Scientific images and visualisations in Digital Age. From Science to Journalism[1]

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Abstract: Science imaging and visualization *(SIV) studies how visual knowledge is produced, what is the role of the image in creating science knowledge and how images diffuse into nonacademic environments. SIVis also analyzing the intersections of different forms of (visual) knowledge.*
Analytic journalism is form of journalism that uses cognitive, visual and storytelling techniques. It aims at explaining and creating meaning on an issue or phenomenon.This type of journalism is not simply trying to communicate science, but to produce knowledge byretrieving and analyzing disparate information and constructing a critical discourse towards otherarguments and explanations.
Digital data is identified, retrieved, analyzed and communicated via a variety of media. This paper'spurpose is to examine how several data visualization tools produce knowledge and to what extent they succeed to offer appropriate and reliable tools to present data from various fields.

Keywords: *analytic journalism, digital revolution, scientific imagingand visualisation, science communication*

Digital revolution and science communication

Most of the newly produced data is stored in a digital form. A study conducted by Lyman & Varian (2003, University of California – Berkley) shows that 92% of

1 This paper was supported by the European Social Fund in Romania, under the responsibility of the Managing Authority for the Sectorial Operational Programme for Human Resources Development 2007-2013, POSDRU/89/1.5/S/63663 -„Rețea transnațională de management integrat al cercetării postdoctorale în domeniul Comunicarea Științei. Construcție instituțională (şcoală postodoctorală) şi program de burse (CommScie)".

all information (audio, video,print) produced world-wide in 2003 was originally in digital format. The same source estimates that almost 800 MB of recorded information is produced per person each year (it would take about 9 meters of books to store the equivalent of 800 MB of information on paper). "Remember, it's not knowledge, just data." cautioned prof. Lyman. "It takes thoughtful people using smart technologies to figure out how to make sense of all this information."

The 21st century'sdigital information revolution provides unique opportunities for information identification, retrieval, analyse and communication: a critical mass of digital data is available; analytic and computing power is diverse and cheap; powerful and easy to operate softwares are at hand.

Lenoir (2002:28) is emphasising on digital revolution's impact on the human existence: „Media inscribe our situation. We are becoming immersed in a growing repertoire of computerbasedmedia for creating, distributing, and interacting with digitized versions of the world [...] In numerous areas of our dailyactivities, we are witnessing a drive toward the fusion of digital and physical reality".

There were dramatic changes both in the **information environment** and in the way how modern societies relate to data. This information environment, called **datasphere[2],** has adouble meaning (Johnson & Ross, 2001): firstly, it definesthat conceptual environment **where all data exists in all forms and all media** (history, news, demographics, economy, laws, entertainment); secondly, it reffers to that conceptual environment **where all information-processing species reside**. Furthermore, four major trends in dynamic datasphere could be identified: the definition of literacy expands; the transparency of governments, NGOs and corporations expands at a global level; the data acquisition power shifts to individuals and data indexes emerge.

Information web resources are presented in various forms: Web-accessible databases; digital libraries; virtual research instruments; virtual reality objects; simulations; multi-sited games; Web surveys; videoconferencing; search engines; crawlers[3]; network analysis tools; Web pages; Web site analysis; Wikipedia; Weblogs; Weblog analysis software; maps and map overlays; GoogleEarth; GIS (Geographical Information Systems[4]); semantic Web structures; portals; e-maillists; multimedia

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2 **Dataspheres**, or **Data-Sphere**, were modules that could be used to hold and retrieve data. They were used by Haninum Tyk Rhinann during his hunt for Jax Pavan. Here the term is employed in reference to the information medium characteristic to the new technologies.

3 **Web crawler** is a computer program that browses the World Wide Web in a methodical, automated manner or in an orderly fashion.

4 **Geographical Information Systems (GIS)** combine several layers of information about a location. It is not only about making a map, it is about analyzing often large sets of data to generate information – hypotheses, conclusions, insights, new hunches – about widely varied socio-economic phenomena. Maps are one unique aspect/artifact of the methodology.

publications; traditional publications as pdf files; history repositories;on-line digitized collections; clinical trial databases; specializeddatabases of annotated and standardized raw research data; ontologies; monitoring systems logging every action incyberspace; podcasts etc.

