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Too Big To See: The Need for Design Strategies to Visualize Multiple Spatiotemporal Datasets

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Abstract

Tracking software paired with 3D modeling now provides animations of movement in nearly every context of our highly sensed world. However, few visualizations exist that show adjacent systems, usually because of wildly divergent data. One such spatiotemporal adjacency is crucial to our safety – our increasingly cluttered skies rapidly filling with drones, budget airlines, helicopters, weather collection sensors and Asian satellites. The scale, number, tiered altitudes and variant speeds of aerial hardware are a physical reality that can only be understood through the moving image. However, no visual model exists to reveal all the machines when stratified causing our culture to lack an understanding of the expanding system. Can stratified aerial traffic be represented through a hybrid of informative data visualization and evocative information arts? What are semiotic strategies and taxonomic delineations that can merge into a visual language understandable across the growing number of cultures now involved in aerial movement and its dangers? This paper will present a creative context to explore visual strategies for better cognitive and perceptual understanding of multi-tiered, spatiotemporal data. Creative design tools will provide insight into finding meaning in dynamic data and may lead to advances in understanding other sets of Big Data.

Keywords

4D Data Visualization; Information Arts; Strategic Design; Spatiotemporal Semiotics.

Introduction

With multiple launches across several nations, Asia's aggressive entry into the space race is quickly adding to the proliferation of hardware in each layer of airspace. The systems above require great cultural, economic, and political coordination yet there seems to be no singular control. In addition, they are separately represented through disparate spatiotemporal animations that are becoming increasingly important as tools of prediction. Individual aeronautic and aerospace software only visualize the assets within their industry, treating altitude layers as lanes of traffic.

As early as 1978, NASA predicted that satellite collisions would increase the amount of debris to a point where a permanent junk belt around the earth could make space flight too dangerous. The invisible borders between altitudes are disappearing and 2009 marked the first space disaster caused by sheer numbers as two communications satellites collided, scattering deadly debris across low earth orbit. Weapons to destroy surveillance satellites were deployed by China in 2007 and 2010, creating debris that classify as the planet's largest environmental disaster and causing further collisions. Current spatiotemporal tracking visualizations failed to predict any of these occurrences. An improved visual model of aerial strata movement is crucial for safety, public understanding, global policy, environmental discussion, artistic resource, and political and economic clarity.

Starting From The Ground Up

Although these animation models can be perceived as technical or scientific visualization, they also closely tie to digital humanities as the resulting tools are often used to inform in cultural and social contexts. The social impact of this design problem can be seen in the ugly racist slurs towards the Chinese in the comments section on NASA's space debris visualization on YouTube. [1] An effective visualization can enhance a cross-culturally shared understanding of aerospace utilization. Finding a solution is both challenging and beneficial due to its interdisciplinary approach but it must begin by looking at research trajectories through data visualization, motion graphics, information arts, big data, art+sci collaborations and media philosophy.

In Data Visualization

Cartography has stretched to consider 4D data visualization semiotics from many perspectives including perceptual psychology, effective design and color strategy, interactivity, and realism vs. abstraction. Temporal visualizations within cartography were pioneered in the 1960's with the work of Torsten Hägerstrand who developed a time-based model for understanding human migration. Hagerstrand's space-time path illustrated navigation through an environment in a new way and affected the development of geographic information systems that visualize movement data. More recent researchers expanding the diversity of ways to present complex spatiotemporal datasets for better understanding include Menno-Jan Kraak and laboratories and research centers like The Bartlett Center for Advanced

Spatial Analysis at UCL and MIT's Senseable City Lab which both focus on large scale temporal visualizations in mostly urban contexts.

