"Standardized Spaces: Satellite Imagery in the Age of Big Data"

Monica M. Brannon
The New School for Social Research

Satellites are seeing machines that collect data from which composite images are produced. Vertically extending human sight, they rely on optics from automated, standardized and mechanical forms. Designed in the 1940's, launched in the 1950's and commercialized in the 1990's, they form part of history of visuality that has moved from reconnaissance military images to commercialized ubiquity in free platforms such as Google Earth. Yet the satellite image itself is just one node in a large sociotechnical, historical network that consists of machines, political and technological decisions, and cultural subjectivities. Though often treated as a real representation of places, the perception of images is particular to the design and development within a historical logic of visualization. Satellites actively orbit, archive, and transmit signals automatically, traveling largely unseen while collecting and recording data that interpreted and translated by analysts into legible 'images.' A new epistemology of visualizing practices is articulated through satellite images in which mechanical objectivity and perspectival design are enfolded into contemporary networks of data circulation, user manipulation and a reductive quantification of social behavior, all of which converge in a locational grid. The emergent form is equally reliant upon discourses of mechanical precision, automatic recording and archiving, and standardization—rendering data into readable, comparable forms.

This legibility is not only a technical visual rendering of space, but is indicative of forms of representation produced through a contemporary political economy. As Jonathan Crary describes, "optical devices . . . are points of intersection where philosophical, scientific and aesthetic discourses overlap with mechanical techniques, institutional requirements, and socioeconomic forces. Each of them is understandable not simply as the material object in question, or as part of a history of technology, but for the way in which it is embedded in a much larger assemblage of events and powers."[1] (8) In order to discern this assemblage, it is necessary to understand what forms converged to make the contemporary present of this technology possible by tracing the networks through which visuality is produced. To do this, this article uses a genealogical approach to parse out the various registers upon which social, technical and political logics converge. Using the material-semiotic method that treats technical artifacts as constitutive of and constituted by social relations offers insight into how a logic of visual subjectivity and relationships to space operate through satellite images.[2]

The emergence of this optical perspective can be traced to technological developments as they converge with new design principles in the post-war period. Presenting a different type of seeing than looking at a single image, or a map, it requires an understanding of organizational patterns of relations that combine space, perspective, scaling. Seeing a single satellite image without any geographical contextualization makes it difficult to recognize, without the ability to zoom in and out, the vertical scrolling effect. This relational focus, the patterns through which we understand the horizontal and

vertical grids that are patched together to offer a complete globe, produce a type of vision and cognition that frames experience through the digital, manipulable screen interface.

Designing for the Relative Size of Things

In 1968, designers Charles and Ray Eames produced the film *Powers of 10,* an inspiration for the original Keyhole project that became Google Earth: "We've always loved *Powers of 10*, the classic 1977 film by Charles and Ray Eames that takes you on a visual ride from inside an atom to the edge of space in under 10 minutes. It turns out Keyhole brings a similarly astonishing perspective to its visual mapping software, and it's an incredibly powerful information tool besides."[3] This "astonishing" perspective of the film is adapted from the 1957 book *Cosmic View* by Kees Boeke, which was made up of drawings depicting the same relative scaling effect. *Powers of 10* opens with the description "A Film Dealing with the Relative Size of Things In the Universe And the Effect of Adding Another Zero." This breakthrough presentation integrating art and science begins with an overhead image of a couple picnicking in a park in Chicago, where the screen shifts every 10 seconds, depicting an image from 10 times farther away, and field of view 10 times wider, all the way until 100 million light years away with the Milky Way Galaxy no longer even in view. The scale then shifts as the screen moves the viewer back down to the couple at rapid speed, and then even smaller, through the cells on the skin to a single proton in the nucleus of an atom in the DNA of the man's hand. The relationship between the interface and the observer presents a form of scaled perception that renders relationships and the interaction between objects and distance the primary connection to space. It is a mathematical, exponential equation of which the content has little significance to the patterned form being presented. There is a further aesthetic sensational element felt by the viewer, as if they are moving away from the screen, and being forced further and further into outer space. The massive distance covered by the film allows the viewer to travel through space, yet presents the seeing eye in an omniscient, god-like manner, outside of the world that is being scaled as the picnicking couple carries on, watched unknowingly.

The film was made to be deliberately overwhelming and dizzying, adding a layer of sensory integration and movement that could not be felt in the static images of the book from which it was inspired. Especially apparent when zooming quickly into the skin of the man, it was meant to feel incomprehensible, awe-inspiring at the aesthetic pleasures of math and science with the viewer experiencing the "travel of the imaginary voyager . . . who covered ten times the distance he had covered in the previous ten seconds." Being pushed to the realm beyond human existence, it was described at the time as "a simple yet staggering perspective of distance and numbers, scientifically precise yet at the peak of poetic imagination."[4] Combining a techno-visual desire of future possibility with the simplicity of a mathematical lesson in scale presented an experience of movement through vision over other sensorial focus, through the careful crafting of perspective.

The Eames' interest was to use films as tools, part of a pedagogy espousing relationships and patterns over content. The attunement was to perception without singular focus on an image that was too quickly being shown. Correlating vertical

movement and scale with speed across horizontal space presents a relational perspective, with descriptions such as, "10^4 meters, 10 kilometers, the distance a supersonic aircraft can travel in ten seconds." In the rough sketch of the film from ten years prior, there was a clock on the side of the image that was counting down, offering the viewer knowledge of the fleeting time left to understand a screen before an image was quickly replaced.

