Sensing in and Beyond the Digital Anthropocene

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Abstract
The imaging of landscape represents the many aesthetic parameters of human consciousness. From the realistic to the surreal, landscape is as evocative as it is political. But with the advent of remotely sensed data, many of which supersedes human capacities of vision, what does it mean to experience a landscape as a digital media object? This visual and textual research opens up a view into the surreal aesthetics of a politically fraught landscape as a digital and virtual reality. It features images as an ethnography of 'factual' image-making–revealing the historically and culturally situated nature of image production–in this case, remotely-sensed images of the most conflicted landscapes during the US-led War in Afghanistan between 2010-2014. These images were computed and created as part of ethnographic research under training with archaeologists performing *remote discovery*; a branch of archaeology that uses digital remote sensing to document vulnerable and threatened landscapes that are inaccessible due to physical and usually, political obstacles. Through an ethnographic approach towards computation, digital cartography, and modeling, I show how landscapes imaged with the digital data offer room for speculative and counter-narratives through the two aspects of *liminality* and *transduction*. Thus, whilst not an archaeologist myself, these images are part of my own creation and research through learning and applying geospatial methods for archaeological research. While my main methods and objectives have followed archaeologists' computational methods with remotely sensed data such as terrain modelling, topographical analysis, NDVI analysis, and probability mapping, I also incorporate interdisciplinary insights from: 1) remote sensing engineers and experts at the Swiss Institute of Technology ETH Zürich and the Geophysical sciences at the University of Chicago, and 2) artistic experiments with the data in Virtual Reality to visualize and experience terrain models using the programming environment called "Field" by the new media art collective called OpenEndedGroup. In this way, the project speaks to the genre of 'para-ethnography' – a collaborative mode of ethnographic research that involves "shared, discovered, and negotiated critical sensibilities" (Marcus 2000).

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Is There a Digital Anthropocene?

The Anthropocene concept has become increasingly controversial for a diverse number of reasons in recent decades. Some of these criticisms stem from the glossing over of the *anthropos* of the anthropocene – the assumption that all humans who are driving deep changes in the Earth's geological and geophysical process are all the same. Given the inequalities created by extractive economics in the fossil fuel industry, one questions if the drivers of the Anthropocene are not very specific groups of people who have historically relied on extraction from resource-rich regions of the world through colonialism (Hecht 2018). Certainly not all of humankind is the same here, for which the term Capitalocene has been proposed as a relatively better descriptive term. Taking away the *anthropos* from the anthropocene has other justifications as well. Feminist theorists like Donna Haraway have called for a move away from the Anthropocene term also to argue for the fact that human beings – the *anthropos* of the Anthropocene – are no longer identifiable as individual or particular beings within a larger web of ecological relations (Haraway 2015); a view we must adopt if we are to better grapple with rapid transformations happening to the Earth's geological processes. The concept of being exclusively human dissolves when we think of the Earth as a broader ecological relation of human and nonhuman beings. In its stead, Haraway proposes the term *Chthulucene* as a way forward from the hegemonic *anthropos* – calling for a new way of tentacular thinking for testing, touching and feeling the world through perceptions that are not merely "two-eyed, two-eared, two-armed and one-brained" but "many armed and many brained" as theorist Elli Moyasebi paraphrases it. This means finding ways of survival through thinking with other beings, selves and perspectives as is echoed in many multispecies ethnographies, even if that multispecies "other" is a machine made by humans. What then is a Digital Anthropocene when the word Anthropocene itself is so complicated, confounding and hotly contested?

For one, there is a digitally driven use of new media and computation that reshapes ecology, environment and landscape as a programmable interface (Gabrys 2016). Yet, I am even more interested in how it reshapes geographical imaginations through more-than-human modes of sensing. This enatils using sensors that capture heat, sound, moisture, humidity and bandwidths of light in a spectrum that lies outside of human perception, creating images that are often more ambiguous and indeterminate than experts would like. In this way, the digital anthropocene is an inadequate term, for it is more-than-human, entailing a collective, an ensemble of human and machine sensing that is constantly searching for new ways in which to map order onto a rapidly transforming world.

The epistemological role of sensory perception in regimes of knowledge and judgement have been well-charted by historians of science and technology. Amongst these is the well-accounted fact that hearing and seeing are techniques that have varied in their methods across the 19th and 20th centuries. The perception and treatment of perceived colour, hue, contrast and form have had a great role in creating and communicating scientific facts and information across regimes of trained judgement and mechanical objectivity (Daston and Galison 2007). Furthermore, through her work with glaciologists in Antarctica, anthropologist Jessica O'Reilly argues that hearing and seeing cannot be taken for granted as 'instinctual' or 'primitive' functions (O'Reilly 2016); they are carried out as techniques nestled within boundaries of expertise and disciplinary overlap. This paradigm is still relevant at some level in remote sensing technologies where this point of view becomes even more obvious and evident: to see and hear with sensing technologies is neither casual nor by chance. However, the more-than-human ensemble entailed offers many grey, ill-defined areas where one sensory modality overlaps with another, for example sound and vision, or temperature and vision. And these areas of overlap are sensorially interchangeable: they can be inhabited in stereoscopic vision or orthographic view. They can be exploded into particles and coordinates or coherently assembled to render a recognizable portrait. They are made *sensible* in different ways to allow the human and the machine to align in their goal and purpose. This is a space of chaos from which many different interchangeable pictorial speculations can emerge from within the gray areas between imagination and truth; quantitative and descriptive; sensorial and disembodied. As a process that precedes the eventual assembly and distribution of factual and evidential imagery in scientific and political contexts, I argue that this preliminary process of making sense of ambiguous datasets is an important process to account for, where the sensory qualities of the data suggest a certain kind of image to the expert. And it is within this grey area that speculation is possible before a determined image is circulated as a re-phrased fact. The remotely sensed dataset is replete with opportunity. A remotely-sensed computational process is a complex new media object derived from conversations and conversions across the tactile sensitivity of a sensors' surfaces, the acoustic systems that capture and transmit signals, and the visual affordances of the resulting dataset.

