

vizNET 2008 Intersections in Visualization Practices and Techniques: Loughborough University, 7-9 May 2008

A belated contribution relating to the final session of the workshop from Meurig Beynon, Computer Science, The University of Warwick

Intersections in Arts / Humanities and Science / Engineering

I was originally commissioned to chair a final session of the workshop devoted to the theme of intersections between visualisation research as practised in many disciplines. As it turned out, my role turned out to be rather similar to that of Charlie Drake's celebrated triangle player (1967), who counts his way through an entire orchestral performance waiting to play a single beat - only to miss his cue. To compensate for this, I've prepared the following short part note-form report, which contains some of the key ideas that I was intending to introduce for discussion at the time.

An extraordinary workshop!

As anyone who attended the workshop will be aware, an extraordinary range of research on visualisation was represented. There was exceptionally interesting work in visualisation across a whole spectrum spanning art, humanities, engineering and science, and for my part I found almost every example of visualisation persuasive in its own terms. The agenda for the second day of the workshop alone included such diverse themes as:

- *Web visualisation and game engine technicalities.*
- *Human and political content of the underwater visualisation case studies.*
- *Making sense of the Italian hospital from a single page of A4.*
- *Appreciating conjectural reconstructions of Roman architecture from excursions in Second Life.*
- *Making virtual gymnasts real, and vice versa.*
- *Making an interactive installation that purposively avoids a direct immediate intelligible correspondence between how the viewer acts and how the installation responds.*

The *Grand Challenges* sessions on the final day likewise covered a very wide range of issues of many different kinds. For instance, I noted concerns such as:

- **Strategic research goals:** collaboration with the broader community, across disciplines, and especially in relation to computer science
- **Creating environments for use:** improving usability, access to data, more intuitive scientific visualisation tools, practices and processes
- **Integration in practice:** means to combine data and tools developed from different perspectives
- **Dissemination and application:** placing visualisation in everyday society, harnessing the technology and appreciating its impact
- **Developing a conceptual framework:** finding holistic perspectives across disciplines, different kinds of perception, blending human and machine perspectives, the formal and informal
- **Technological developments:** exploiting - making developments in hardware and interface developments

With agendas of such breadth, there is a great danger of incoherence, and there was a clear theme running through the challenges that relates to the integrity of the research field. This motivates what I regard as a central question:

To what extent can we see visualisation as a coherent discipline?

It is to this question that I would like to respond in a personal way that (by way of acknowledgement and explanation) is intimately bound up with the concepts, principles and tools we have developed in Computer Science at Warwick in connection with the "Empirical Modelling" project - of which more at

<http://www.dcs.warwick.ac.uk/modelling>.

Relevant publications (as indexed on that website) are referenced in my account. Perhaps the primary publication of interest in this context is paper #103: "Visualisation using Empirical Modelling principles and tools", which reviews applications of Empirical Modelling to visualisation spanning many disciplines, and can give a useful impression of the qualities and limitations of such an approach.

What is the difficulty of giving integrity to visualisation across many disciplines?

The obstacles that concern me most were scarcely addressed in the workshop, and in my view reside

- in commonly accepted philosophies of science and - in particular -
- in computer science (with its vital role in visualisation).

Relevant issues in this context are

- the emphasis in much scientific visualisation ...
... where rules and methods apply, and where objects and theories exist (cf. #098)
- the paradigms for computer use to which computer science has led us
- the character of our metaphysics, as (for instance) based on traditional empiricism, or Kantian "transcendental realism"
- dualities in the two cultures (#082)
- the problems of constructivism (as discussed by Latour in his paper "The Promises of Constructivism", and reviewed from an EM perspective in #100)

The following notes (organised in the form of annotated slides for presentation) indicate how these issues relate to giving integrity to visualisation across many disciplines and include references to relevant content in talks presented at the workshop.

Characteristics of "(Computer) scientific visualisation" / 0

An important theme in scientific visualisation is *separating* the underlying application from the visualisation ... a standard "separation of concerns".