Digital revolution is radically influencing all domains of the human activity, changing the users' behavior, either they are simple consumersor scientists. There are new ways of approaching the science and they go along with the traditional ways of carring out a research. U.K. Research Councils launched in 2001 the E-Science program: "What is meant by e-Science? In the future, e-Science will refer to the large scale science that will increasingly be carried out through distributed global collaborations enabled by the Internet.Typically, a feature of such collaborative scientific enterprises is that they will require access to very large data collections, very large scale computing resources and high performance visualisation back to the individual user scientists."These changes will have indirect consequences on the research, which will be essentially modified in three ways: methodologies, work modes and representation (Nentwich, 2003:64). The media – methodology interaction is a complex issue and it should not be reduced to the simple assertion that "new media demand new research methods". A crucial distinction in the clasical analytic framework seems undermined in digital media: the distinction between epistemic object and experimental system. (The Virtual Knowledge Studio, 2008:339)

All these changes produced in the digital media influenced the retrieval, selection, processing and representation of the data. Not only the scientific community was affected. Journalism seized this new opportunity and addapted itself.

Analytic journalism (AJ)

Journalism quickly reacted to the digital revolution that challenged the traditional journalistic process (RRAW: research – reporting – analysis – writing). Therefore, a new phase emerged, that of **producing** information (RRAW + P process). Computer assisted reporting (CAR) challenges journalists to acquire or even create digital data sets and to learn how to use new knowledge/analysis tools (spreadsheets, Database files – DBF, simple stats, Geographic Information Systems – GIS.

AJ is a form of journalism that uses cognitive, visual and storytelling techniques. It aims at explaining and creating meaning on an issue or phenomenon. This type of journalism is not simply trying to communicate facts, but to produce knowledge by retrieving and analyzing disparate information and constructing a critical discourse towards other arguments and explanations.

Analytic journalism in Digital Age retrieve and adapt methodologies from other disciplines, such as DataMining, Accounting, Biology, Anthropology, Geography etc. Similarly, analytic journalism borrowed methodologies from epidemiology, crime analytics, enviro-sciences, cyperspace, mapping of concepts;computational linguistics, forensic accounting, visual statistics and complex adaptive systems.

Therefore, we may say that analytic journalism came as an answer to this new information environment and to the way how modern societies relate to data and information.Analytic journalismis meant to be a symbiosis between the scholar's ways of seeing and knowing social phenomena and the journalist's skills in interpreting and explaining those findings in a compelling way to the general public.

Succesful analytic journalism relies on four variables: framing the appropriate question; finding and retrieving the appropriate data; using the appropriate analytic tools and showing the output with story-appropriate media (Johnson &Ross, 2001).

Analytic journalism products contextualize the subject by describing its background, historical details and statistical data. The result is a comprehensive explanation, intended to shape the audience's perception of the phenomenon. AJ collects disparate data,tries to make connections that are not evident and compares different data sets, offering arguments and explanations. Thus, analytic journalists attempt to give a deeper understanding of an issue.

There are several information and analytic tools that journalists must know (Johnson & Ross, 2001): *General Systems Theory; Statistical Analysis; Simulation Theory and Graphic Presentation*.

General Systems Theory is used to describe the variables in any system – social, mechanical, economic etc.; the relationships between those variables; the boundaries of the system at hand and; the goals of that system.

Statistical Analysis is often the fundamental, initial tool to describe phenomena in a systematic manner (it ranges from simply counting to correlations, regressions and multi-variant analysis).

Simulation Theory is used to describe a broad range of tools for inquiry ranging from game theory on to Chaos Theory and Complexity Studies to role-playing computer games.

Graphic Presentation of statistical and geographical data, sometimes coupled with what has come to be known as "exploratory data analysis," is only one of many routes toward recognizing phenomena and explaining relationships.

Analytic journalism dwell on a complex process, during which digital data is identified, retrieved, analysed and communicated through a variety of media.

Image creation and data visualisations preoccupies both analytic journalists and scientists and therefore an insight is necessary.

Scientific images and visualisations

Images are inextricable from the daily practices of science, knowledge representation, and dissemination. Diagrams, maps, graphs, tables, drawings, illustrations, photographs, simulations, and computer visualizations are used in everyday scientific work and publications. Furthermore, scientific images are increasingly traveling outside the laboratories and entering news magazines, courtrooms, and media. Burri & Dumit (2008:297) consider that today, we live in a visual culture, which also values numbers and science. Scientific images rely on these cultural preferences to create persuasive representations.