Remote sensing technologies do, of course, continue a deeply rooted history of the Eurocentric imperial gaze. Creating maps and images of remote landscapes with sensing technologies still does very well inhabit the same voyeurism and disembodiment of imperial cartographic vision (Cosgrove 1998, Mitchell 2008, Gregory 1994, Deutsche 1991); a gaze that seeks to create structure in what it percieves as 'chaotic'; a form of control that is imposed from outside the land being mapped. Classifications of subjects, lands, boundaries and borders occur just as much through remote sensing ensembles as they do within 18th century colonial cartographic missions. There is indeed a continuity of the imperial gaze that tries to align spaces of percieved disorder with its own logic and structure; an extraneous and rational mode of vision particular to the history of colonialism. Laura Kurgan's *Close Up from a Distance* carries this theme further in neo-colonial vein, initiating discourse on the capitalist structures that govern access to such remotely sensed data: it addresses the creation of databases on part of imperial powers like the US in their justifications for advancing kinetic action and war; along with a rebuilding of territories under conflict before the war is even over (Kurgan 2013). The imperial and military imperatives behind remotely sensed imagery of the war-torn Middle East and Central Asia becomes a commodity; reifying the role of remote sensing and its cameras, scanners and sensors as a tool of political domination and narrativization. For example, Lisa Parks' analysis of the satellite imagery surrounding the 1992 massacre of Srebrenica shows how the evidentiary nature of the satellite image is not at all "evident"; therefore states tell stories with satellite images through the use of narratives, often through textual labels and graphic overlays (Parks 2001). These narrativized images are a black box where the process of assembling the images and interpreting it for analysis remains opaque to the non-expert viewer. Such narratives around conflicted regions present remotely sensed images as an 'ultimate' or 'final' reading that seems natural, obvious and uncontroversial. It takes place without reference to the ambiguity or obscure recordings of satellites that are subject to their own orbits, times of day, and weather conditions while each being equipped with sensors that vary in their specifications.

Some of the ways in which remotely sensed imagery has been used in military and geopolitical contexts (such as the Iraq War) shows an obvious continuation of the Euro-American investment in privileging sight. However, my interest in this article is not to repeat this well-charted political history. I am concerned with challenging the idea of vision as a *singular* sensory modality – which becomes explicit when we look deeper into the in-betweenness of sound and image that exists in all the processes that precede the production of a final image. It is in this grey zone that speculative and imaginative processes reside, with the power to shape new meanings of the same landscape. I would like to emphasize that unpacking the latent opportunities in more-than-human geographical sensing entails grappling with *liminality* and *transduction* – the processes that occur in working with and analyzing the data captured by sensing technologies. I am concerned with how landscapes, especially conflicted ones, are made intelligible in more-than-human systems. By doing so, I will highlight how remotely sensed data, as deeply rooted in military and imperial visions as it may be, offers computational opportunities for avenues that are more rewarding than the long histories of imperial vision itself: a chance to inhabit the speculative facets of remote discovery and analysis; in which more questions are asked than answers offered. It offers a chance to construct speculative counter-narratives, and turn the imperial gaze upon itself. To imagine the geography of Helmand and Kandahar through a series of surreal and even un-recognizable portraits of more-than-human sensing. Produced under training and conversation with archaeologists at the University of Chicago, I investigate these remotely-sensed images through their process of creation that entails a process of conversion from one medium into another: acoustic to visual and vice-versa. Each image leads to another computation, producing and reproducing the same dataset in a myriad of ways that (re)figures the landscape continuously, allowing for multiple narratives of a militarized zone where insurgents are not the only ones to have caused violence and destruction of environment and heritage. To interrogate the materiality and possibilities of the datasets I also incorporate interdisciplinary insights from a few other field sites and collaborators as well: 1) remote sensing engineers and experts at the Swiss Institute of Technology ETH Zürich and the Geophysical sciences at the University of Chicago, and 2) artistic experiments with the data in Virtual Reality to visualize and experience terrain models using the programming environment called “Field” by the OpenEndedGroup. I refer also to the civilian imaging company Maxar that dominates the world of satellite imagery, and a programming environment called Circuitscape created by engineers and scientists Brad McRae, Viral Shah, Tanmay Mohapatra, and Ranjan Anantharaman.

On Remoteness

To be remote is to be distant and close at the same time (Kurgan 2013); oftentimes that distance implied here is to be physically far but visually close. Late 19th century ethnographies of Afghanistan (see Robertson 1896) often describe some villages and territories (then called “Kafiristan”) beyond the Durand line as “remote”, since they lay beyond the well-mapped and traversed borders of the British Raj and its grand project of building logistical infrastructure. Kafiristan, a mythical series of highland villages were considered removed from access to British soldiers due to their terrain and topography – but also “remote” by virtue of their lack of logistical connection to the territories of British India. As an extra-colonial space, the inconquerable “otherness” of Kafiristan was a geographically inaccessible otherness, entailing a series of carefully guarded highland villages of steep and formidable terrain requiring distinct cultural rites from any foreigners wishing to enter them. Here, a remote territory in the mind of the imperial system was to be poorly connected and even almost aloof. To be separated from what is central; to be peripheral and maybe untameable, unintelligible, or unchartable. In this imperial sense, to be remote implies being unstructured, and at times, unrestrained. However, in another sense, to be remote is also tied to a kind of action: the 'overseer' of distant lands, from the vantage point of an empire – one of the many facets of colonialism. It creates subject positions of who is remote and from what. Remoteness in this sense signifies a kind of operation or use at a distance without having to embody or identify with the object under control. The lack of tactile contact between a surface and the human operating it is thus to be remote. Here, the power is for the one operating at a distance; for remoteness producers controllers.