At the very farthest view presented (juxtaposed against the static physical space between viewer and screen), the narrator ominously describes, "this lonely scene – the galaxies like dust, is what most of space looks like. This emptiness is normal. The richness of our own neighborhood is the exception." This draws attention to not the content of the image itself, but the viewer's place in relation to that space, forcing to see beyond the 'on the ground' experience to recognize the 'abnormalcy' of our experiential level that we must reject to understand the reality of space at large. On the voyage back to earth the narrator suggests: "notice the alternation between great activity and relative inactivity, a rhythm that will continue all the way into our next goal: a proton in the nucleus of a carbon atom beneath the skin on the hand of a sleeping man at the picnic." Space is patterned, a 'rhythm' and is constituted by 'activity' or the lack of it. Content is described here as action or inaction, as visible and recognizable movement 'on the ground' alongside the invisibility of large scale movement in outer space, as time and space appear to stop, with the scale rendering movement as a frozen image. Interestingly, movement is frozen in all images, and so the activity is an inferential one, rather than a presented one. Using this comparative mode trains cognitive perception to view space in a systematic, patterned way relying on the vertical scale to create difference. In *Powers of 10*, as well as in other of their works, the Eames' layer information in multiple forms—text, movement, equations—anticipating an organization that gestures toward today's computers. Placing information in the same register and forming a particular experience that is mediated through the screen presents the viewer as both part of and also beyond the images, moving through space, yet outside of that space—an ambiguous position that highlights both wonder and sensorial amazement with a message of math, scale and patterned relationality. The exponential connections of a vastly ordered system are made sense of through a visual, quantified experience.

Ending the film on the microscopic level, the narrator notes: "we are in the domain of universal modules. There are protons and neutrons in every nucleus, electrons in every atom, atoms bonded into every molecule out to the farthest galaxy." Recognizing that while scale is being manipulated, the matter is the same, it is the relational aspect that is again highlighted over the content, the universal similarities as presented through the singular image form with difference only mathematically. The film ends with: "as a single neutron . . . on our screen, we've reached the edge of present understanding." The 'edge' indicates not a boundary, but a step in a vast and endless field of scale, limited only by technological development that will certainly be surpassed.

The original intention for Boeke was to place ourselves in relation to a vast world, which he describes as: "we all . . . are inclined to live in our own little world, in our immediate surroundings, or at any rate with our attention concentrated on those things with which we are directly in touch. We tend to forget how vast are the ranges of existing reality which our eyes cannot directly see, and our attitudes may become narrow and

provincial. We need to develop a wider outlook, to see ourselves in our relative position in the great and mysterious universe in which we have been born and live."[5] This moral plea for a more 'global view' outside of ourselves is tied directly to the pedagogy of quantifiable relativity. In a *New York Times Book Review* Stephen Jay Gould notes "man asleep on a blanket is truly at the center—perhaps the measure of things, after all."[6] The relationship between math and the human subject presents a relatively that puts the body as the center of the pedagogical as a training device to see, though this is counterbalanced with the omniscient otherworldly view. Provinciality in our 'little world' denies the 'mysteriousness' of the universe, though here it is presented as exponential equations. In the film, this relation to the vast world is at a disjuncture. While meant to understand ourselves as made up of the same atoms from outer space to the microscopic level, it is precisely this distancing through the screen, alongside the view itself, that creates a logic of perception based on rational understanding rather than experiential or sentient knowledge. Instead of seeing the difference among spaces and places, the uniqueness of individuals and diversity of experience, it is the relational sameness that is prioritized as the form of seeing, standardizing space as algorithmic patterns.

Gould goes on to describe the smallest scale: "we are inside an atom, and common notions of visible fail."[7] The 'visible fails' as it moves farther from the 'measure of all things', when the seeming connection between a man and the inside of atoms which make him up are no longer conceivable on the visual level needed to understand the relational congruence among all atoms. However, while it fails at the time, this view becomes the visual imaginary that manifests in the normalized perspective offered by Google Earth decades later, though the human as the center of understanding remains illusive as this level is absent from the scaled perspective offered.

Powers of 10 was designed by the Eames' for IBM as a pedagogical tool, a response to concerns that American school children were deficient in understanding math and science. Described by the grandson of the Eames': "Throughout its relationship with Charles and Ray Eames, IBM believed that if you educate society, you not only do a positive good, you also create a group of people who are better able to appreciate the work and products of IBM."[8] Educating viewers in how to cognate in computational ways and operating through IBM products, this film also disciplined viewers in perspectival seeing, introducing the view from above and planting the seed for the normalization of this optic in later decades.

As Orit Halpern notes, this movement in the history of design forged by the Eames' presents data in a particular way: "There is pure pleasure in this process, a zeal for manipulation over capture; the same objects constantly re-presented through different frames of reference as the essential organizing logic for this technology of design."[9] *Powers of 10* is both indicative of this shift in perception and also offers a visual desire as that has yet to be reached in our contemporary world. Satellite imagery and the scaling effect was made legible through design as a presentation of information, one that contributed to an overall perception of the world as a total entity—a systematic rendering of space. At the level of atoms, the microconnectivity presents the whole earth as being made up of the same comparable and standard units, where difference is of scale rather

than form.