Scientific imagining and visualisation (SIV)follows the life of images from a social perspective and includes the study of both imaging practice and the performanceof scientific imagery paying a particular attention to its visual power and persuasiveness. SIV explores the trajectoriesof scientific images from their production and reading through their diffusion, deployment, and adoption in different social worlds to their incorporation into the lives and identities of individuals, groups, and institutions.

If most of the people accept that seeing is believing, Burri & Dumit (2008:300) consider that SIV should demonstrate how image production and use,seen as parts of scientific truth construction process, are confirming this aphorism.

When analysingimage/visualisation *production*, Science and Technology Studies examine how and by whom images are constructed by analyzing the practices, methods, technology, actors, and networks involved in the making of an image. With computer visualisations, a great number of new specialties have appeared: simulation modelers, programmers, interface designers, and graphic designers.

Engagement analysisfocuses on the instrumental role of images in the production of scientific knowledge.

DataMining techniques, qualitative visual selections and quantitative formulas are used to generate different types of images. These visualisations (often called models, hypothesis, maps or simulations) are interactive and their life is very short due to the fact that the researchers constantly intervine on them, modifying their parameters, changing their color scales, and subtituting algorithms. Lynch & Edgerton (1988) consider that the aim of these changes is to invest data with semnification and to transform it in knowledge. In this construction process, the image is modified following both aestetical and scientific conventions, in order to be coherently received by the public.

The analysis of scientific visualisations' deployment in different social milieus deals with the way how images diffuse in nonacademic environments and analyzes the intersections of different forms of visual knowledge. Outside the laboratoires, scientific images and visalisations meet visual products of science, arts, mass culture and digital media. Together they create meaning and generate significante for the public. Martin (in Burri & Dumit, 2008:305) explains how the graphs and abstract images operate within codes that tell "very concrete stories rooted in our particular form of social hierarchy and control. Usually we do not hear the story, we hear the 'facts', and this is part of what makes science so powerful".

When discussing the meaning creation process, Arnheim (1969:153) emphasises on the relationship between two processes that contribute to knowledge construction: "perception consists in the grasping of relevant generic features of the object [...] thinking, in order to have something to think about, must be based on images of the world in which we live". Thus, thought elements in perceptions and perceptual elements in thought are complementary, making the human cognition a unitary process, which leads from the elementary acquisition of sensory information to the most generic theoretical ideas.

Digital media bring scientific images and visualisations into the everyday practice of the users, whether they are educated scientists or lay public. But the visual knowledge creates shred meanings only when the producers and the recievers of the message use the same codes.

Graphic presentation of the data

Images allow complex ideas to be communicated with clarity, precision and efficiency. Edward Tufte (1997) spent a career in identifying the best modalities to convey a complex message to an audience through a scientific graphor visualisation.

Tufte, in *The Visual Display of Quantitative Information* (2001) proposed a set of general rules that graphical displays should obey: to show the data, to induce the viewer to think about the substance rather than about methodology, graphic design or technology of graphic production, to avoid distorting what the data have to say, to present many numbers in small space, to encourage the eye to compare different pieces of data, and to reveal the data at several levels of detail.

A similar work - *The Wall Street Journal Guide to Information Graphics* -was carry out by Wong (2010). The author brings arguments and offers advices regarding the graphic presentation of the data. Bar charts should show data following a decreasing pattern, and a specific bar should be marked using a darker tone. The pie charts the producer should bear in mind that the eye is scaning the image clockwise and from top to down. Therefore one should never place the slices from the small ones to the bigger, nor to use more than five slices in one pie chart graph.

The production of graphical representations that allow the viewer to analyse huge data sets is not anymore depending on expensive computers and sofwares that can be afforded only by research laboratories. These tools become more and more affordable and one can use performant freewares.

Data visualisation tools

In order to better understand how data visualizations work and how can they convey information, we will analyse several free applications used to visualize large data sets retrieved from the www.

Newsmap[5] is an application that visually reflects the constantly changing landscape of the GoogleNews aggregator. Its objective is to divide information into quickly recognizable bands which, when presented together, reveal underlying patterns in news reporting across cultures. It also reveals the relationship between data and unseen patterns in news media and some patterns of different journalism

5 http://newsmap.jp/

cultures (emphasis on a subject, the balance between hardnews and softnews). Newsmap application got in 2004the Prix Ars Electronica.