However, my ethnographic research with using these datasets and technologies illuminated yet another kind of remoteness; one that does not necessarily have to succumb to these already well-charted imperial histories as a distance between the observer and the observed. The *remoteness* of remote sensing also entails a series of mediated subject positions within fully networked systems. To see temperature and experience acoustic *sight* in combination with a set of autonomous sensing technologies opens up a kind of remoteness that addresses the *perceptual* distance between the way that humans and machines sense differently. To be remote isn't always to be physically distant; distance can also be construed as a perceptual distance and this does not mean that the voyeurism of the imperial gaze has become irrelevant. Instead, it complicates the idea of voyeurism, since the sensing expert doesn't simply view, but also *inhabits* perceptual systems outside their own biological sensorium. This entails seeing like a infrared sensor, or experiencing terrain through an acoustic signal. It certainly maps order through borders and classification systems in much the same way as imperial cartography did, but the datasets – often publicly available to use in environmental research – have many affordances that also allow for continuous and successive reclassification and reordering. One single dataset is often enough to be able to tell several narratives all at once, becoming a speculative tool amongst diverse groups of researchers for counter-narration or speculative imaginations of the same landscape. In short, remote sensing need not be reducible to the military and imperial imperative alone, and much of this is due to two aspects of remotely sensed data that I wish to illuminate: *liminality* and *transduction*.

On Liminality and Transduction in Remote Sensing

In the the early twentieth century, the word liminal in psychology concerned a certain sensory threshold; to be barely perceptible. For example, a vibration that is sensed in a tactile way but not heard as sound. Or more precisely, a frequency of sound that lies so close at the lowest threshold of human hearing, that it is barely detectable, requiring an immense level of sensitivity to be sensed or heard. Liminality was also used in this way to describe something that lies at a gateway between two stages. Thus construed, it can be considered a transitional or intermediate state; or to be right at the border between two sides. For example, to be both a sound and an image. Or to be convertible between the two and while not being exclusively one or the other. Much of remotely sensed data is exactly like this; it may be captured by acoustic systems or it may describe an acoustic phenomenon while being more easily expressed in imagery than as sound. Similarly, some sensor bandwidths such as infrared, are sensitive to surface textures and smoothness, recording them in ways that might also be interpreted as temperature. There is a sensorial fluidity in what the dataset represents, depending upon what kind of sensor recorded it. And in order to process such sensory liminality, the analyst often processes the data in a series of *transductions* – conversions from one medium into a corresponding one, or one signal format into a series of corresponding wavelength and frequencies. The anthropologist Stephan Helmreich illuminates the importance of transduction as a process by which both perceptible and imperceptible phenomena are made intelligible, into meaningful natural objects like ocean waves or in this case, topography and terrain in the process of remote archaeological discovery.

1. Landscape as a Sounding

Figure 1 features the confluence of Kandahar, Helmand, Uruzgan and Zabul from a mosaic of radar soundings collected from the Shuttle Radar Topography Mission (SRTM) in 2000, the turn of the new millennium. Led by The National Aeronautics and Space Administration (NASA) and the National Geospatial-Intelligence Agency (NGA), the mission was an international project for creating the very first comprehensive database of global land elevations. Every pixel in this image represents one *sounding*, the height of a single point on the ground sensed by radar. Versatile forms of analysis can be performed with the help of this radar-sensed dataset because it produces a simulation of a real landscape that has been surveyed at a fixed moment in time (in this case, February 2000) and in space (over a prescribed orbit of the shuttle). A *sounding* refers to a unit of three-dimensional measurement created by the contact between an electromagnetic wave and landcover materials on the surface being scanned. As the shuttle flew over Afghanistan at this moment in 2000, the radar antenna mounted on the shuttle scattered electromagnetic radio waves towards the surface of the Earth. The waves bounced back after making contact with the surface of the Earth. When bouncing back, the sensor measures a signal indicating how close or distant the point of return was, interpreting it as the height of the terrain. Shiny, reflective or smooth surfaces reflected the wave back at the