In the present use of satellite images and scaling in Google Earth we achieve only part of that which Boeke and the Eames' offer us, the vertical view from outer space, but never reaching the level of where humans exist. Instead we are forced to stop only at the level objects a half meter in length, so that humans, and the level of sociality, are not seen in satellite images.[10] While the design imaginary that the Eames' develop marks new thinking through which to understand perception in relation to space—designing for organizational patterns and structures which condition possible ways of seeing—we must further question the contemporary state of this normalized vision as tools are dispersed to new users, through new interfaces. What new possibilities, and prohibitions exist in how we see and relate to space? The interface with a personal computer screen, or a mobile device through which the observer chooses where to look and at what scale, alongside other associated technologies of tracking and marking locations, presents a transformation in optical logic from Eames' *Powers of 10,* though with strong residual characteristics from the early post-war period. There are real implications in this exponential logic of seeing without a human scale, prioritizing the geographic as the primary mode of seeing. This new standardized norm conditions a perception that privileges a mechanical objectivity over the narrative, 'on the ground,' social experience; this way of seeing ultimately reduces spaces to renderings of mathematical measurements. What is at stake in this normalized optic is the closing down of possibilities for qualitative, creative and critical interrogation of the technical as it structures action, with a standardized data-driven view reifying notions of 'true' representations of space.

Modular Optics

The post-war period transition integrated the development of military technologies with information theory and communication science. Advocating a new post-war theory of design that combined cybernetic with communication theory, vision became based on relational organizational patterns to invoke a field of visual perception. The designer Gyorgy Kepes who brought the Eames to MIT helped to articulate the transition from a static picture to an interactive screen, where perception is based on communicative technological and human exchange. This technical practice of perception reconceptualized normative models of vision through design practice and science and technology. The mechanical data acquisition and continuous recording of global space as collected by satellites requires this form of perception that contextualizes images in a larger understanding of space rather than a subject-object or viewer-image model. Viewed through screens that call for interaction and modulation, the viewer is integral in shaping the data exchange.

Kepes introduced three tenants into post-war conceptions of visuality that changed the design field: infinite electronically enhanced archives; a focus on relations, process and scale; and 'action-seeing' as a new form of materialized vision. Collapsing perception and cognition in pattern recognition deletes the separation between image production and seeing, instead existing as a performative practice that produces subjects

"capable of such an algorithmic sense of perception and attuned to managing data fields."[11] Scale, for Kepes, was emphasized, and he trained his students in data recombination and information manipulation. This presented new problems in the organized management of data based on the interactive technology of the screen, the abundance of data forms, and new computational power. "Post-war design practice, therefore, demonstrated a particular unbinding, if we will of vision, from a normative location in a naturalized body, to a multiplous, plastic process, that could be replicated, reproduced, and re-imagined through multiple technologies and new processes both in design and science." [12] Working closely with Kepes, the Eames' contributed greatly to this transformation with a great concern for communication theory, arguing that design should be based upon the transmission of information. With multiple interfaces, mediated screens and layers of 'reality' this is increasingly clear as abstractions and representations stand in for experience and further shape our understanding of the places they present.

Kepes was invited to begin a program in visual arts and design at MIT by the president James R. Killian whose mission was to integrate arts and sciences. Recognizing both their friendship and intellectual relationship, Killian wrote in the introduction to Kepes' autobiographical book *Gyorgy Kepes: The MIT Years, 1945-1977*: "With his stress on the syncretic relationship of the arts to science and engineering, Kepes is numbered among the large company at M.I.T. who contribute importantly to this common air."[13] Killian shared this vision of integrating science and design, and was integral to the realizing of satellite technology. As Special Assistant for Science and Technology to President Eisenhower between 1957 to 1959, he also wrote the famous Killian Report (1955) that called for the immediate priority of developing reconnaissance satellites amongst other military technologies such as intercontinental ballistic missiles because of the immediate threat of Soviet attack. This document, and Killian's influence in the Eisenhower administration, is credited with the massive investment of resources into new war technologies that largely determined the course of the Cold War. Reconnaissance satellites further united the mechanical and political achievements of undetected space flight with a particular way of viewing spaces that required seeing as relational, scaled, automated and from a nonhuman perspective.

While the Boeke/Eames model offered a new understanding, and a pedagogical training that disciplined the viewer to see in spatial relations based on mathematical scales, relational and organizational patterns and nonhuman perspectives, the contemporary digital globe contributes to a new structure of seeing that includes the horizontal scrolling through user manipulation. As described by the Ari Bar-Zeev, co-founder of Keyhole, which became Google Earth, the digital form had to feel like spinning a model physical globe. This mimicry creates a smooth epistemological transition between the model of a globe and the screen, as "GE was designed to work like a physical globe on steroids (in a good way). With a physical globe, you can grab it, spin it, and so on, all in a very natural, intuitive manner. You don't need to form complex queries to see interesting and useful results in GE**.** That kind of complexity comes pre-digested for you, for better or worse. And that pre-digestion also makes the system much more nimble in terms of performance, which goes back to the ease of use and the basic 'wow' factor."[14] Replacing the tactility of the globe, and instead appealing to the optical

senses and the dramatic interaction with the screen, the viewer is offered a rendition of complex data that has been carefully crafted to look like a recognizable and legible space; and with it, the sensorial experience of virtual movement. However, reduced complexity by offering a "pre-digested" product limits a critical awareness of this constructed image by the public and strengthens false notions of 'real' objective mechanical production.

While seen by the public as true depictions of reality—satellite images seen in digital globes are designed and produced products. They are visual outputs that are representational forms relying on quantitative measures and calculations, codes and algorithms that turn spaces of nature and built environments into pixilated, scalable, scrollable merged and seamless globes. They are one piece of networked communicative machines, telling a particular narrative that is mechanically organized and modeled to represent natural space, but these images are in fact interpreted data sets that have been manipulated to produce simulated models of territories.

