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# The deception of an infinite view – exploring machine vision in digital art

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**This paper examines prediction product called *Queryable Earth* a project to "make Earth searchable for all". A project pitched by the company Planet, owner of the largest fleet of Earth-imaging satellites in orbit and an archive of satellite images growing with terabytes of fresh data every day. The aim of *Queryable Earth* is to combine geospatial intelligence with machine learning. By training artificial neural networks to classify objects, identify geographic features, and monitor change over time, the implied intention is to create a predictive, omniscient oracle. In this paper *Queryable Earth* functions as an example of a 'nonconscious cognitive assemblage' combining aerial image with machine learning techniques such as artificial neural networks. To examine the predictive potential and the assumed objectivity of machine vision systems such as *Queryable Earth* I turn to histories of aerial photography and examples of contemporary digital art to illustrate how human and technical cognition entwine revealing how seemingly automated processes such as rendering of satellite images and pattern recognition still inherit human biases and are prone to emphasize them. Furthermore, I use digital artworks to illustrate how *Queryable Earth* as an "all seeing machine" is limited to a singular aerial perspective which cannot penetrate the surface and how predictions produced by such systems are constrained the quality and selection of data they are trained on.**

**Digital Art, Machine Vision, Geospatial Intelligence, Machine Learning, Aerial Photography**

## 1. INTRODUCTION

With the objective to examine what limits of machine vision digital art can reveal, I will be focusing on a very specific combination of machine vision technologies: satellite images and machine learning. I will be using Planet's *Queryable Earth* as an example of what Shoshana Zuboff calls a surveillance capitalist's prediction product (Zuboff, 2019). Planet's aim is to create a tool for tracking, targeting and predicting change on Earth. Their vision is to "index physical change on Earth and make it searchable for all." (Marshall, 2018) *Queryable Earth* is not yet an existing product, however many of the technologies required for this project are available. Planet's webpage lists the behavioural future markets the prediction product is most likely intended for: agriculture, civil government, defence & intelligence, education & research, emergency management, energy & infrastructure, finance & business, forestry & land use, insurance, mapping and maritime. ("Satellite Imagery, Insight and Monitoring Solutions by Market," 2019). If *Queryable Earth* and products alike are intended to eventually predict change and "empower people with the insights that drive better decision-making" (Marshall, 2018), it is worthwhile to examine its technical, material and cognitive boundaries. Rather than conducting close readings on one or just a few artworks, I have chosen to use *Queryable Earth* as a case study and I will be approaching this emerging prediction product through a number of artworks.

When artist Clement Valla describes his work *Postcards from Google Earth* (2014), he thought that the stretched highways and bridges resembling Salvador Dalí's clocks in *Persistence of Memory* (1931) were digital glitches and errors. Soon he realized that he was witnessing the logic of the automated machine vision at work. The image is actually a database of constantly updated images stitched together by a software to create an endless view in a limited data space (Hoelzl & Marie, 2015). Valla's images bring to focus processes of creating images that incorporate "network of algorithms, computers, storage systems, automated cameras, maps, pilots, engineers, photographers, surveyors and map-makers that generate them". (Valla, n.d) When one uses Google Earth or a future *Queryable Earth* according to N. Katherine Hayles, the person becomes part of a nonconscious cognitive

assemblage "including technical and human cognizers" (Hayles, 2017, prologue:2), an assemblage that includes human, biological, technical and material components. Hence, in applications such as *Queryable Earth* human and technical cognition are deeply entwined and ought to be considered when evaluating predictions, such a system produces.

What makes *Queryable Earth* especially interesting as a case study is their wish to remove the image from the interface. The aim is to train the machine to interpret satellite images in order to answer queries such as "how many planes were on an airport on a specific day" or "how many trees were cut in a rainforest over a certain time period". Such an interface leads to a situation in which most satellite images produced will never be seen by human eyes, instead data extracted from those images is solely intended for machine to machine communication. *Queryable Earth* is exemplifying Trevor Paglen's concept of 'seeing-machines' (Paglen, 2014). Paglen writes about this fundamental change in the world of images: "These images aren't meant for us: they're meant to do things in the world; human eyes aren't in the loop" (in Heiser, 2014). However, despite the ambition of removing the images from the interface, Marshall asks us to trust the image. With his statement "Pictures don't lie" (Planet, 2018a) he is implying that satellite images interpreted by machines are not touched by the human hand, hence they appear to be objective. However, artworks such as Emilio Vavarella's *THE GOOGLE TRILOGY – 3.The Driver and the Cameras* (2012) unveil the role of human labour in the seemingly fully automated production of image making. In this artwork Vavarella has captured eleven images of google car drivers who are maintaining the street view cameras. Vavarella's work exemplifies Hayles' argument that 'nonconscious cognitive assemblages' have 'punctuated agency', affirming that such systems need longer periods of human agency in designing, programming and further maintaining the systems, so that these systems are able to work autonomously for a shorter period of time. Vavarella (2012) interprets the visibility of the drivers faces in Google Street View as a symbol of an error, and wonders if they reveal the limits of technological power.

