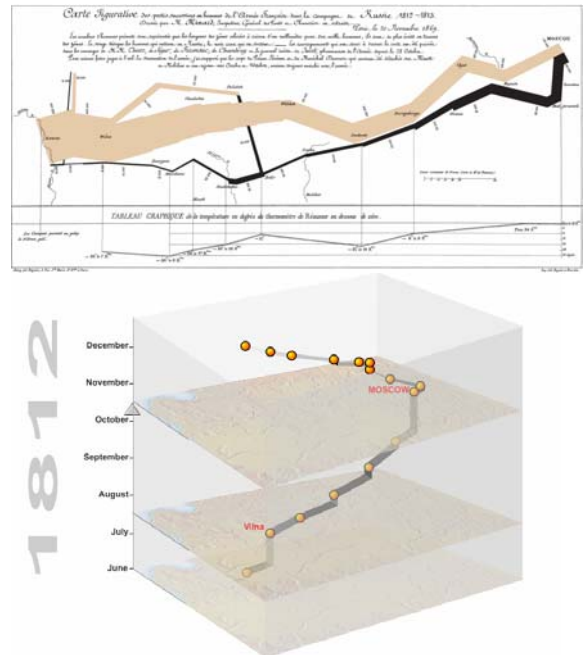


Figure 5: Notions of path in a geo-space: (a) Minard's map of human losses during Napoleon's 1812 campaign into Russia; and (b) its geo-visualisation in a time cube (Kraak, 2009).

Further examples such as landslides in geology, growth of plants, energy economics, economics will be shown in chapter 7.

For implementing the idea to project the t axis onto the Δ axis we need to have clear insight how time quantitatively changes reality.

In other words: we need a model, which (explaining how processes occur) determines the representation of time (Fig. 6). Examples are sliding geology, Δ GDP/cap, plant growth.

One cannot perceive *time* (never!), only its effects: what was perceived in this time span (duration)⁴? This is why the t axis is projected onto another axis denoting the *effect of elapsed time*; what this means to the individual sciences is shown in Fig. 4.

Very similarly, in physics nobody can feel force, only its effect (deformation, acceleration), and still forces have been undisputedly a key concept for centuries.

*What is **time**? Just a substrate for procedures.
What is **space**? Just hooks into perceived reality.*

We retain from this chapter 2 that we need a clear model of how elapsing time changes reality. Then we can map time as suggested: by its effects.

³ Patriotic War (in Russian): Отечественная война

⁴ T. de Chardin's (1950) concept of *durée* (French).

3. How to write time?

The big picture shows us various examples:

1. as a wheel (see the Indian flag): revolving zodiacs, rounds in stadiums, economic cycles, Kondratieff's waves
2. as an arrow (see Cartesian coordinates): directed processes, causal determinism, d/dt , d^2/dt^2
3. as the engine for further improvement (evolutionary economics): decrease vs. increase in global income gaps, autopoietic systems, self-organisation
4. as the generator of new structures (institution building, political integration, progressive didactics): new global collaborative institutions, peer-review, culture of understanding, self-responsible learning, interculturality
5. as evolving construct (music).

From this chapter 3 we only keep in mind that the concepts to understand and represent time are fundamentally and culturally different.

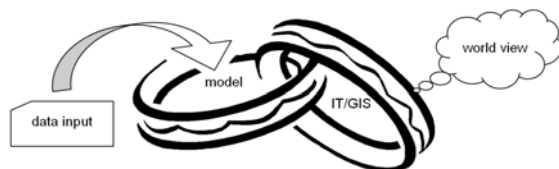


Figure 6: All data⁵ representations require models.

4. How to write space?

The big picture shows us various examples:

1. as a container of any fact and any process (geography and GIS)
2. as result of human action (landscape planning)
3. as evolving construct (architecture).

Examples span space as

- received and prefabricated versus
 - final product of one's actions, namely:
1. spaces as the key notion for one's own science: everything that can be geo-referenced means GIS
 2. space as the product of human activity
 3. expanding space into state space: the entirety of possible situations is represented by the space of all "state vectors" which is suitable only if procedures are smooth.