Measurable Landscapes

The first U.S. spy satellites launched successfully in 1960, with the intent to gain knowledge of the Soviet weapons capabilities. They ejected film canisters that were acrobatically caught in midair by airplanes to be developed as photographs. The transition to the digital transmission of scientific satellite images in 1972 was a major technological move that ushered in an epistemological shift in perception and visuality in how images of data were presented. Aerial and satellite images produced from film relied on photochemical technology to show a picture, though often marred by cloud cover or other problems in calibration. Scientific satellites of the 1970's collected data not with a photographic camera, but through measuring energy emitted from surfaces. These measurements were reliant on the computer technology developed in the 60's that could process large amounts of numerical data in order to make sense of these technical outputs. Primitive compared to current capabilities, computers at the time were able to print out graphics on line-printers, with one pixel represented with one graphic. To see recognizable patterns, however, several had to be hung up and then viewed from afar for context.

Crucial to linking the practices of mechanical seeing with mathematical viewing of space is the automation of the image interpretation process by the digitalization of data and computer processing. Multispectral scanning refers to the process by which data is collected from several bands on the electro-magnetic spectrum in order to characterize matter, some of which are beyond the visible portion of the spectrum and thus offering more complex data set than an aerial photograph. Because this process is one of measurement, the image produced is necessarily of a statistical nature that is then developed into visual output. Through either comparing amounts of energy emitted from a known surface, or through using algorithms to cluster similar levels together in order to render difference between land cover, the type of ground cover is determined. So, spaces that record similar radiation levels are considered to be of like space based on quantitative measurements of the energy they emit.

In order for this to be 'accurate', however, spaces need to be bounded and

homogeneous. They must be defined as a particular territory in order to compare the data to other classifications. The higher the resolution of pixels, the more variance is shown in radiation levels and the more heterogenous spaces appear (mixed forests, for example). The algorithm (written with parameters of allowable difference) determines what a space is made up of, as defined by the analyst depending on how much heterogeneity is desirable or manageable. A singular set of data on one space can be interpreted into endless images with differing characteristics, and the analyst decides at what level of data to mark in rendering an image of the space. Pixels that don't fit in to clusters well are marked as 'unclassifiable' and too small clusters are eliminated based on parameters set by the user. Therefore, based on what the user is interested in knowing about a space, the processing is controlled to create a visual output and determination of what the space 'actually' consists of.

To produce an identifiable image, a false-color composite is created through combining data from multiple spectral bands (filtered to only measure one portion of the spectrum) that produced the highest contrast in order to show difference of spaces according the desired output regarding what should be highlighted.[15] When desirable amounts of contrast and clarity are reached, these are then processed into 'true' color composites. To produce a visual image that represents space, as in Google Earth, 'real' color is simply added to the image to make it appear similar to how humans visually experience on the ground space. Absolute true color is impossible to achieve as displayed through the medium and on the screen and the variance is much too great to show digitally.

For Google Earth, the goal is not to present comprehensive information regarding the makeup of spaces, but instead to make them appear visually as accurate photographic representations of space—a simulation of human vision. It is not the content that is of concern, but that it looks like an appropriate color composite--making it appear to the human eye as the original subject would 'on the ground'. Essentially, what is being done is a reduction of the data collected along the electromagnetic spectrum into a mimicry of visual experience by inputting 'true' color onto spaces calculated to be of the same material.

Therefore, what this process shows is that spaces are quantified, made measurable, categorized statistically and calculated according to algorithms. The images that we see in the public domain are automated renditions, processed to reproduce what we see 'on the ground' after being cleaned of inconsistency, reduced of complexity and erased of unknowable variables. Now normalized, this seeing of space can be traced to what was once the design pedagogy promoted by the Eames' constructing relational aspects of quantified spaces.

Visualizing Data

John May coins this emergent new epistemic mode, 'statistical-mechanical geographic vision' as the " a result of historical coalescing, operative since at least the outset of the twentieth century between a specific way of thinking about the natural and

social worlds as aggregations of statistical regularities and a way of seeing that was from the outset rooted in certain technological devices and their attendant methods."[16] May argues that the already embraced automated visual domain of photography influenced the acceptance and integration of the mechanical measuring of spaces because it complemented existing forms of metrology and the creation of maps from aerial photography and similar techniques. This replaced the human dimension of the interpretation process with automated and mechanized ones. The integration of the measurement with the already automated visual domain concretized mechanical seeing that allowed for ease to accommodate automation of image-processing as well. Satellite sensors, "would certainly never have appeared absent the basic premise—whose time, relatively speaking, has only recently arrived—that life is not only quantifiable but that the most appropriate methods of quantification belong to inferential statistics."[17] This calculated standard of space is based on a predicted correlation with other known measured spaces.

Prior to the 18th century, while crude models relating data to images such as maps and diagrams were being invented, the relationship between theory and measurement, alongside geometry, were focused on problems of time, distance and space for applications in astronomy, surveying, map making, navigation and territorial expansion.[18] Beginning in the 18th c., the collection of data relating to people—demographics, economics, crime and medicine—marked the birth of the relationship between statistics as a form of social measurement alongside graphical visualization forms.

In what Michael Friendly calls the "modern dark ages" of visualization, between 1900-1950 the rise of quantified statistics in the social sciences replaced an interest on graphics as "pictures were—well, just pictures: pretty or evocative, perhaps, but incapable of stating a 'fact' to three or more decimals. Or so it seemed to many statisticians."[19] The 1950's brought new interest through technological innovations, machinery with the computational power and later the display devices to mark a re-birth of data visualization. Expanding statistics beyond mathematics and toward 'exploratory' forms of data analysis built into software programs became recognized in the field, along with a replacement of hand drawn maps and graphics by high-resolution software. What Friendly notes is that most innovative thinking in data visualization arose from the need to solve concrete problems and achieve practical goals. With new data on populations and needs for organization and management of this data—as related to economics, health, state planning, navigation—there was necessarily parallel development in technologies to compute data and build designed outputs for desire ends.[20] The important point to make is the historical contingencies at play in creating visual graphics, ways of seeing data were not inherent to the data, technology, or the subject, but were built epistemologically through the intersections between these phenomena. While these are modern developments in statistical thinking, some of these forms have very deep roots and rely on early map-making.