WikiMindMap6is a tool to browse easily and efficiently in wiki content. It was inspired by the mind map technique. Its objective is to support users to get a good structured and easy understandable overview of the topic they are looking for.

Fig. 1. *Newsmap*: Graphic representation of the global news map (May 31, 2012).

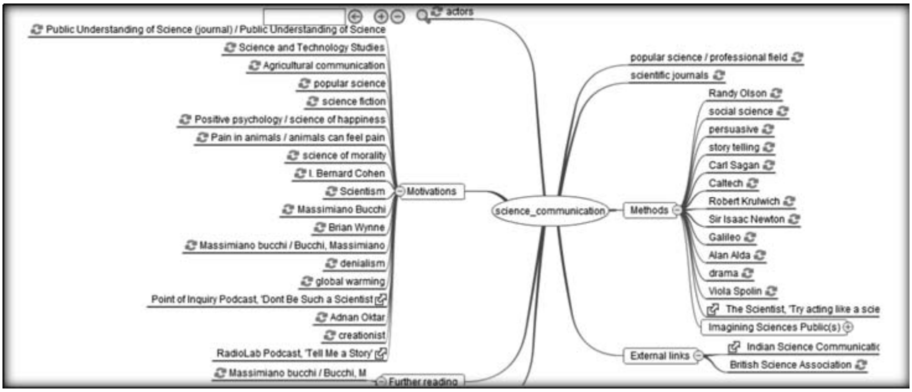

Fig. 2. WikiMindMap: Graphic representation of the *science communication* concept.

Akamai Real-time Web-monitor[7]offers areal time overview on the global internet conditions. The application identifies the global regions with the greatest attack traffic, cities with the slowest web connections (latency) and geographic areas with the most web traffic (web density). It allows the user to make inferences on how the web activity was pertubed by specific political, social, economical events.

6 http://www.wikimindmap.org/
7 http://www.akamai.com/dv1

Fig. 3. *Akamai Real-time Web-monitor*: Graphic representation of the internet attacks areas (June 9, 2012).

Analytic visual products

Scientists and analytic journalists use a wide range of computer programs in order to produce visual knowledge and the result are very diverese. We will analyse only two visual products, which we consider to be semnificant.

How scientific paradigms relate[8] is a giant chart originally published in *Nature* review, then in *Discover Magazine, SEED and Geo* etc. The image is mapping the relationships among scientific paradigms and it was constructed sorting around 800.000 published papers into 776 different scientific paradigms and it is based on how often the papers were cited together by authors of other papers. The graphical presentation was improved by the author during the time: attention distracting lines were eliminated, dots representing single papers were deleted, the explanations were made more discreteto not compete with the nodes.