The *main thesis* here is: the "effects of time" are *structurally similar* in many scientific disciplines, and they often imply "changes in structures" too. Information Technology (IT) is already providing scientific tools to visualise such structures.

⁵ datum (Latin): what is given (unquestionable)

5. How to map space and time?

The detailed picture: it is obvious that a choice must be made for *one* mode of representation and for *one* view of one scientific discipline:

1. (x, y, t): cartography, GIS (Fig. 7)
2. (x, y, z, t): geology
3. (x, y, z, v_x , v_y , v_z ; t): landslides
4. (x, y, z; biospheric attributes; t): ecology, tree-line modelling
5. (countries; economic attributes; GDP/cap) or (social attributes; structural shifts; elapsing evolutionary time): economic and social facts in the "Global Change Data Base"⁶ (Fig. 8)
6. perceiving rhythms and structures: (only) these are "worth recognising": music, architecture, fine arts.

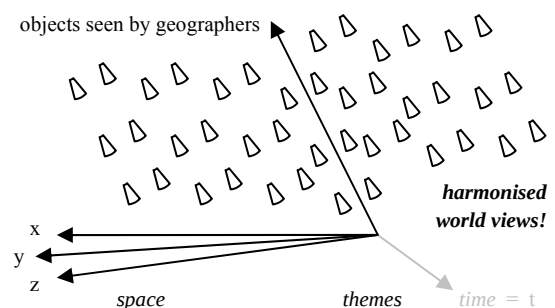


Figure 7: Harmonising world views: GIS reunites world views by relating everything to its location.

Different sciences may have considerably different outlooks on reality (Fig. 8). A humble attitude of recognising facts⁵ instead of believing in the theories one's own discipline offers can empower people to survive even in the midst of other scientific specialties: Galileo's (1632) spirit: give priority to observation, not to theories!

This is the essential advantage of geography as a science: geographers describe realities, just as they appear. Such a model-free concept of science has promoted the usefulness of GIS tools to people *independent of personal convictions*, scientific models or theories.

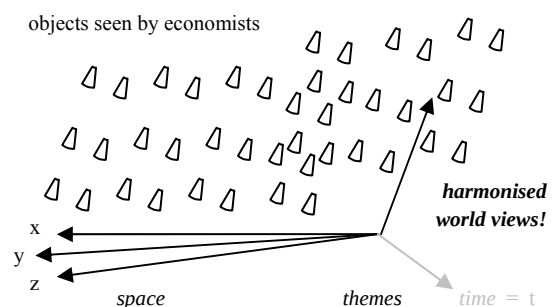


Figure 8: Different but again internally harmonised world views: explain facts from another angle.

⁶ This GCDB is described in Ahamer (2001)

6. What IT does, did, and could do

6.1 IT helps to *organise* the multitude of views (= perceptions) onto data that are generated by humans:

- IT constructs world views, such as: GIS, history, economics, geology, ecology etc.
- IT has already largely contributed to demolishing traditional limitations of space and time:
 - o Space: tele(-phone, -fax, -vision), virtual globes (Longley et al., 2001)
 - o Time: e-learning, asynchronous web-based communication, online film storage (Andrienko & Andrienko 2006).

6.2 This paper investigates non-classical modes of geo-representation.

We would like to point out that there are two already well-established fields that offer solutions to *mapping* (space and time, Fig. 9) views: Scientific and information visualisation are branches of computer graphics and user interface design which focus on presenting data to users, by means of interactive or animated digital images. The goal of this field⁷ is usually to improve the understanding of the data presented. If the data presented refers to human and physical environments, at geographic scales of measurement, then we talk about Geovisualisation, e.g. (MacEachren, Gahegan et al. 2004; Dykes, MacEachren et al. 2005, Dodge et al., 2008).