Mechanical Objectivity

The transference from human vision to mechanical vision, observation of spaces from beyond human accessibility presents a form of objectivity that emerges through the

confluence of mechanical automation and continuous, nondiscretionary seeing alongside the mathematical production. The real world simulation of data management becomes the primary mode of interpreting space through reducing landscape to information points. Satellite imaging technology was developed out of a drive to have 'hard facts' of the Soviet threat described in the Killian Report. And, as mentioned in a CIA analysis, spy satellite images have been attributed with "unquestionable objectivity" that also presented a "quantum jump in the use of intelligence derived from photographs, satellite electronics, overflights--a whole series of technological achievements."[21] The conflation of technology and objectivity has implications for how images are seen as accurate representations of space then used as evidence and claims of truth.

Daston and Gallison trace objectivity to show that it is a constructed and accomplished ideological concept derived through the convergence of historically distinct phenomena, rather than an inherent ontological form, and is therefore malleable to take on new meanings and symbols. Technological developments that allowed for the mechanical production of the images was the exemplar of the removal of human intervention rendering the mediation by the observer seemingly inconsequential to the integrity of the form. The preciseness and rigor required for objectivity from scientists is placed instead on the machines themselves, who, through standardized reproduction present a reliability not attainable with human subjectivity. Through photography, the image became the ideal of scientific representation with mechanical objectivity replacing human agency with control by automatic means.

The objectivity of machine seeing was two fold in its correcting of human deficiencies: it created standardized identical objects and a new model of scale and perfection; it also "embodied a positive ideal of the observer: patient, indefatigable, ever alert, probing beyond the limits of the human senses."[22] It could observe, measure and record without the inattention or distraction of the human. Mechanization and automation, in the case of satellite imagery, resulted in a particular standardization in the taking, producing and reading of images.

Used as evidence at all levels, from court cases to international disputes, images are not scrutinized as products of social production, but are instead privileged both because of the visual and the mechanical 'god-view' perspective. Further, with no humans visible in satellite images, intention is implied or extracted and interpreted through residual social behavior in the 'evidence' of the frozen action of a built structure or ruins of space. With objectivity given a status of moral authority over the deficient and subjective human accounts of events from 'on the ground', they are positioned as agents of moral truth, yet based on their mechanical nature, they are not seen as such, but integrated into disciplining structures distancing the material from the social in increasingly abstracted practices. Epistemologically, this elevates the prioritization of the scientific precision over the subjective.

Satellite imaging can be seen at the crux of two processes, on the one hand, representing a technology that relies on the social practices of establishing truth through a particular seeing of space, while on the other needing to hide those social practices of production to maintain that truth. This shows how technologies claims of objectivity and truth of 'real space', has been understood through purification from the social and also in how objectivity is socially performed through technological artifacts as meaning is embedded, through social practices, onto scientific practices.[23] The implication of this

constructed distancing between the material and social is that "where technology is not seen as a social relation, it is fetishized and aestheticized, the contingent nature of technical outcomes is overlooked, and the struggles waged over the choice and application of any particular technology are ignored."[24] The technology is not seen as the performance or action that was designed as an art of relational patterns of the Eames', but instead as fixed mechanical and mathematical outputs.

The ability of satellite or aerial images to present a reality, "serves as an index of a specific moment in time and a representation of that ontological materiality captured by the photographic technology."[25] So, it is the 'real relation' to the space being imaged that marks it as an index, as well as a particular moment in time that is being marked. Regardless of how it is interpreted, the 'ontological materiality' of the on the ground space that is being referred to through this representation complicates the image as being purely representative. This highlights the complex nature through which science and technology relate to a world understood to be empirical, and how they act through the construction of that world. Seen as objective and machine produced, this indexicality operates as a 'natural' way of seeing rather than a produced and historically contingent one.

This theoretical insight offers a mode through which to think of what sort of data is being transmitted by satellite images. Not without referent, the data is measured of and through a space, and is seen only through the register in which reality is presented that is identifiable in our mode of seeing. Therefore, it is the history of data visualization that allows this index to operate as a representation of reality in a way that was not always possible. Contingent upon a literacy developed through the confluence of contemporary cartography, digital imagery and aerial photography, this index has been developed through the political and scientific use of images as the truest form through which to see space. However, even though there does exist an ontological materiality, what is shown through the image is also an erasing of certain registers of that space, including the social level through the inability to see people.

Ordering Archives

In addition to the 'real' depiction of space, the continuous recording and the automatic data collection of satellites enhances a mathematical and computational form of order. As exemplified in the massive archive of 50 years of satellite data recorded to be recalled, another form of objectivity regarding data manipulation marked a transition in the post-war period with computing technology. The recombinatory possibility produced an "objectivity [that] was redefined in terms of the production of algorithms, methods, and processes that facilitate interaction based upon the assumption of an infinitude of stored information."[26] The ability to juxtapose contemporary images of spaces with those from the 1970's presents a fixed record of space frozen in the archive. Preserved for an imaginary future use to mark shifts in space, it is this standardizing function that allows images to sit as data storage archives to be compared with seemingly like data from a different, future point in time. The objective rendering of real space as a photographic ideology gets enfolded into the archival, creating a reductive, standardized

database that is understood to be true representations that allow for continual comparisons of fixed renderings of space.