Research in computer graphics has focused on generating increasingly realistic displays; the successful abstraction found and accepted in cartography pre-computer has not carried over to the computer age. Recent research suggests however, that we are beginning to see a return to symbolization systems and map-type taxonomies. The deluge of temporal data and advances in technology are allowing for more thematic portrayals. In addition, the modes of design - color, font, layout, metaphor – are recognized to have distinct cultural meaning in data visualization. These cultural implications appear in the research of Mei-Po Kwan who juxtaposes visualization strategies of temporal datasets created in China and the U.S. She highlights the differences between Eastern/Western visualizations, stating that "Chinese and U.S. terminology and approaches to space and time concepts and their integration in GIScience research draw from distinct deeply established cultural, historical, religious, and scientific traditions and foundations." [2] She argues that we must find a shared language regarding complex concepts related to space-time integration research.

Information sets that are too large and complex for database management tools to negotiate is appearing in nearly every discipline. In addition, computational sensing is finding new patterns and shifts that were once indiscernible. Machine learning real-world applications have flourished over the last two decades. Theorist Lev Manovich outlines three trends in information display: designers and scientists are trying to show more data, represent relationships between more dimensions of data, and break from the ideological paradigm of simpler, reductionist approaches that may not apply to the current evolution of complexity. Properly visualizing scale and recognizing the abstract feelings associated with Big Data may help understand it.

In Motion Graphics

Two examples from media history, one mechanical and one on film, are still effective spatiotemporal displays. Orreries were antique mechanical models of the solar system not used for scale or prediction but holistic understanding of multiple objects travelling at multiple speeds across multiple layers. Charles and Ray Eames' "Powers of Ten" was a 1977 film commissioned by IBM to show the relative scale of the entire universe. The image advances on the 'y-axis' from a frozen moment in a Chicago park by zooming to limits of the observable universe and then back to the limits of known atomic structure. In this, it provides a profound historical example of strata visualization within one holistic semiotic language. Government and scientific communities are developing powerful software to model, simulate, visualize and analyze dynamic aerial systems. However, like lanes on a highway, each industry stays within a specific band of vertical space. There is no collective system that combines these animations. MIT's Ben Fry posits that "there is a space of highly complex systems for which we lack deep understanding because few techniques exist for visualization of data whose structure and content are undergoing continuous change." [3]

In Information Arts

Data Visualization embraces clarity yet the emerging field of Information Arts favors evocation placing Cartography in a tug-of-war between them. Many within the visualization community consider adding artistry a reduction in precision to reach a broader public; art and visualization have distinct functions and "in the case of Information Visualization, Form follows Revelation." [4] However, others argue that the era of a single minded pursuit of clarity will be replaced by the importance of engagement, that visualization is becoming a mass medium. "By recognizing that being expressive and engaging doesn't mean giving up clarity, we will have fulfilled the promise of visualization." [5] Still others insist that due to massive new data, art's abstraction and aesthetic skills are now required in information display, as science "ha(s) no photo-realist technologies to fall back on." [6] And finally, some believe that the best direction is a hybrid of both objective and subjective strategies, joining to form new insight.

In Art + Science Collaboration

The Data Visualization/Information Arts dichotomy is contrary to visionaries in both science and the humanities working to form research partnerships. There is much extant research by scholars who acknowledge the value of art/sci collaborations in moving knowledge forward, partially driven by the humanities now being confronted with large datasets themselves and having to "create practices that incorporate their own disciplinary values and ethics." [7] In a personal communication, leading nano-physicist Dr. James Gimzewski explained, "Science tends to be, in my opinion, too reductionist… and increasingly in science we're more and more aware of complexity, that we can't isolate something. An artists' natural way to work is non-reductionist; it's the opposite. They can look at very complex problems in a way that we are trying to learn."

In Media Philosophy

By presenting the hovering hardware as a system outside the context of human perception, alternative display may connect to metaphysical movements in Object Oriented Ontology and speculative realism. Researchers like Timothy Morton and Ian Bogost argue that philosophy should encounter non-living things and objects. Object-oriented Ontology (OOO) questions Kant's view that objects find their existence through our subjective perception of them and insists on objects existing and relating independent of us. Once we accept an object as a being, we can speculate on a larger range of interactions. Even if only metaphorically, a better visualization of a network of object-object relationships interacting above us, eerily independent from

our perception or consciousness, comments on the equality of object relations.