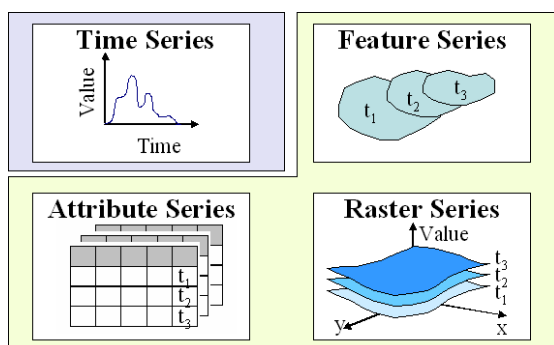


Figure 9: Time series and 3 spatio-temporal data types (<http://www.crrw.utexas.edu/gis/gishydro05/>).

6.3 IT could *develop tools* that are then interchangeable across scientific disciplines, e.g. landslides that may structurally resemble institutional and economic shifts (see 7.1).

IT could prompt scientists to also look at data structures from other disciplines.

Whatever the disciplines may be, the issues are structures and *structural change*!

7. Examples

The authors are members of the “Time and Space” project at their institution named “Geographic Information Science”⁸, a part of which explores the cognitive, social, and operational aspects of space & time in GIScience. This includes models of both social and physical space and consequences thereof for e.g. spatial analysis and spatial data infrastructures. We investigate how space and time are considered in these application areas, and how well the existing models of space and time meet their specified needs (see e.g. Fig. 9). This investigation is expected to identify gaps. Analysis of these gaps will result in improved or new spatio-temporal concepts particularly in support of the above mentioned application areas.

7.1 Sliding realities: geology

The notion of the path in geography (x, y, t) is extended by the z axis (see item 5.2) which produces a map of “time”: Fig. 9 (Zobl, 2009).

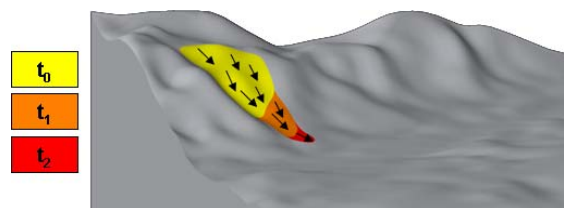


Figure 9: Geology takes the $(x, y, z; t)$ world view.

The “effect of time” is sliding (luckily in the *same* spatial dimensions x, y, z): we take the red axis in Fig. 10. Space itself is sufficiently characteristic for denoting the effects of time.

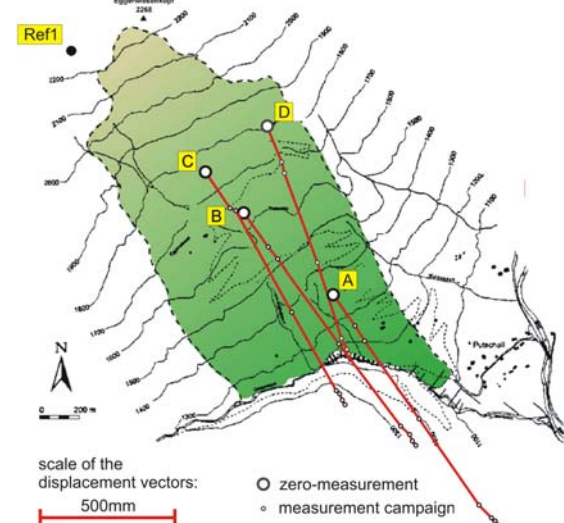


Figure 10: These effects of time occur in space, most helpfully. Source: Brunner et al. (2003).

⁷ http://en.wikipedia.org/wiki/Scientific_Visualization

⁸ The overarching aim of the GIScience Research Unit is to integrate the “G” into Information Sciences (GIScience, 2009)

7.2 Slices of realities: geology

Despite the lucky coincidence that the effect of time (Δx , Δy , Δz) occurs in the same space (x , y , z) we try to produce slides carrying more information (item 5.3) and hence recur to the so-called attributes mentioned in Fig. 9 such as grey shades or colours.