A marked transformation in the post-war technological development was the building of archives of categorized information, as satellite images, especially in their digitized state, able to further fix places that are easily recallable. Used as indication to mark change over time, these images hold definitive claims on the nature of a space in the past and makes truth claims of the social action that was taking place, often times without any social context or narrative history. Compared to another image that 'accurately' defines the space in a contemporary period, the focus is on change and difference rather than the construction of each image itself. Digital images overlayed from different points in history present a form of remembering that is framed through a true depiction, evidence of a change in two moments locked through the visual, despite the already constructed form of images and the multiplicity of possibilities for what each images shows, as noted above.

Of course this isn't an all-encompassing archive, but one that has already been selected by what data was translated into images: highlighting the archive as a constructed organization rather than a collection or total repository. As Derrida argues, an authority is directly tied to the archive and its construction through the building of boundaries that encompass it. The power of the archive is not in the reserve of information past, but how it gestures towards the future of possibilities.[27] However, the seamless presentation of digital globes obscure this fact.

In Google Earth, images are not time stamped, nor collected at the same point and so the globe is a merging of multiple moments presented as a collective whole to conceal the difference in acquisition, and made to appear to show the present. While cartographic 'sleuths' report when imagery is updated on community forums, for users to recognize 'out of date' imagery requires a change in landscape—either marked seasons or architectural changes due to construction or demolition or disaster, though only those on a large enough visual scale. The architectural takes precedent and is at the forefront of how to structure a history. 'Evidence' of historical transition and the visual authority of images present a way of remembering that is documented and referenced over a narrative passing of time. However, not being time stamped and with heterogenous collection points muddles the fact that satellite images themselves do fix points in time through spatial image representation. Time is manipulated by observers through what image is chosen to represent spaces, editing the flow of time by technical means through the visual presentation of time as static, and then ordered.[28] This marks another register through which spaces are technologically managed.

Data Circulation

A distinguishing feature of contemporary viewing of satellite images is their integration into individual and mobile technologies. In these forms personalization operates through user manipulation and interaction, as the observer creates her own narrative as an extension of place alongside action. The seemingly private embodiment of technologies is juxtaposed alongside the distanced view from the inhuman mechanical rendition of place, where the viewer can even zoom in on the place they currently 'are' while also being part of an unseen information network. This leaves the viewer

"radically individuated, personalizing their data space in seeming isolation. At the same time, this spectator [is] psychically flat, always networked, a conduit for accelerating the circulation of information."[29] The network consists of the integrated data grids and technology practices including, in part, participation often unknowingly in massive data collection projects by Google. The user's personal searches become the archived, recorded, recalled and compared data sets, against millions of other users, and present in a grid of locatability in the fixing of subjects and place. Communicating location by users as they publicize place through social media, in conjunction with data tracking, exist as circuits of data exchange made possible through the standardization of spaces as quantitative codes. Geographic latitude and longitude coordinates become materialized and inscribed on place and aligned with specified standard categories of action that can be correlated in databases.

Site-to-site sharing reformulates the previous distinction between developer and user, challenging the single source linear producer-consumer model. This is largely a result of the commercialization of the industry that allows companies to both distribute and collect imagery from owned satellites and encourages users to alter, or add values to them. In the case of satellite imaging, however, this is not an equal or open process, as there are political limitations to what the user can see, and also technical limitations in that users are adding to already static images in Google Earth, so that the politics of image creation are further buried below with the attention focused on the creative building, exchanging and personalizing within image platforms. The base layer of images, comes, as mentioned above in the interview with Google Earth developer, in 'predigested' forms, reducing complexity to make the form usable as a priority. So, the networked, layered, searchable and manipulable possibilities offer an illusion of user autonomy and creativity, when, in fact, they are greatly limited by the initial produced images offered and owned by Google. Further, the form presented is a simulation, a modulated spatial experience that is produced to appear visually as a place but is created through accumulation of data. It is a mimicked referent that allows for different interaction than the space it portrays, a platform of recombinant data manipulation by users. The self-selected data configurations give the individual a feeling of autonomy alongside a claimed democratization of information based on free accessibility. The user, however, is the site of data circulation rather than autonomous producer of knowledge forms.

Echoing the film *Powers of 10,* scale as a mode of manipulation is an ordered quantification of relational space. As discussed by geographer Goodchild, "geographic scale is important because it defines the limits to our observations of the Earth. . . it is also important because it is often a parameter in the physical and social processes that shape geographic phenomena."[30] Scale today is defined through the legacy of paper mapping which denotes a ratio, but also largely indicates content, such as what can be seen on the level of buildings, cars, or people. Scale, then, is the exposing of complexity. The smaller the scale, the more intricate and conflicting data can be seen, making the image one in which large swaths of land that at a larger scale appear as all the same surface, to instead be one where landscapes are intermixed and man-made and natural worlds collide, exposing a less generalized space. The 'accuracy' is the same in both, and so this is always a ratio of perception to minutia. "The case is often made that

generalization adds information rather than reducing it, because some types of geographic information can only be apparent if the world is viewed from a distance."[31] The problem with standards of scale are that by limiting digital earth's to single scale layers, all spaces are treated reduced so that complexity is lost. Scales are mathematical adjustments to already flattened depictions of space. When resolution is used as the demarcation of what is allowed to be seen by the public for security reasons, this enforceable measure ignores the quality of what is actually depicted.

Quantifying the Social

Along with statistical-mechanical quantification and manipulation, adding value to images allows territories to be recombinant. The parsing together of data from different registers—radiation measurements alongside political borders, economic transfers, consumption sites, traffic patterns, etc. places different social action within a grid of intelligibility that standardizes data units into a seamless globe interface. This creates an organized space that is coded, cleaned and is constituted by the exchange of information through data transfer. This modeled simulation of space precedes experience in the referenced place, and frames perception of a located subjective experience.