8 http://wbpaley.com/brad/mapOfScience/

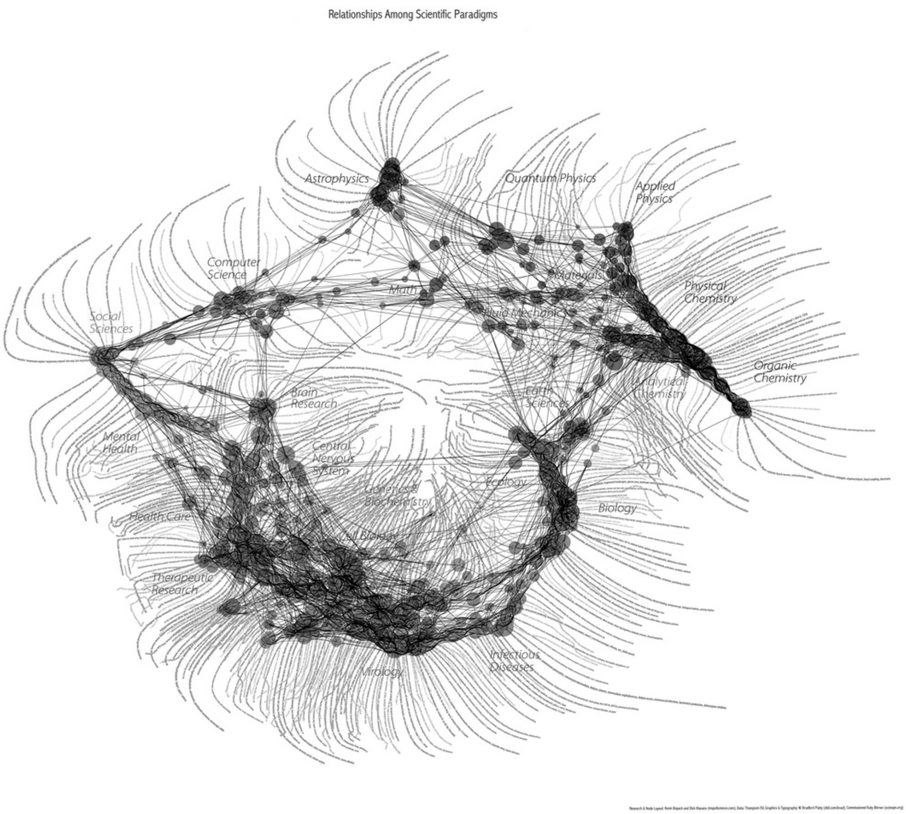

Fig. 4. *How scientific paradigms relate*

Remixing Rosling[9]is a graph that was published in *Think Quarterly Magazine* as visual supportfor the interview with swedish medicine doctor and statistician Hans Rosling. It that combines in a static version two different types of demographic data (fertility and life expectancy). The inspiration source were the animantes graphs produced by another interesting application, Gapminder[10]. Circles' diameters are scaled according to the years and interlacing them induces the idea of movement and time evolution.

Conclusions

Digital revolution imposed new standards both in research methodology and science communication. Scientists and professional communicators are more and more preoccupied by transmitting knowledge in an accessible and even persuasive visual form.

9 http://moritz.stefaner.eu/projects/remixing-rosling/

10 http://www.gapminder.org/

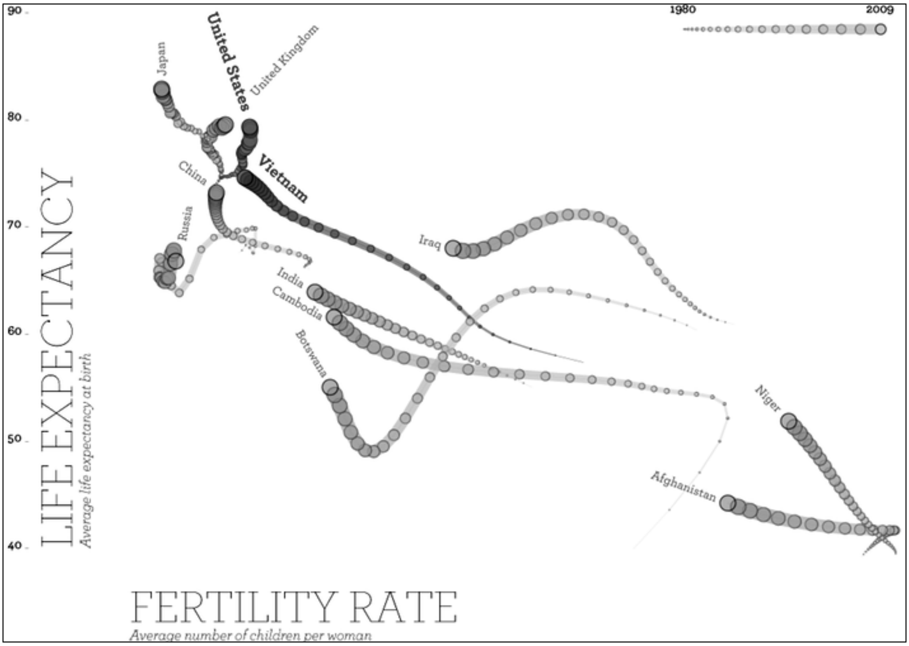

Fig. 5. *Remixing Rosling*

Analytic journalism exceeds the boundaries of traditional journalism and adopts methodologies from other disciplines, using analytical instruments featured for media visual products (*NewsViz, InfoViz, and DataViz*).

Knowledge communication through visual instruments is challenge for both e-scientists and analytic journalists, because we live in a visual culture that values both numbers and science.Effective science communication should adapt to these cultural preferences and provide eye-catching scientific visualisations.

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