Common practice in computer science to make the distinction:

data + interpretation of data

and to draw attention to the hierarchical nature of computer representations, as in:

binary_content_of_machine_location integer room_number

This view of data and its representation supports a view of the visualisation process as comprising different phases (as illustrated for instance by Nick Avis in introducing RAVE):

input data filter map render

This distinguishes two broad kinds of activity: "extracting the data of interest" and "creating graphics". Such phased process views of visualisation support a potentially sharp separation of roles that is a positive advantage in certain applications (the person who supplies the data and the person who processes it for visualisation "*don't need to be friendly*" as Martin Turner says).

Leitmotif of (computer) scientific visualisation is "separation" ...

... this is not "wrong" - it is entirely appropriate in some contexts, but it is far too limited to apply in general, and needs to be complemented. For this purpose, it is helpful to consider ...

A fundamental change in philosophic outlook ...

Leitmotif of William James's **Radical Empiricism** is "conjunction". As explained in his "Essays in Radical Empiricism":

Conjunctions and separations are, at all events, co-ordinate phenomena which, if we take experiences at their face value, must be accounted equally real (p.51)

Knowledge of sensible realities ... comes to life inside the tissue of experience. It is made; and made by relations that unroll themselves in time. (p.57)

... *subjectivity and objectivity are affairs not of what an experience is aboriginally made of, but of its classification.* (p.141)

[Note the sharp contrast between James's position and Kant's *transcendental idealism*, the philosophical outlook that was mentioned by Tom Corby in his talk. The key point of difference concerns the status of objective reality. Where James associates objectivity with a classification of experience, Kant's accords a quite different status to outside reality. This is irreverently described in passing by Latour in his essay "The promises of constructivism", where he refers to

... the comical role of being-there-just-to-prove-that-one-is-not-an-idealist role invented by Kant and replayed over and over again by philosophers ... : things are there but play no role except that of mute guardians holding the sign, "We deny that we deny the existence of an outside reality".

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James's outlook is particularly significant for visualisation, since conjunction is such a fundamental characteristic of (visual) experience. This is in contrast to the outlook promoted by a computational view of mind ...

Characteristics of "(Computer) scientific visualisation" / 1

A slogan that is often used to coax computer science students into the right mindset for writing a computer program or making a database is: "The computer is only good for representing logic".

This perspective is definitely unhelpful when taking the whole range of discipline and needs for visualisation into account. This was forcefully brought out by Stuart Dunn in his discussion of visualisation in archaeology. He quoted a Southampton rapporteur at a workshop, as saying:

"You can't take control of a disciplinary vocabulary and impose it on other researchers. We are not all logicians. I am certainly not a logicist, and never will be."

*"You shouldn't even **try** to formalise vocabularies."*

There is an endorsement for this suspicion of formalisation of vocabulary in William James: *"The truth is that neither the elements of fact nor the meanings of our words are separable as the words are"*.

Recognising the limitations of formal interpretations of language is part of a vital shift of perspective needed to achieve the integration to which Dunn alluded later in his talk:

- of space and time
- of multiple and heterogeneous data sets

Characteristics of "(Computer) scientific visualisation" / 2

The privileged status accorded to formal languages and interpretations in classical computer science has important consequences for how visualisation is regarded. Visualisation is seen as:

- a secondary rather a primary source of knowledge - computer science leads us to consider the experiential aspects of computer-based artefacts *post-conceptualisation*
- as a second-class citizen in the discipline of computing: algorithms are the essence and perceptualisations are the ephemera (e.g. being technology dependent, under continuous development, "merely" externalising).

... yet, as Richard Hamming (cited by Roy Kalawsky) observes: "the purpose of computing is insight, not numbers", whilst Tom Corby aspires to give much greater authority to the 'felt experience'.

The priorities of traditional computer science reflect a deeply entrenched philosophical stance to which William James draws specific attention. James (p.238) quotes Kierkegaard's assertion to the effect that:

"We live forwards, but we understand backwards"

- giving priority to the intellectual analytic processes that make sense of our world ... to which William James responds:

"Understanding backwards is, it must be confessed, a very frequent weakness of philosophers, both of the rationalistic and of the ordinary empiricist type. Radical empiricism alone insists on understanding forwards also, and refuses to substitute static concepts of the understanding for the transitions in our moving life."