Beyond the Skies

Such a diverse background suggests that resolving this design problem requires a holistic approach, one often found in creative strategies. Indeed, arts-inflected methodology is offering new signification approaches in scientific visualization. NASA's recent ocean current animation was created by their 'van Gogh' team, designers who used brushstroke techniques from art history. As large quantities of data increases, effective visualization draws increasingly greater attention from researchers as well as practitioners in many fields, including science, education, engineering, interactive multimedia, medicine, etc. Finding the best possible visual strategy for explaining complex datasets is an important field for artists and sciences to create new knowledge and contribute to a richer understanding of the creative methods for spatiotemporal visualization and the mechanisms of the aesthetic components (e.g., sensory functioning, semiotics, animation, narrative, and cinema).

In addition, conceptualizing and measuring those components may reveal interdisciplinary approaches that integrate technology, media arts, and human cognition to enhance understanding. The repercussion of using new media art as a tool for elucidation of Big Data can be applied to a wide range of industries and sciences that have interests in utilizing their Big Data for enhancing user engagement (e.g., marketing), learning (e.g., education), and pattern prediction (e.g., transportation). The long-term impact affects science and art intersections exploring the problems of representing large-scale, complex and evolving systems.

References

1. Trin Kun (screen name), "Animation of Earth with Near-Earth Orbital Debris [HD]" Comments section (2014)," YouTube website accessed October 3, 2014, http://www.youtube.com/watch?v=6ATPaIBZiZA

2. Mei-Po Kwan, Douglas Richardson, Donggan Wang, Chenghu Zhou, *Space-Time Integration in Geography and GIScience: Research Frontiers in the US and China* (Springer eBook, 2014): 2.

3. Ben Fry, "From his homepage (2005)" accessed January 29, 2005, http://www.benfry.com

4. Manuel Lima, "Information Visualization Manifesto (2009)" accessed September 27, 2014, http://www.visualcomplexity.com/vc/blog/?p=644

5. Fernanda Viegas and Martin Wattenberg, "How to Make Data Look Sexy (2011)", accessed September 29, 2014, http://edition.cnn.com/2011/OPINION/04/19/sexy.data/index.html?_s=PM:OPINION

6. Sara Diamond, "Lenticular Galaxies: The Polyvalent Aesthetics of Data Visualization (2010)" in *Code Drift: Essays in Critical Digital Studies* ed. Arthur Kroker and Marilouise Kroker, accessed online October 3, 2014, http://www.ctheory.net/ articles.aspx?id=651

7. Mark Hansen, "Faculty Q&A: Professor Mark Hansen Works to Integrate Data Science into Journalism (2013)" interviewed by Bridget O'Brian, accessed October 9, 2013, http://news.columbia.edu/research/3213

Bibliography

Jacques Bertin, *Graphics and Graphic Information Processing* (Berlin: Walter de Gruyter, 1981).

Claudia Blume, "Asian nations gaining ground in space race (2007)" accessed October 3, 2014, http://www.globalsecurity.org/space/library/news/2007/space-070517-voa01.htm

Ian Bogost, *Alien Phenomenology, or What It's Like to Be a Thing* (Minneapolis: University of Minnesota Press, 2012)

John Corbett, "Torsten Hagerstrand: Time Geography (2001)" The Center for Spatially Integrated Social Science, accessed September 27, 2014, http://www.csiss.org/classics/content/29

Max Craglia, Kees de Bie, Davina Jackson, Martino Pesaresi, Gábor Remetey-Fülöpp, Changlin Wang, Alessandro Annoni, Ling Bian, Fred Campbell, Manfred Ehlers, John van Genderen, Michael Goodchild, Huadong Guo, Anthony Lewis, Richard Simpson, Andrew Skidmore and Peter Woodgate, "Digital Earth 2020: towards the vision for the next decade," *International Journal of Digital Earth,* Vol. 5, No. 1, (2012): 4-21.