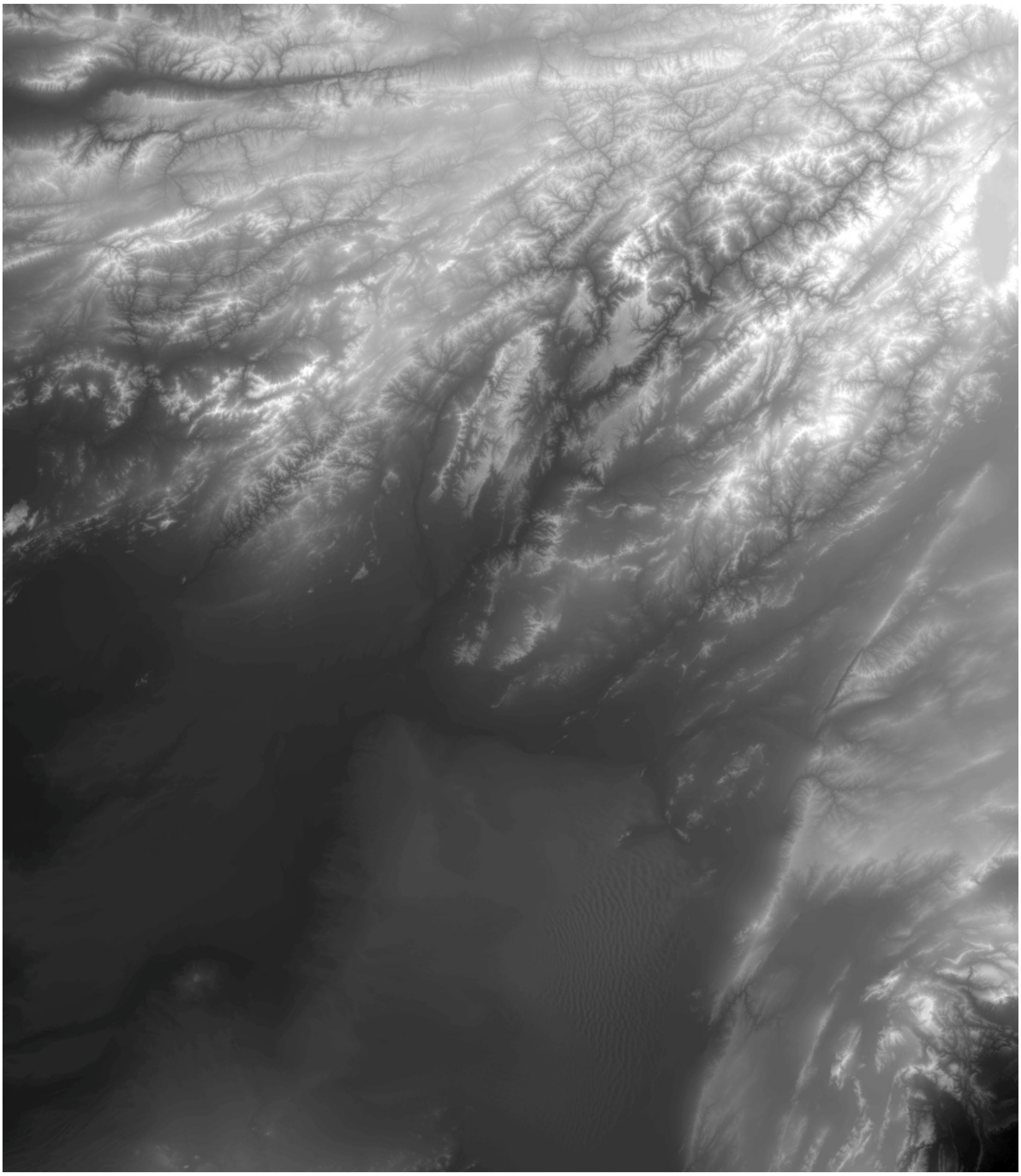

Figure 1. A rendered version of a radar-sensed Digital Elevation Model (DEM) captured by the Shuttle Radar Topography Mission in the 2000s, USGS Earth Explore. Computed and rendered by the author.

sensor, strong and sharp. Textured land cover absorbs and diffuses the signals, returning it as a much more attenuated signal than the one that was sent out. Angular protrusions like rocky areas and mountainous terrain with high deviation between the highest and lowest points on their surface deflect the waves until they meet and bounce off another surface to return the signal back to the sensor. One single sounding is thus the holistic sum of these many reactions over a 30-meter spatial resolution. We can say that the final value sounding recorded by the sensor is but a relational, acoustic, and interactive choreography of between the radio wave, the topographical properties of the terrain, and the sensing abilities of the radar antenna that are subjected to the analysts' interpretations and computational practices. The apparatus (radar) that measures and captures information thus becomes a part of the very materiality of the object under observation (terrain elevation), evoking the term 'material discursivity' (Barad, 2003) and how matter and meaning are mutually entangled in a single scientific object.

This three-dimensional mapping of the surface of the Earth by the SRTM is called a Digital Elevation Model (DEM) and has since become a timeless dataset used by researchers across multiple fields and disciplines that might be even remotely concerned with the Earth's landforms. Thus, analysts in a diverse range of fields use it to their own ends. Glaciologists might use it to pinpoint the moments in time when icebergs have calved, geologists might use it to model the form of terrain as it might have looked in the past, and landscape archaeologists might use it to speculate upon historical migration routes. The dataset can be computed in ways that show not only the present form of the landscape, but also help to generate models that create hypotheses of its past – i.e., historic morphology – the historic evolution of its shapes and forms. While these tasks seem highly mathematical, quantitative, and computational, the dataset has inherent sensory affordances – the manner in which the terrain is classified offers the analyst overall visual "impressions", which, at a glance, allow them to select specific features on the surface of the earth that they wish to isolate or emphasize from others in the model. Oftentimes, exaggerated brightness and contrast are used to do this (*Figure 2*). These sensory qualities carry "the cognitive, affective, and social effects" of media technologies and how they make the world 'sense-able' to humans (Helmreich 2007).

I wish to point out just how liminal this radar-sensed model is with regard to its sensory modality. Remote sensing apparatuses like scanners, cameras and other recording devices are designed to hear and see, but in ranges of the electromagnetic spectrum that differ from humans. They also entail a different modality in terms of spatial systems – remote sensing devices do not hear binaurally nor see stereoscopically by default, unless they are calibrated on purpose to do so. In the case of radar sensing, the DEM image you see in this article is derived from data that is not visual; the data has a somewhat liminal status in-between sound and image. Radar is an acronym for Radio Detection and Ranging, referring to electromagnetic radiation with wavelengths longer than light for transmitting sound messages. They are acoustic in nature, ranging between 300 gigahertz to 30 hertz, making sound communication and transmission possible in television, radio, cellphones, and satellite systems. This image is thus a case of 'transduction' – referring to changes in the state of signals and energy – but applied in a linguistic perspective by anthropologist Stefan Helmreich as the conversion of signals across media formats from one modality into another in order to render a meaningful natural object (Helmreich 2007). Thinking beyond a digital anthropocene requires acknowledgment of this process of *transduction* – where human experts navigate these manifold sensory modalities captured by sensing machines. The liminal nature of such data that is 'sensed', yet is neither sound nor image nor tactile to begin with, offers us the possibility of creating many narratives and counter-narratives with a single dataset and herein lies the greatest potential of working with such technologies. The following images demonstrate this through presenting the various interpretations of this single DEM seen in *Figure 1*.