Alongside the statistical/algorithmic seeing is the searchable digital database, presenting a convergence of the geographical alongside the organization and management of data. As exemplified by the Google Earth homepage declaring: "Google Earth combines satellite imagery, maps and the power of Google Search to put the world's geographic information at your fingertips," the searchable organization of information places geographic data points within the internet hierarchy of the endless knowledge archive and the power of the corporation itself. This is indicative of contemporary network of satellite images as folded into the logic and power of the "Age of Big Data." As described by Gary King at Harvard, "We're really just getting under way. But the march of quantification, made possible by enormous new sources of data, will sweep through academia, business and government. There is no area that is going to be untouched."[32] This 'march of quantification' is the convergence of the archival recalling abilities of digital recording, the algorithmic rendering of predictive computing, and the new institutional uses for quantification—of social behaviors, identities and even locations. The ways in which digital devices record, organize and transmit data as it becomes translated into a digital form, associated with the compact or compressing of vast amounts of information into micro spaces alongside the mechanical recording of information, are part of larger discursive regimes that privilege this type of fixing of data thriving on access and archiving, alongside calculation and comparability.[33]

The constant tracking and recording of information—beyond the visual, but through geolocative practices—along with predictive analysis of trends, marks a new type of surveillance that takes place through our technological screens, as actions made seeable. Praised as having the ability to fight poverty, crime and solve environmental crises, total quantification requires a depiction of the social world generated as traceable, locatable and calculable. Relying on data to solve social problems, and used to predict action, "in business, economics and other fields . . . decisions will increasingly be based on data and analysis rather than on experience and intuition."[34] As both free accessibility

and user personal choice get inscribed as 'democratizing' information, they present contradictions between the freeing technologies that allow for creativity, collaboration, unpredictable practices within a realm of competition and exchange of capital and surveillance through individuating practices. To participate with this free information is to place oneself under scrutiny by the companies that offer it and placing oneself firmly in massive data archives.

While commercialization allowed for increased use of images by the public, it is the bundled behaviors that mark new social practices that are being institutionalized, rather than new actors, which mark a total paradigm shift. By looking at these exchanges as creating and stabilizing the social, the spatial flows of behavior can be traced in a post-individualist, non-humanist way that understands social groups as practices and contacts. The way in which these practices are used by marketers, governments and analysts further deviate from the individual and instead focus on correlative practices to create 'profiles' to predict social action—from consumerism to criminal behavior. This extension of networks including social groups and also individuated actions or data points presents the paradox of commercialization as offering both democratic accessibility but also the loss of autonomy over individual actions as they are translated into statistical patterns.

Reductive Spaces

The juxtaposition between the mobility of images and the simultaneous fixing of location within images further adds to this reductive form of seeing: "by reducing our spatial experiences to latitude and longitude coordinates, social/spatial interaction can take on a totality, precision and predictability that it lacks."[35] While images are more mobile or transferable across networks, making location less constraining in the communication networks of the globalizing world, there simultaneously exists the converse practices of fixing social action within images. With the public capacity to manipulate, collaborate and build upon images in other GIS and creative capacities, there is an increased mobility and flow of information, collaboration, and capital in these disembodied platforms. Therefore, they present both tying action to location and a disembodiment of location based on the digital and exchangeable form. These seemingly contradictory practices operate through the same logic of perception and quantification of space as data that can be communicated. Again, this communication operates through subjects as individuated data points and nodes of circulation, modulation and transaction. Location as a marker of communication channels through self-reporting is integral to both social identities and also data tracking, working to discipline subjects to be placed and connected to a grid as a primary mode of identification.

Yet, there is a subsequent problem regarding places that are not present in the digital grid—unmapped places, localities that don't have social media mapping technology, places without cell phone service or without high-speed internet such as much of the geographical United States. The deprioritization of certain locations over others through technology that centralizes the spatial in the visual optic creates a territorial hierarchy, and subsequently, a social hierarchy that includes access to networks and media forms, but also identities. The lack of presence of places further fades as the investment of resources—whether economic, commercial, technological—are

increasingly based on the data collected through networked means described. Images are within an assemblage of technologies that are reforming territorialization through the monitoring, measuring and calculating—turning landscapes into pixilated rationalities to track social action, and make decisions that affect vast populations.

Google Earth exists as a dominating form that embodies how maps present technology, mechanical objectivity, and standardization allow the world to be reduced to organized data bytes, rendering the visual perception of spaces as prioritizing the geographic and "to transmute the world into tradeable values. . . literally cod[ing] the modern world in ways that have turned geography into gold."[36] Further, maps engender space rather than being a passive representation of it. More than just a functional representation, satellite images present a dialectical relationship as communicative, representational, and hegemonic devices. The interfacing with graphical images is not just a reception of these ideologies, but a perceptive exchange deeply seated in other social norms and cultural imaginaries that contribute to the epistemological visual optic.