Simone Garlandini and Sara Inna Fabrikant, "Evaluating the Effectiveness of Visual Variables for Geographic Information Visualization", *Lecture Notes in Computer Science*, 5756 (2009): 195–211.

Rosemary Hill, "How Social Semiotics Can Help Us Understand Big Data Visualizations (2014)," accessed September 26, 2014, http://seeingdata.org/project-blog/how-social-semiotics-can-help-us-understand-big-data-visualisations/

Mikhail Kanevski, *Advanced Mapping of Environmental Data* (New York: Wiley, 2008).

Gordon Kindlemann, "Visualization is Not A Hard Science (2006)," in *IEEE Compendium* accessed September 27, 2014, http://mike.teczno.com/img/2006-12-16/Jankun-Kelly-2006-ItS.pdf

Menno-Jan Kraak, "Geovisual Analytics and Cartography (2014)" accessed September 27, 2014, http://www.itc.nl/personal/kraak/research/

Alan MacEachren, "An Evolving Cognitive-semiotic Approach to Geographic Visualization and Knowledge Construction (2001)" accessed October 3, 2014, http://www.geovista.psu.edu/storage/alan/amm_InfoDesign.pdf

Lev Manovich, "Forward" in *Visual Complexity: Mapping Patterns of Information*, ed. Manuel Lima (New York: Princeton Architectural Press, 2008).

MIT Video, "Perpetual Ocean (2012)", accessed October 24, 2014, http://video.mit.edu/watch/perpetual-ocean-10824/

Timothy Morton, "Here Comes Everything: The Promise of Object-Oriented Ontology," *Qui Parle*, Vol. 19, No. 2, (2011): 163–190.

Museum of Modern Art, "Design and the Elastic Mind Exhibition (2008)" accessed October 14, 2012,

http://www.moma.org/interactives/exhibitions/2008/elasticmind/#/86/
Nick Rabinowitz, “Interfaces for Geotemporal Visualization (2011)” presented at SXSW, presentation slides accessed October 3, 2014, http://www.nickrabinowitz.com/projects/sxsw/sxsw_slides/
Casey Reas and Chandler McWilliams, *Form+Code in Design, Art, and Architecture* (New York: Princeton Architectural Press, 2010)
Bernt Resch, Florian Hillen, Andreas Reimer, and Wolfgang Spitzer, “Towards 4D Cartography—Four-Dimensional Dynamic Maps for Understanding Spatiotemporal Correlations in Lightning Events” *The Cartographic Journal,* Vol. 50, No. 3 (2013): 266–275.
Hans Rosling, “Asia’s Rise - How and When (2009)”, TEDIndia, accessed September 27, 2014, http://www.ted.com/talks/hans_rosling_asia_s_rise_how_and_when
Richard Stenger, “Scientist: Space weapons pose debris threat (2002)” accessed October 2, 2014 http://edition.cnn.com/2002/TECH/space/05/03/orbit.debris/index.html?_s=PM:TECH

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Scott Hessels (b. 1958) is an American filmmaker, sculptor and media artist based in Hong Kong. His artworks span different media including film, video, online, music, broadcast, print, kinetic sculpture, and performance. His films have shown internationally and his new media installations have been presented in museum exhibitions focusing on technology as well as those presenting fine arts. His recognitions include patents for developed technologies, references in books and periodicals on new media art, and coverage in cultural media like *Wired* and *Discover*. He is currently an associate professor at The School of Creative Media in City University of Hong Kong and executive producer of the Extreme Environments Programme which organizes art/science expeditions to environmentally significant sites.