## 2. AERIAL PHOTOGRAPHY – LIMITED TO THE SURFACE

As many machine vision technologies, the advancements in aerial photography such as that used in *Queryable Earth* have also been propelled by warfare. According to established Western narratives of aerial views, a camera's ability to capture anything in its aim resulted in an arms race of aerial image making that led to the launching of the 'super eye' into the orbit during the Cold War. (Bousquet, 2018) The linear progression and techno-determinism of aviation and aerial image making has been problematized (Kaplan, 2018), yet the aura of reality and truth linked to aerial photographs endure. Donna Haraway (1988) in *Situated Knowledges*, describes how "the eye of any ordinary primate like us can be endlessly enhanced" (p.582). The desire to augment and eventually see without the human eye has been especially evident in military context. Haraway does bring us to the conclusion that the "view of infinite vision is an illusion", however the desire to "see everything from nowhere" is what has propelled aerial machine vision. Since the renaissance and the linear perspective, first with the help of mathematical techniques and instruments, and later through automatization machine vision technologies have gradually tried to remove the human from processes of image making. Linear perspective and general projective geometry laid the base for surveying and mapping the enemy terrain. Alberti's *De Pictura* is credited for formalizing the rules of linear perspective and Albrecht Dürers string method is present as an early strategy to eliminate the human eye from the process of creating a pictorial representation (Bousquet, 2018). The telescope allowed the commander to overlook the battlefield from an established headquarter and reconnaissance missions could now be done from a safe distance (Bousquet, 2018). Félix Tournachon, better known as the political cartoonist and portrait photographer "Nadar", is celebrated for having made the first aerial photographs from an air balloon. Due to the loss of Nadar's first photographs, *Boston, as the Eagle and the Wild Goose See It* by James Wallace Black taken 1860, is the earliest aerial photograph from a balloon which remain until today (Kaplan, 2018). British meteorologist Douglas Archibald is honoured for making the first experiments using kites and cameras. In his book he describes an 1887 attempt "to photograph objects below by means of a camera attached to the kite wire" (Archibald, 1897, p.185).

A great deal of resources, effort and enthusiasm have gone into developing and perfecting techniques of aerial photography. Some were speculative, other flawed or technological dead-ends. Artist Andreas Zingerle's media archaeological work *Überfliger* (2009) reconstructs an aerial reconnaissance technique invented in 1907 by the German Julius Neubronner. A strategy that was also tested during WW1 and deployed during WW2 involved trained pigeons wearing cameras. The *Überfliger* documents the amount of work invested in training pigeons to conduct flights with modern cameras and GPS recorders, which in the end resulted in a seemingly random set of images. *Überfliger* demonstrates why military use

of pigeons quickly became obsolete and was abandoned with rapid development of reconnaissance aircraft during WW1 and intensified collection of aerial reconnaissance in WW2. However, ideas of spy-pigeons have resurfaced for example in China, where current hi-tech drones resemble and fly like pigeons (Chen, 2018).

The development of reconnaissance aircraft was further intensified during the two World Wars. Tensions during the Cold War, especially due to the repeated violation of Soviet Union airspace by US aerial reconnaissance missions led US military to experiment with satellite images permitting surveillance of any spot on the globe without infringing on sovereign airspace. The first test launches were made by US military in 1959 as part of the Corona program. More than half a century of advancing the quality of satellite images has enabled enhanced vision to peer through cloud cover, penetrate foliage and provide imagery regardless of night or day. Antoine Bousquet (2018) describes these advancements in the book *The Eye of War – Military Perception from the Telescope to the Drone,* illustrating how technology from the invention of photography to the wider sensorium of the "material gaze" has declared the human eye dysfunctional and inferior to its artificial counterparts. Karen Caplan (2018) argues that these now rather well-known, unified and techno-determinist histories of aerial perception support the assumption that "an aerial viewpoint provides a more objective and impartial view of the ground based on the distance between subject and object and the wider scope of inclusion of objects of vision." (p. 14)