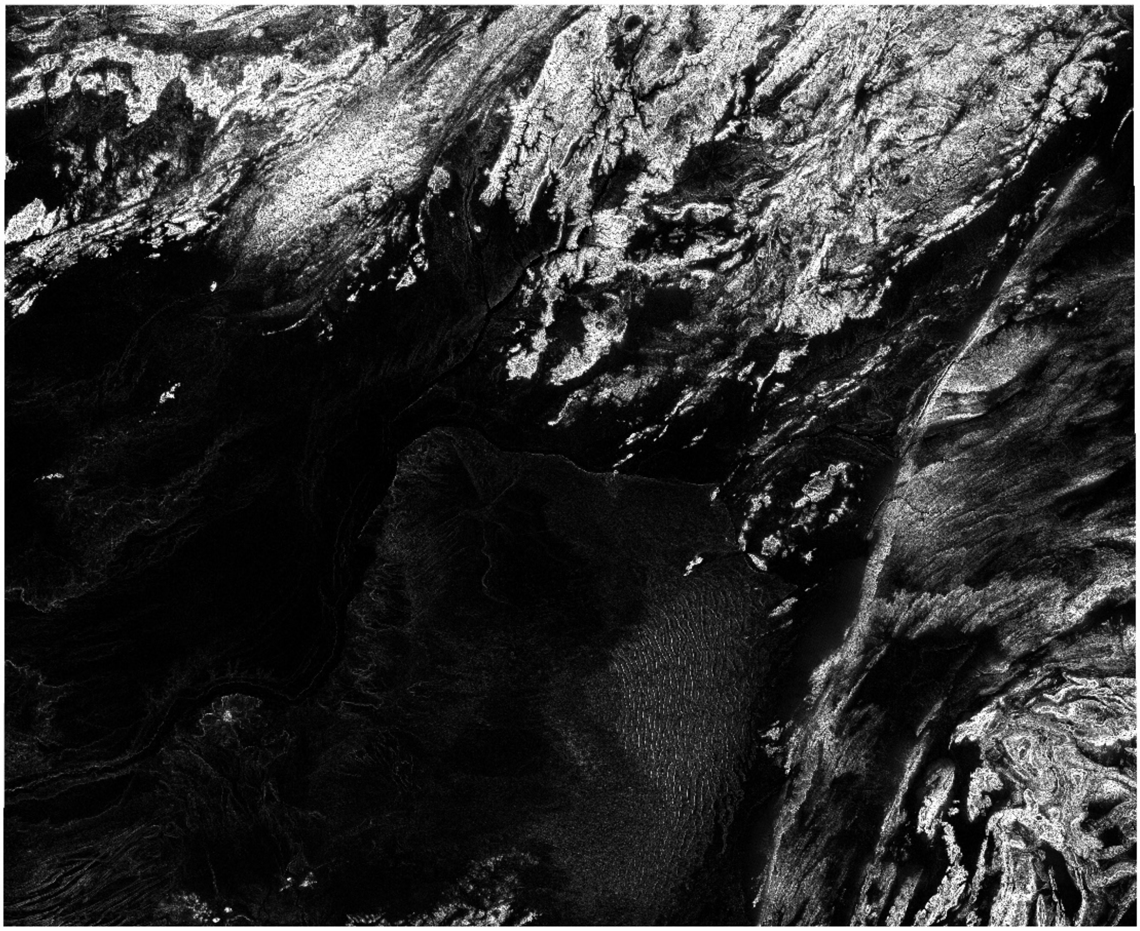

Figure 2. The same DEM data shown in *Figure 1*, rendered as topographical deviation, showing the areas with greatest terrain fluctuation. Computed and rendered by author.

2. Landscape as a Contrast

In *Terrain as Insurgent Weapon*, political geographer Gaston Gordillo writes about the affective geometry of mountainous areas of high topographical variation. Writing about the on-the-ground, embodied and phenomenological aspects of hiding and camouflaging in Afghanistan's Korengal Valley, he cites the importance of understanding weather, seasons and ambience in areas of high topographical fluctuation where Taliban insurgents hid from the intelligence of NATO troops. Topographical deviation (*Figure 2*) shows the intensity with which the highest and lowest points of a landscape occur within a short distance from each other. In this image you are seeing a speculation of areas in which there is high contrast between smooth and rough areas, and steep slopes that go from very low to very high in a short amount of distance. From a military planning view, such interpretations of the DEM in *Figure 2* allow speculation on where insurgents are likely to hide and camouflage themselves due to the extreme variations in the form of the terrain. They also show which areas are tactically dangerous; where high variations can also result in unexpected attack. And yet, these interpretations of landscape for archaeological purposes allow the mapping of the region to reflect its most iconic terrain. They are also most likely distinctive and prominent in their shape and form; possibly able to offer visual landmarks and become visually iconic when seen from particular lines of sight, making it possible to think about them from a monumental perspective. High topographic variation entails seeing landscapes through the lens of contrast and salience that mean different things to different observers. For example, they can represent helpful landmarks for locals traversing the region on foot. They can represent places where insurgents can hide from the all-seeing eyes of military surveillance (for example, large and smooth boulders in mountainous topography can confuse the infrared sensors of drones from certain distances, offering relief from armed drones). They can represent areas too steep to climb and might inform military analysts on which areas to rule out as possible hiding areas for insurgents. Computed in a sequence using the same dataset as *Figure 1*, this image quickly goes from a point of departure for thinking archaeologically about wayfaring and culturally iconic topographies to being a comment on military tactical (dis)advantage. It presents aspects of an archaeological landscape where the topographical distinctness itself becomes a series of many possible narratives – a game of hide-and-seek; an iconic terrain as a cultural object; a cognitive process of wayfinding; a textured space of contrast and salience to a human traveler. But it does not do so ready-made for the human eye, instead offering a quality of the terrain that can be read as salience through transductions and conversions of the dataset.

Figure 3. Using the same DEM data shown in *Figure 1* (rotated 90 degrees), the region is re-mapped with the Circuitscape program to generate a probability-based connectivity map that shows areas more likely to be traversed by the human body. Computed and rendered by author.