Making sense of commonality across disciplines ...

The theme proposed for this final session of the workshop on visualisation concerned "intersections in Arts / Humanities and Science / Engineering". The phrase "intersection in X and Y" makes mathematical sense for sets of elements of the same type, prompting the question:

"Where is the intersection / are the commonalities between visualisation activities across domains?"

- a similar question to Julie Tolmie's:

"What is visualisation-related research in your area?"

The crux of commonality in visualisation is in the nature of the sense-making activities that are involved, for which the stance on "understanding" is a most important factor ...

.. as Tolmie observes, this criterion suggests bonds that link individuals, but not necessarily disciplines. For instance, such bonds exist between the

mystic artist / ignorant enquiring scientist / radical designer / speculative humanist

In this respect - though they are practising computer art - Tom Corby and Gavin Baily, with their exploitation of the algorithmic and their distrust of the post-modern, are perhaps closer to the traditional computer scientist's viewpoint than Gordana Novakovic or even than Fred Yeardon, whose explorations of gymnasts in VR are potentially vulnerable to misrepresentation and meaninglessness (cf. Yeardon's observation concerning the visualisation of the gymnast's interaction with the trampoline: *"the bounce is a fudge"*).

Computer science likes to claim for its discipline a particular affinity to mathematics because of its roots in formalism. This stance tends to distance scientific visualisation from the kinds of human-centred practices that characterise some applications of visualisation that are represented in all disciplines, the humanities and arts, engineering and science. To get a less partial picture of the relationship between computing and mathematics, it is helpful to recognise that mathematicians themselves do not necessarily or typically see themselves as formalists.

[For instance, from the flyleaf of William Byers's "How Mathematicians Think":

To many outsiders, mathematicians appear to think like computers, grimly grinding away with a strict formal logic and moving methodically - even algorithmically - from one black-and-white deduction to another. Yet mathematicians often describe their most important breakthroughs as creative, intuitive responses to ambiguity, contradiction and paradox. ... mathematics is a profoundly creative activity ...

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From that perspective, visualisation is intimately linked to the authentic spirit of mathematics, emphasising

human construction and appreciation of persuasive argument

rather than the familiar parody of mathematics as pure logic and reason.

In the appreciation of mathematics, contemplating a beautiful ingenious rule-based behaviour has its place, BUT

- the engagement involved in mathematical proof
- the interaction that is involved in the construction of meaning

are of the essence. This involves making perceptible the knowledge and the process that convinces the mathematician of the truth of a theorem, both with a view to gaining personal assurance about its truth, and communicating that understanding to another mathematician.

The kind of activity that is involved in discovering and presenting a mathematical proof has its counterpart in

what Hugh Denard calls "*intellectual transparency*" in creating visualisations for the humanities. The character of the personal conviction and the demonstration differ in so far as the humanist cannot expect to banish ambiguity, contradiction and paradox to the same degree that a mathematician might, but in other respects the role played by creating artefacts to expose intuitions and arguments to scrutiny is similar.

The above discussion sets the scene for ...

An alternative perspective on visualisation ...

Visualisation can have a different character and serves different purposes in different disciplines. For instance, a visualisation may or may not have an aesthetic or explanatory purpose, and there may or may not be an external referent for a visual artefact (as in e.g. representational art, models in the humanities, engineering models, visualising a natural phenomenon). There is not always a sharp distinction between one kind of visualisation and another. In some applications, the same instance of visualisation can serve different roles as the sense-making activity proceeds (cf. Kant's notions of "purposiveness and purpose" cited by Corby).