The speed of sliding ($d/dt x$, $d/dt y$, $d/dt z$) is denoted both by horizontal offsets and whitish colours in the spaghetti (Marschallinger, 2009) of Fig. 11.

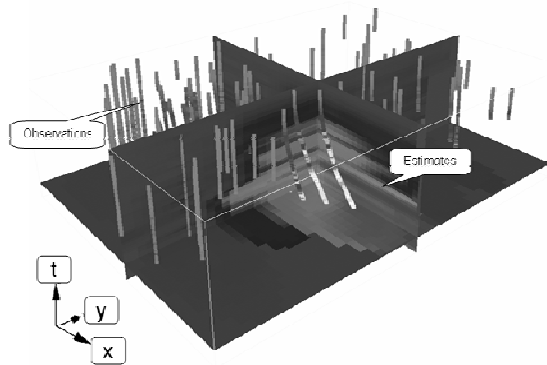


Figure 11: The (x , y , z ; v_x , v_y , v_z ; t) view of a landslide process (shades of grey mean speed v).

7.3 Slide shows

How to map spatial realities that are not any longer isotropic displacement vectors of space itself? For the example of changing tree lines in the Alps (Wallentin, 2009) a slide show is used to present the change of growth patterns made up of the multitude of individual agents (= trees = dots in Fig. 12). Moving spatial structures are depicted as a film of structures (item 5.4).

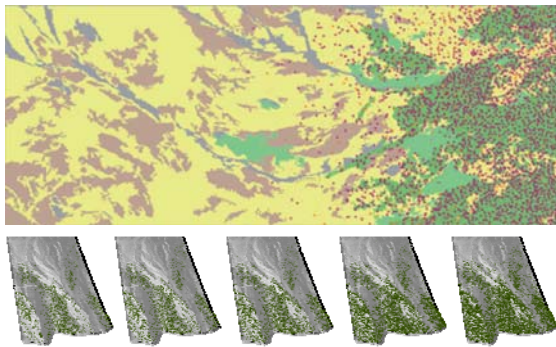


Figure 12: The (x , y , z ; biospheric attributes; t) view of the Alpine tree line (above) and its shift induced by climate change as a slide show (below).

In such processes which involve independent behaviour of autonomous agents (here: trees) it becomes seemingly difficult to apply a transformation of space itself, e.g. $d/dt(x, y, z)$.

7.5 Global deforestation

One key driver for global change is deforestation; easy to map as change of land use category of a given area (Fig. 13).

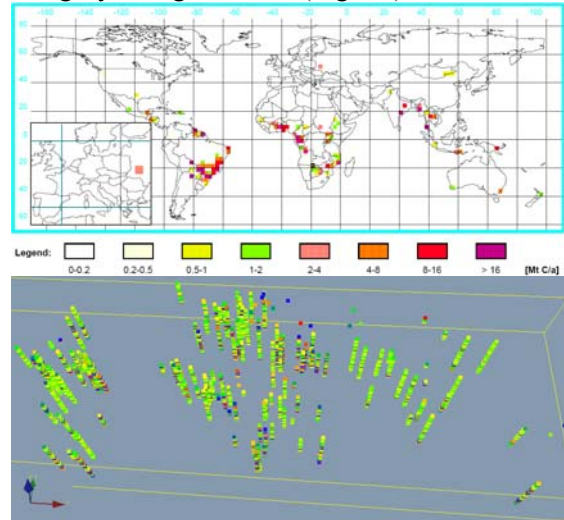


Figure 13: The (x , y , z ; Δ biospheric attributes; t): view of the global deforestation process in megatons carbon. Above: map of carbon flow, below: time series of GCDB data per nation symbolically geo-referenced by the location of their capitals.

This representation is analogous to Fig. 11. In both, the focus shifts from maps(t) $\rightarrow$ maps(t , Δt). Interest includes temporal dynamics: t = colour (above); Δt = height+colour (below), enriching the purely spatial interest.