3. Landscape as Connectivity, Probability

In the 2000s, software engineers and conservationists Brad McRae, Viral Shah, Tanmay Mohapatra, and Ranjan Anantharaman wrote a new programming tool called Circuitscape to model landscape connectivity. Arguing for a more speculative and multi-dimensional approach towards environmental phenomena, their program allowed analysts to model multiple connective pathways in landscape analysis. Answering the problem of randomized walking in migration analysis, Circuitscape enabled visual modeling of ecological connectivity based on probability that spanned across the disciplines of ecology and conservation. While probability maps have a long history in cartographic imagination starting from the military cartographies of French engineers in the Old Regime of the 1800s, Circuitscape is now established in archaeology as a contemporary means of expressing the probability of movement of humans and nonhumans across landscapes with an ecological interaction of multiple environmental criteria in the same model. I computed this model using Circuitscape yet again from the same DEM in *Figure 1*. The resulting landscape connectivity model in *Figure 3* represents the common pathways and networks between 6 crucial archaeological sites and the preponderance of IED (improvised explosive devices) in the Kandahar-Helmand region of Southern Afghanistan. In this map, each pixel represents the likelihood that the human body on the ground will traverse that point based on energy cost (the energy taken by humans to hike) and the slope steepness of the terrain. I computed this map under training to assess the logistical ease between prominent militarized archaeological sites in the region – i.e., military bases that had been turned into archaeological sites – with regard to the broader connectivity in the landscape where the Wikileaks Afghanistan War logs showed the highest number of IED attacks. Again, such an image reflects upon a military tactical vision (Bélanger and Arroyo 2016) of where alternative road-building was possible in landscape littered with IEDs as if it were minefield– on the other hand, it shows where movement is most likely and possible on a scale of white (high likelihood) to black (the lowest likelihood). The greatest narrative that emerges from this connectivity map is the high preponderance of militarized archaeological sites in one of the most violent hotspots of the war. Yet it also speculatively offers a depiction of the landscape as a historical connectivity between monuments, showing a continuity in the treatment of the region's terrain as an infrastucture. As ISAF troops came to occupy and connect archaeological sites that militarized – and successively fragilized – a historically and culturally important network of heritage sites. the computation expresses more than a mere formal structure of terrain; it tells narratives of how an ancient landscape's most powerful and iconic topographies also become its most fragile and vulnerable spots. This model does not just communicate power, it also illuminates a narrative about how infrastructural strength becomes tactical vulnerability.

A curious aspect of such computation is the way that the landscape ceases to be recognizable to the human as a terrain. At first glance, it barely resembles what the human eye recognizes as a landscape. Appearing more like a microorganism seen under a microscope, its details are wispy and stringy; each computational 'transduction' of the map changes the visual form of the landscape using the same terrain data until it no longer looks like what the analyst started with. In doing so, the analyst is required to first *unlearn* the landscape, and then relearn it anew. This is one of the most distinctive capacity of more-than-human sensing – to make the familiar unfamiliar in ways that open up new imaginations of territory. As destructive as its military application may be, for the archaeologist the dataset can be assembled in ways that open up powerful speculative imaginations of what the Arghandab Valley in Kandahar could look like. The transductive process forces the analyst to think through a different kind of geometry to imagine an alternative system of relations.

Figure 4. An image of the Helmand-Kandahar region from Maxar, at 30-meter resolution. It It is a patchwork of five years of data from 2009-2014, rendered in "true" colors that mimic the way the human eye sees colour. DigitalGlobe, 2017.

4. Landscape as an Average

Maxar (formerly DigitalGlobe) is a private company owning and operating a network of civilian satellites and their imaging technologies. The satellite images used by researchers in a diverse range of disciplines are made available via Maxar's satellites. Dominating the world of geographical imaging, Maxar's data forms the base of all contemporary geographical products from Google Maps to industry-standard basemaps in geographical analysis. Offering a perfect 60 meters of cloudless resolution, Maxar's satellite imaging offers a commercial product that is not without its own series of complex computational processes. Marketing cloudless resolutions to researchers, Maxar overcomes the problem of weather-based obscurity in geographical imaging by computationally averaging together several years of image-data into one single, perfect cloudless image for researchers to work with. This image (*Figure 4*) is not a photograph, though it is computed to look like one as it would appear to human eyes. The image is instead an idealized form of the landscape not belonging to any one moment in time or space; but 5 years of the clearest satellite bandwidths that compromise the specificity of one single timestamp in favour of the most cloudless image possible. Their process eliminates the uniqueness of the landscape under varying conditions of weather. In *The Conflict Shoreline*, author Eyal Weizman reflects similarly on how the aerial imaging of the Negev desert in Israel is possible only within certain months in the year in which the aridity of the desert makes a cloudless view possible. Meanwhile the relatively more vegetated state of the region gets omitted from view during the rest of the year when it rains, reducing the area to an image of arid, barren and infertile land (Weizman and Sheikh 2015). Reckoning with the composite image-making techniques of the 19th century by overlaying and removing deviations from hundreds of images, this Ma/xar image is a computerized average of many times, spaces and satellite orbits, offering the illusion of clarity. A quick glance at the images metadata explains this: some pixel-groups in the image come from 2009, while others are extracted from 2005, 2004 and 2003 under varying times of year.

Image-averaging has a long and disturbing history in regimes of surveillance, criminal profiling and forensics. However, averaging as a technique in geographical analysis is a peculiar kind of transduction. It is created from an existing set of images, yet also generates a *new* image that is distinct from each of the images (or in this case, data) used in its production. What it produces is an image rendered in *true* colour – i.e., the colours that the human eye would see if flying over the region, along with a set of topographical and land cover properties whose averages represent a uniform reality — an 'idealised' landscape. Devoid of its diverse landcover, it is an image that is research-worthy, but which does not carry the unique stamp of time, date, year or weather. It exists as an idea, a template, a benchmark for a perfect rendering that gives the human full visibility. This kind of transduction makes an image that narrates physical properties, but provides no atmospheric values. It is devoid of speculative imaginations until it is reversed back to its constituent datasets: all the blurry and obscure cloud-covered images with messy patches of missing data and its unwieldy, unrecognizable features from which deviations had been omitted and erased (*Figure 5*).