In developing visual artefacts using the computer, it is helpful to distinguish four different varieties:

artefact - construal - model - program

- **artefact:** build visualisation for the sake of the experience it offers.
- **construal:** associate experience offered by artefact with something to which it refers ... understanding of this referent is expressed implicitly through the correspondence between interactions with the artefact and with its referent [cf. David Gooding's definition of the term 'construal' in his book "Experiment and the Making of Meaning"]
 - ... at this stage, may identify observables, dependencies, agency, but
 - observational framework is still embryonic, insecure
 - interpretation is still fluid and uncertain
 - ... kinds of uncertainty
 - what is recognisably reliable and reproducible?
 - what is significant in the present context?
 - what is an error in measurement vs a conceptual problem?
 - limits in skill in measurement of established observable
 - ... different construals are being explored and interpretations negotiated
- **model:** make an artefact - and develop an associated stable context for interaction - for which there is a close correspondence between specific families of observables and observables in a referent: and potentially optimise for these.
- **program:** circumscribe interaction with a model to serve a specific set of operational functions for specific "*users*": and typically (and *characteristically* from the perspective of classical computer science) optimise and customise to their agendas.

A fundamental issue ...

Conventional programming and the conceptual framework of classical computer science does not give appropriate support for this kind of visualisation because it *relies* on understanding backwards ...

... compare

modelling as distilling key observables, capturing the simplified conception

with

exploration aimed at *identifying* key observables, exploring the unbounded subtlety of experience

cf. the danger of underestimating the importance for the engineer's of "an intuitive feel for the incalculable

complexity of engineering practice in the real world." as identified by Eugene S Ferguson in *Engineering and the Mind's Eye*.

Visualisation reveals its true essence through maintaining conjunction, which (except perhaps when visualising a process rather than a state) is most easily apprehended when the computational mechanism is no longer explicit - cf. Martin Turner's demonstration at the ShowCase of programming of the GeoWall, with its "hidden / implicit recompiling" of the script.

This is the motivating idea behind *Empirical Modelling* - a methodology for modelling with dependency that aspires to directly support the creation of "one experience that knows another".

BUT ... to deliver to their potential, EM principles and tools needs to attract the wider interest, adoption and critique that a broader community affords.

At present, the technical quality of the visualisation that can be realised using EM tools is nothing like as impressive as what was demonstrated in this workshop. EM artefacts typically have more in common with preliminary sketches and exploratory designs than finished products. Their unusual qualities relate to their openness to diverse interactions and interpretations. Concepts such as dependency do feature prominently in effective visualisations and have some support from existing mainstream visualisation tools, but they are not well-matched to traditional thinking about programming computers. EM concepts are much better suited to the objectives of giving integrity to visualisation as an inter-disciplinary activity.

References

Talks at the workshop

- Tom Corby and Gavin Baily: Information Aesthetics: Data Visualisation as Art
- Hugh Denard: Recent developments in the Humanities Visualisation
- Fred Yeardon: Visualisation in Sports Science
- Gordana Novakovic: Visualisation in the Arts
- John O'Brien and Nick Avis: Web-based visualisation and grid-based visualisation
- Stuart Dunn: Combining the real world and abstract visualisation
- Julie Tolmie: Intersections in visualisations practice

Papers etc

- William Byers, *How Mathematicians Think: Using Ambiguity, Contradiction, and Paradox to Create Mathematics*, Princeton University Press, 2007
- Charlie Drake, 1812 Overture (but no triangle alas!) at <http://uktv.co.uk/gold/video/aid/604532/searchArea/971/sr/49/csl/2/cst/home/mf/video/sb/recent>
- David Gooding, *Experiment and the Making of Meaning*, Kluwer 1990
- William James, *Essays in Radical Empiricism*, Bison Books, 1996
- Bruno Latour, The Promises of Constructivism, in Ihde, D. (ed.) *Chasing Technoscience: Matrix of Materiality*, 2006, 27-46

Empirical Modelling sources

- EM website at <http://www.dcs.warwick.ac.uk/modelling/>
 - Meurig Beynon, Visualisation using EM principles and tools, <http://www2.warwick.ac.uk/fac/sci/dcs/research/em/publications/papers/103/>
 - Other EM publications at <http://www2.warwick.ac.uk/fac/sci/dcs/research/em/publications/>
 - The Web EDEN modelling tool at <http://weden.dcs.warwick.ac.uk/>
 - Some introductory workshops illustrating the use of Web EDEN at <http://www.dcs.warwick.ac.uk/~wmb/sudokuExperience/workshops/>
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