Even if to the aim is to enlarge the scope of the information delivered from the static map (Fig. 13 above) to the “dynamic map” (Fig. 13 below), readers will remain unsatisfied because no insight into the dynamic properties of deforestation is provided (Fig. 18).

Increasingly, the viewer’s focus turns further from “facts” to “changes of facts”, to “relationships with driving parameters⁹” and to (complex social and political) “patterns¹⁰”.

7.6 Realities beyond slides

But what if the information belongs to the social or economic realm (Fig. 14)? How to depict economic levels, education or policies?

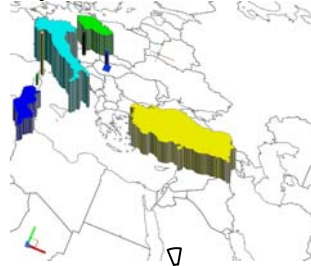


Figure 14:
Example for graphic notation: one (hypothesised) parameter per nation (seen across the Jordan = نهج الأردن).

⁹ see the suggested scenarios for water demand, water supply and water quality (Ahamer, 2008)

¹⁰ Patterns: name of the journal of the American Society for Cybernetics ASC

8. Transformation of coordinates

8.1 All the above examples have shown that

- various “spaces” can be thought of
- it would be suitable to enlarge the notion of “time”.

8.2 Suitably, a *transformation of coordinates* from time to “functional time” may be thought of.

8.3 In chapter 2, we suggested already to regard time as the substrate for procedures. Consequently, different “times” can be applied to different procedures. As an example, in theoretical physics, the notion of “Eigentime”¹¹ is common and means the system’s own time.

8.4 Similar to the fall line in the example of landslides in chapter 7.1 (red in Fig. 10) the direction of the functional time is the highest gradient of the envisaged process. This (any!) time axis is just a mental, cultural construction.

8.5 According to chapter 2 (Fig. 6) a clear understanding (mental model) is necessary to identify the main “effect of time”. We see that such an understanding can be culturally most diverse. Just consider the example of economic change:

- optimists think that the global income gap decreases with development
- pessimists believe that it increases, hampering global equity.

8.6 Therefore, any transformation of coordinates bears in itself the imponderability of complex social assumptions about future global development and includes a hypothesis on the global future.

8.7 Still, a very suitable transformation is

$$t \rightarrow \text{GDP/capita}$$

(Fig. 17) both because of good data availability and increased visibility of paths of development. GDP/cap resembles evolutionary time.

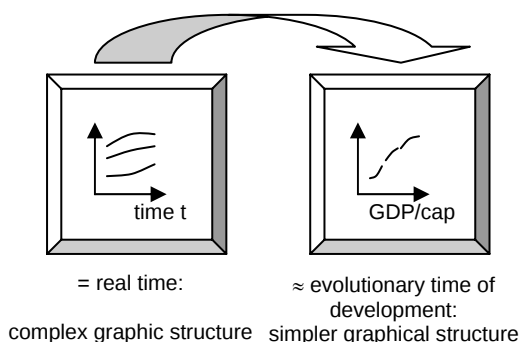


Figure 17: A suitable transformation of time uses the economic level, measured as GDP per capita.

¹¹ literally (German): the own time (of the system)

8.8 The strategic interest of such a transformation is “pattern recognition”, namely to perceive more easily structures in data of development processes. Examples for such “paths of development” are shown in Fig. 18 for the example of fuel shares in energy economics.

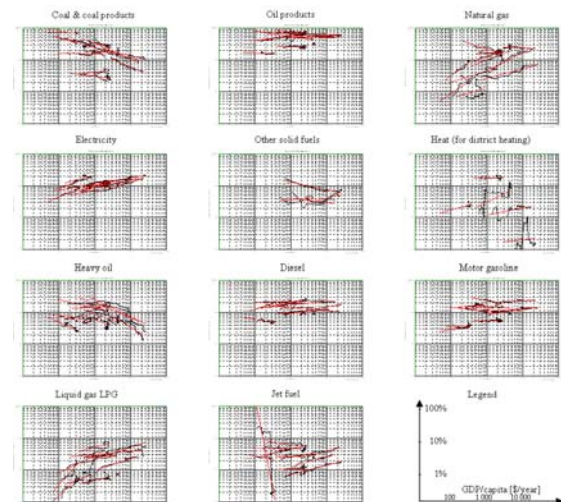


Figure 18: Structural shift of percentages of various fuels in all nations’ energy demand 1961-91. Data source: GCDB (Ahamer, 2001).