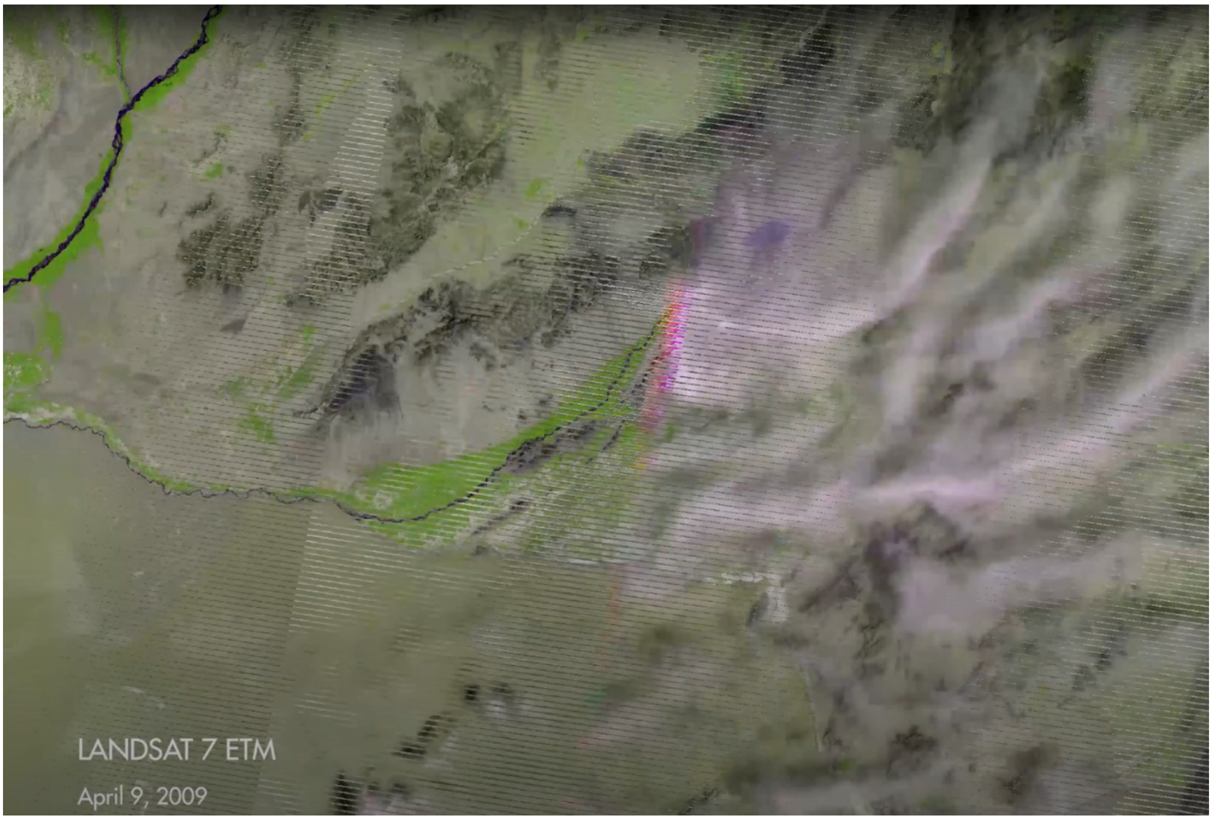

Figure 5. An image computed and rendered from LANDSAT-7 data from 2009, showing just how low visibility is when there is cloud cover. This is not an averaged image. Furthermore, a problem with the satellite's scan-line shows zig-zag patterns of missing data. Computed and rendered by author. USGS Earth Explorer.

5. Landscape as a Point Cloud

Although radar is so fundamentally acoustic in nature, analysts visualize it to make its unwieldy realities more legible. It is not pictorial before it is computed. The radar signals show up as waveform oscillations of the soundings, which are indeed visual, but do not form a picture of the landscape surveyed but represent the physics of the soundings. As part of fieldwork interviews, a computer vision scientist I contacted in the department of Remote Sensing and Photogrammetry at ETH Zürich tells me it is a dataset that is, at best, "image-like, but not an image until it is computed to become one." This process of an analyst visualizing a dataset to extract rich visual information from that which is only "image-like" to begin with, can be assumed a 'transductive' process in which "the technical transformations of sound and signal that support (cybernetic) sensibility and consciousness" become a focal object, with the aim prod and uncover "the cognitive, affective, and social effects of transducing", i.e., the conversion of "the physical nature or medium of a signal into corresponding variations in another medium" (Helmreich 2007). Becoming the basis upon which natural or cultural objects become imbued with social significance, this is a process of constant oscillation between mediated 'sensory evidence' and 'formal intellect' (Picon 2018).