Conclusion

To understand what this technology has contributed to visualizing practices in how a particular way of seeing has emerged through the contemporary form of satellite imagery it is necessary to understand the multiple intersections of practices, ideas, technologies and structures that contribute to a logic of perception. Because seeing is normatively essentialized as a physiological practice, highlighting the historical construction of these converging logics offers insight into how the social imaginary has shifted to accommodate, and shape relationships between observers and objects that create subjectivities and practices. While *Powers of 10* offered a technological imaginary and new perspective of space, Google Earth both normalizes this visual logic while also being deeply embedded in configurations of data organization, individual manipulable simulations of space producing quantifiable measures of social action in a company-user feedback. Through the enfolded discourses of mechanical objectivity, automatic recording and archiving, and quantitative standardization—rendering data into comparable forms—the visualized spatial is normalized and embedded into daily life, hidden behind the interface in its design. The difference between subjective spatial experiences and this technologically represented reality is the social action that can not be mapped, that which is imprecise, unpredictable and allows for difference, change and possibility. Because perception or vision is not autonomous or inherent to a single subject, it is the collective assemblages of disparate parts that emerge through the normalized and normalizing practices of satellite image use that must be vigilantly 'seen'.

---

[1] Johnathan Crary Techniques of the Observer: On Vision and Modernity in the Nineteenth Century (Cambridge: MIT Press, 1992).

[2] See John Law "Actor-Network Theory and Material Semiotics," in Bryan S. Turner, The New Blackwell Companion to Social Theory 3rd Edition, (Blackwell, 2008), pp. 141-158; Bruno Latour, We Have Never Been Modern. (Cambridge: Harvard University Press, 1993).

[3] Jonathan Rosenberg, "Power of 2" Google: Official Blog, October 27, 2004. URL: http://googleblog.blogspot.com/2004/10/power-of-2.html
[4]Pett, Saul, "Versatile Charles Eames Impatient With Over-Simplification," Daily News, July 16, 1971.
[5] Kees Boeke, Cosmic View: The Universe in 40 Jumps (New York: John Day Company, 1957).
[6] Stephen Jay Gould, "Science," *New York Times*, Dec. 4, 1983.
[7] Gould, "Science" (above, n. 5)
[8] IBM, "Powers of 10 day, an adventure in Magnitudes," URL: http://www.ibm.com/ibm/ideasfromibm/us/powers_of_ten/20101010/index.shtml
[9] Orit Halpern, The Eye of Time: Histories of Representation, Perception, and Archiving in Cybernetic Thought (Durham, NC: Duke University Press, forthcoming), 5.
[10] This is due to government regulation of company contracts, though military reconnaissance satellites can see much closer.
[11] Halpern, The Eye of Time, p. 10.
[12] Halpern, The Eye of Time, p. 19.
[13] Gyorgy Kepes, Gyorgy Kepes: The MIT Years, 1945-1977 Cambridge, MA: MIT Press, 1978), p.4.
[14] Jeremy Crampton, "Keyhole, Google Earth, and 3D Worlds: An Interview with Avi Bar-Zeev," Cartographica 43:1 (2008) pp. 88-89.
[15] NASA, Goddard Flight Center, "The Landsat 7 Compositor" URL: http://landsat.gsfc.nasa.gov/education/compositor/index.html
[16] John May, "Preliminary Notes on the Historical Emergence of Statistical-Mechanical Geographic Vision," Perspecta: The Yale Journal of Architecture, 40, 2008, pp. 43.
[17] John May, "Preliminary Notes," p. 47.
[18] Michael Friendly, "Milestones in the History of Thematic Cartography, Statistical Graphics, and Data Viszualization" August 24, 2009, pp. 1-2. URL: http://www.math.yorku.ca/SCS/Gallery/milestone/milestone.pdf
[19] Michael Friendly, "A Brief History of Data Visualization," Handbook of Computational Statistics: Data Visualization, C. Chen, W. Härdle and A. Unwin, eds. (Heidelberg, Springer 2008) p. 37.
[20] Friendly, "Brief History."
[21] Clarence E. Smith, "CIA's Analysis of Soviet Science and Technology" in Watching the Bear: Essays on CIA's Analysis of the Soviet Union 1947-1991 Gerald K. Haines and Robert E. Leggett, ed (Center for the Study of Intelligence, Central Intelligence Agency, 2003).
[22] Lorranie Daston and Peter Galison, "The Image of Objectivity" Representations, Volume 0, Issue, Special Issue: Seeing Science (Autumn 1992) p. 119.
[23] Latour, We Have Never Been Modern.
[24] John Pickles, "Representations in an Electronic Age: Geography, GIS and Democracy" in Ground Truth: The Social Implications of Geographical Information Systems. (New York: The Guilford Press, 1995), x.

[25] Jason Farman, "The Digital Empire: Google Earth and the Process of Postmodern Cartography," New Media & Society. September 12:6 (2010) p. 875.
[26] Halpern, Eye of Time, p. 12.
[27] Jacques Derrida, Archive Fever: A Freudian Impression (Chicago: University of Chicago Press, 1998).
[28] Friedrich Kittler, Optical Media. (Cambridge, UK: Polity, 2010).
[29] Halpern, Eye of Time, 29.
[30] Michael Frank Goodchild, "Scale in GIS: An Overview," Geomorphology (2011) 130 p. 2.
[31] Goodchild, "Scale in GIS," 4.
[32] Steve Lohr, "The Age of Big Data," New York Times, February 11, 2012, URL: http://www.nytimes.com/2012/02/12/sunday-review/big-datas-impact-in-the-world.html?pagewanted=2&hp
[33] John Law, Evelyn Rupert, and Mike Savage, "The Double Social life of Methods". Centre for Research on Socio-Cultural Change, 2011, Working Paper No 95.
[34] Steve Lohr, "The Age of Big Data."
[35] Anne Galloway and Matthew Ward, "Locative Media as Socialising and Spatialising Practice: Learning from Archaeology" Leonardo Electronic Almanac, 14: 3/4, 2006, p. 28.
[36]John Pickles, A History of Spaces: Cartographic Reason, Mapping, and the Geo-Coded World (London: Routledge, 2004) p. 20.