8.9 It is suggested here that implicitly during many mapping endeavours such transformation occurs. This is legitimate, but care must be taken to take into account the (silently) underlying model of human development.

8.10 Suitable transformation of coordinates can facilitate to see and communicate evolutionary structures, as it enables common views of humans and is therefore *helpful for global consensus building*.

8.11 Also the “effects of time” are projected into a common system of understanding which might give hope to facilitate common thinking independently of pre-conceived ideologies.

This plan creates the “common reference system of objects”.

8.12 This paper suggests enlarging the concept of

- “globally universal geo-referencing” (one of the legacies of IT)

to

- “globally universal view-referencing”
- or “globally universal referencing of perspectives”¹².

Fig. 19 illustrates this step symbolically.

¹² The facts themselves may well be delivered by endeavours such as Wikipedia but here it refers to the *perspective on facts*! A huge voluntarily generated database on people’s perceptions, views and opinions would be needed.

9. A futuristic vision

9.1 Building on the vision of “Digital Earth” (Gore, 1998), the deliberations in this paper might eventually lead to the vision of “Digital Awareness”: the common *perspective* on realities valid for the global population, aided by (geo)graphic means.

9.2 The primordial element of (human and societal) evolution is *consensus building*. Without ongoing creation of consensus global “evolutionary time” is likely to fall back.

The futuristic vision is to map global awareness.

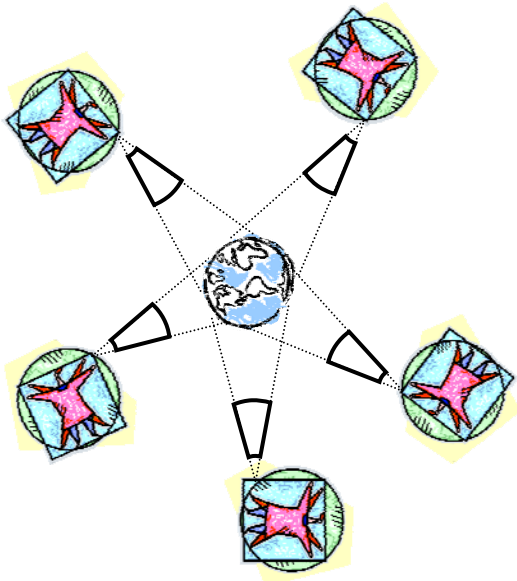


Figure 19: The global society perceives the world.

9.3 Much like the georeferenced satellites which circulate around the world produce a “Google, Virtual [or similar] Earth”, the individual spectators in Fig. 19 circle around the facts – and they create a “common virtual perception”: an

IIS = Interperspective Information System.

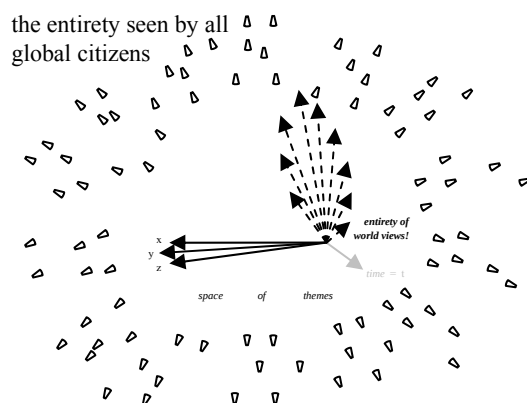


Figure 20: Divergent perceptions circulate around earthen realities. The entirety of world views creates the IIS (Interperspective Information System).