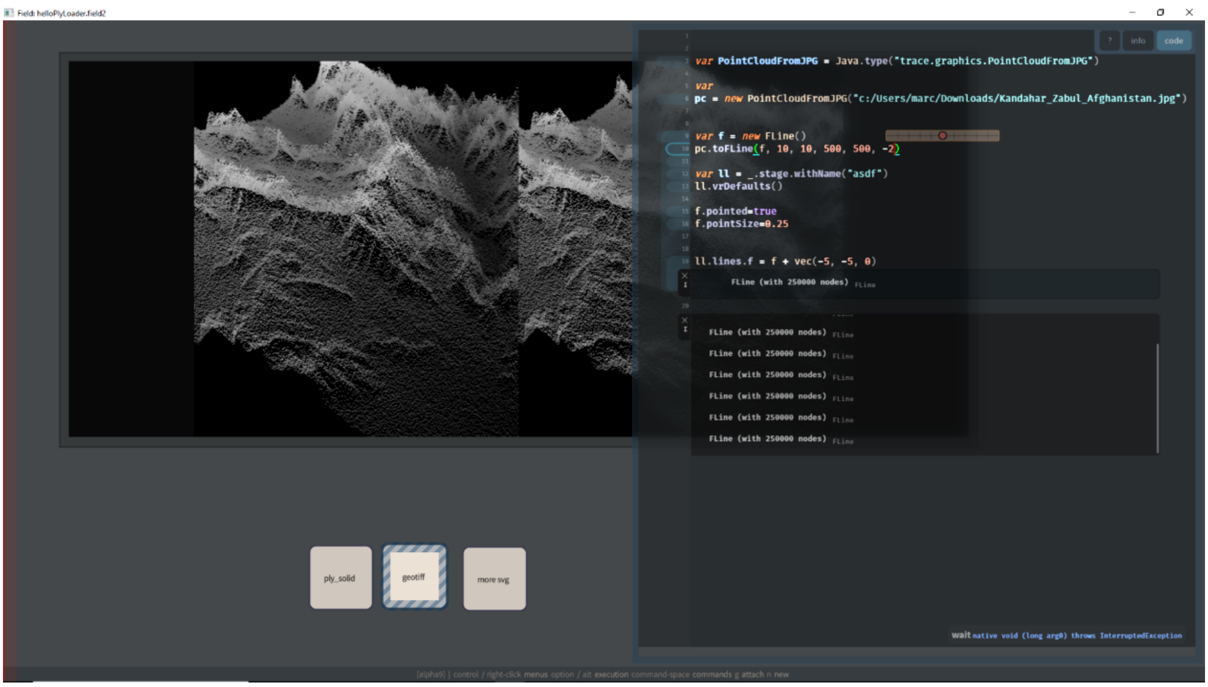

Figure 6. A 3D point-cloud under construction for a Virtual Reality (VR) demonstration using the program Field by the OpenEndedGroup. Credits: Author with Marc Downie.

Geophysicists often create randomization with such DEM datasets to look for features of a terrain that persist despite the randomized changes in topography. It helps model, albeit speculatively, what the same terrain could have looked like in the past or will look like in the future, based on surface features that reoccur in tandem with each other every time a new random configuration is made (*Figure 6*). As I attempt to perform this task, I am reminded by the software architect of the program that "math is not random". By generating a new randomized configuration, the model no longer appears like an identifiable landscape; the valleys and mountains disappear into numerous points that are no longer patterned to look like anything. There is no pictorial representation anymore, only chaos. I see no structure, no image, and hence, no information at first. "Look at those points that emerge together each time you make a new random configuration," the software architect points to the screen, "See how those points trail together each time? Do you think they represent the dips of the valleys?" Under training with a virtual reality (VR) artist, I take the DEM into a virtual stereoscopic world where the DEM is no longer a flat image but a spatial object one can fly over. We are not the first people to fly over the terrain of Afghanistan in VR", he says, "but we are maybe among a group of people to do something else with it". That 'something else' is to interrogate its very construction in the first place.

Beyond the Digital Anthropocene

Following the series of remotely sensed transductions above, I argue that the collaboration between human sensing abilities and the capacities and affordances of machines and technologies created what philosopher Gilbert Simondon would argue as a human-technological ensemble. In many ways it represents a kind of many-eyed and many-eared way of testing and feeling landscapes and their affordances. At the same time, the end to which this many-eyed and many-eared testing and feeling is put to use is deeply anthropocentric as we see in this morphology of Afghanistan's most ancient but also politically-troubled landscapes; rendering the interpretations of sensed landscapes and geographies to political and military interests. However, as argued in the beginning of this article, the liminality of remotely sensed data before these transductions means it is neither image, nor sound, nor texture, nor terrain to begin with. It is with this promising liminality that one can resist the notion of one single narrative about terrain and topography as an instrument of war in an ancient landscape.

Through these images, I focus on the liminality and transductive processes of remotely sensed data and its analysis, as a method that is connected to structures of power but is also a tactic for some hope – that the networks of sensing need not be merely objectifying tools of hegemonic military histories of tactical vision. There are opportunities to tell multiple stories with one dataset alone, and to use it in different ways that allow the landscape to move fluidly between subject (a fragile and vulnerable place) and object (a quantitative space). In order to better chart the opportunities offered by such fluidity, the concepts of liminality and transduction in such environmental sensing data are key. I argue that they are all part and parcel of a concept of human-environment relations in which visuals, sounds and words come together holistically in a single image to signify human intelligence of a terrain. The liminality (or the indeterminate nature) of sound, images and words in these datasets that are used for constructing and understanding spatial relations are thus the ground for a more fluid empiricism – i.e, a kind of empiricism where sensory impressions do not occur in a singular modality. Sound is not always heard and lightwaves are not always seen. It is through transductive processes that they come to embody the meanings we make of them. In this way, it is a phenomenon that precedes the eventual image that is circulated in pedagogical, institutional and most importantly – political contexts. In all of this, remoteness must come to be seen much more conceptually – as the distance that always remains between the human sensorium and that of the machinic sensor. That remoteness is a *sensory* distance rather than a physical one, relevant to a multiperspectivist view such as that of Eduardo Vivieros de Castro's – an ontological perceptual distance between how humans and nonhumans sense and perceive differently (de Castro 2013). We are thus looking at knowledge as a constant *negotiation* with the perception of materiality in the digital realm; and not a hackneyed problem of representation from within the subject-object dichotomy. In a world of sensors that are mapping and transmitting information ceaselessly, transductive processes become a salient tactic by which researchers grapple with are the multiple and manifold modalities that allow for narratives and their speculative alternates to exist hand-in-hand within a single dataset

Thus, what this liminality and transduction in sensing technologies offers is first – a chance to embody rather than witness the construction of Anthropocenic imagery in all its nuances and then having done so – to move away from the anthropocenic by inhabiting its speculative potential. While the categories of Anthropocene/Capitalocene/Chthulucene offer equally critical perspectives on what it means to be human, these digital technologies remind us that it is the realm of the sensory, in all its ambiguity and intertwined sensibilities, where the negotiation begins. These technologies are distributed in scale and diverse in sensory modalities, for example they mobilize acoustic soundings to offer a glimpse into the texture of something we cannot touch for ourselves and allow us to visualize topographies we didn't expect. Its speculative potential, furthermore, allows other narratives to emerge through the process of "seeing faithfully from another point of view" (Haraway 1988). In a world of sensors that are mapping and transmitting information ceaselessly, transductive processes become a tactic by which researchers grapple with the multiple and manifold modalities that allow for narratives and their speculative alternates to exist hand-in-hand within a single dataset.

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