9.4 Do we just mean interdisciplinarity? No. Nor do we simply refer to people looking into any direction. Fig. 21 shows the difference to IIS.

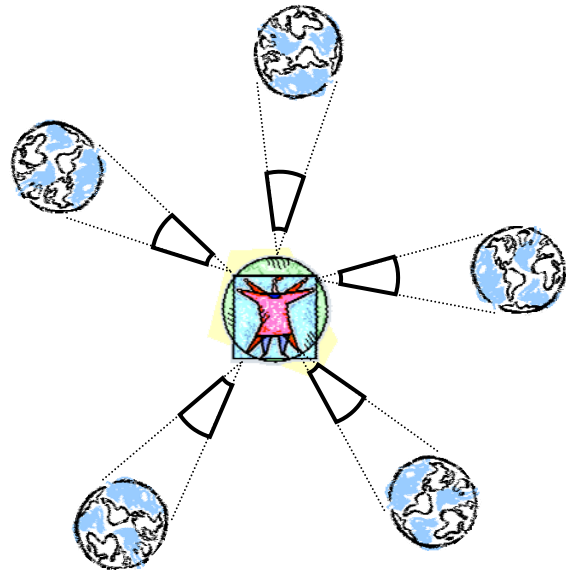


Figure 21: This is not IIS.

9.5 The science of the third millennium will allow dealing with a *multitude of world views and world perspectives* (see Tab. 1) with an emphasis on consensus building.

When learning, the emphasis lies on social learning and may also make use of *game-based learning* (such as the web-based negotiation game “Surfing Global Change”) which allows to experimentally experiment with world views without any risk involved.

Table 1: The science of the third millennium encompasses multiple perspectives

	element	interaction	perspective
single ones	Mechanics	Logics	Teaching
manifold	Thermo-dynamics	Systems analysis	Social learning gaming, IIS
	19 th cent.	20 th cent.	21 st cent.

9.6 A suitable peaceful “common effort¹³” for a peaceful future of humankind would involve developing tools and visual aids in order to understand the opinions of other citizens of the globe.

The future is dialogue.

Or else there will be no future.

¹³ جهاد (jihad in Arabic) also means: common effort of a society

10. Conclusion

Sciences are similar to “languages” spoken by people, they differ globally. Understanding for others’ languages is essential for global sustainable peace.

Human perceptions are also strongly influenced by underlying models, assumptions and preconceived understandings.

Studying geo-referenced data sets (GIS) can help to facilitate bridging interperceptual gaps.

For the transformation of world views – to make them understandable – it is necessary to know about

- the “effect of time”, namely the “path along the continuum of time” which a variable is expected to take
- the speakers’ underlying model of a complex techno-socio-economic nature
- the resulting perception of other humans.

A future task and purpose of IT could be to combine the multitude of (e.g. geo-referenced) data and to rearrange it in an easily understandable manner for the viewpoints and perspectives of another scientific discipline or just another human being. Such a system is called *Interperspective Information System IIS*.

Merging a multitude of perspectives to form a common view of the entire global population is the target of an IIS.

Symbolically, a “Google Earth”-like tool would eventually develop into a “Google World Perspective”-like tool, or a “Virtual Earth”-like tool would become a “Virtual Perspective” tool encompassing all (scientific, social, personal, political, etc.) views in an easily and graphically understandable manner.

In the above futuristic vision, IT can/should(!) become a tool to facilitate consensus finding. It can rearrange the same data for a new view.

Symbolically speaking: similar to Google Earth which allows one to view the same landscape from different angles, a future tool would help to navigate the world concepts, the world views and the world perspectives of the global population.

IT can reorganise extremely large data volumes (if technological growth rates continue) and could eventually share these according to the viewpoint of the viewer.

Such a step of generalisation would lead from “Geographic Information Science” to “*Interperspective Information Science*”, implying the change of angles of perception according to one’s own discipline.

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ⁱ GIScience goes way beyond this view of time and space (considering time as function) because it allows for much more complex queries and analyses.