Contemporary artists have developed various techniques to contest assumptions of an all-seeing God's-eye view (Haraway, 1988). Ingrid Burrington in her series *Reconnaissance* (2016), directs the gaze of aerial machine vision on itself, revealing the supporting infrastructures of airbases used to launch the satellites up into the orbit, markers for cameras attached to aircraft and rockets to calibrate their light balance, and the data centres distributing todays satellite images; hence she exposes the limits of the technology in use. Each image in the series of large-scale lenticular prints shows two points in time of these politically relevant locations. When moving from one side to the other the high-resolution images reveal the advancing construction of infrastructure as well as attempts to camouflage it. Attempts to obfuscate the images and to cover locations provokes questions of what is being hidden. Furthermore, Burrington's work exposes the limits of the orbital gaze – we can only see the surface of objects, only guess what buildings hide or what lays beneath – "no view is total or definitive." ("Reconnaissance," 2016) Satellite images can't penetrate the surface, they only imply that there is an underneath, be it inside a data centre or under the crust of Earth itself. That said, Ryan Bishop (2011) writes about the US military project *Transparent Earth* in which: "Sound will let us see where vision stops." (p.277) The prosthetic organs of perception that survey the battlefield have advanced to the extent that underground bunkers and tunnels are the only place to hide, consequently propelling research in technologies to see through Earth's crust.

## 3. HIDE AND SEEK PROPELLED BY MACHINE VISION

There was little attempt to hide army presence with the exception of spies and scouts before the end of nineteenth century. Armies wore colourful uniforms until the technological developments of gunnery increased the distance of accurate fire (Bousquet, 2018). When targets could be hit from a distance visibility became a dangerous liability, consequently enhanced vision an advantage. This launched a game of hide and seek; armies developing strategies of camouflage and decoy hand in hand with advances in machine vision technologies. The *Reconnaissance* images by Ingrid Burrington show us how being invisible is perceived as an advantage. Since satellite images became publicly available there have been attempts to camouflage sites of strategic value for corporations or military. Conflicting interest result in regulations and policies limiting access to satellite images. Before the 9/11 and the war on terror, aerial images of violent scenes such as the 'before' and 'after' bombing scenes of Hiroshima were either classified secret or released on a very selective basis by the military (Kaplan, 2018, p.5). Now almost every news story contains the aerial perspective while drone and satellite footage has become widely available. However, artist lead experiments with publicly available satellite images recording efforts to camouflage strategic sites. The attempts to obfuscate satellite images in Burrington's work implies are investigated further in *Sharing locations* (2018) by KairUs. In this mixed media installation, strategies of concealing two U. S. military infrastructures in South Korea are examined by using mapping services such as *Google Maps*, *Bing Maps*, *Naver Maps*, and *Strava Global Heatmap*. A part of the installation is a video which reveals how the Yongsan garrison in the middle of Seoul is camouflaged as a green park on a hill. In *Bing Maps,* somewhat surprisingly, the park pasted on top of the garrison is only visible on the "Labels" layer; when deactivated a high-resolution image of the garrison is revealed. In *Google Maps* the map-view-mode shows the area in green as it would be a park, yet when changing to satellite mode, low-resolution images shows the garrison and the outskirts of the area can be explored through the 'Street View', providing hints of military activities in the area.

Korean *Naver Maps* makes the most effort to hide the site, yet the automated artificial camouflage reveals the manipulation of the image content. Whereas most of the mapping services obviously follow some policies in place to camouflage these sites from public view, the *Strava Global Heatmap* reveals a different layer of activity in the area. Strava is a mobile app that is used to track athletic activities and share them on a social networking site. The app is compatible with several GPS watches and head units, including the devices US Army staff is equipped with. When Strava is used with default privacy settings, workout routes and personal times on activities such as running, cycling or swimming are logged and publicly available. In the case of Yongsan Strava exposes a network of streets and paths. Furthermore, it visualizes behaviour and patterns which contrasts with the park camouflage used in other mapping services. Yongsan is a well-known US military base, yet traced movement in desolated locations has drawn attention to them exposing secret activities. In January 2018, when the security risks linked to Strava were discovered, officials reacted quickly to tighten regulations (Hern, 2018). Everyday machine vision and geolocation technology makes it increasingly hard to hide. Histories of aerial reconnaissance and the techniques to obfuscate satellite images imply that aerial intelligence will never be fully available and searchable for everyone. Camouflaging strategic sites in plain view is merely the very extreme form of how satellite images are manipulated. The satellite imagery aesthetics now normalized for the everyday user are made 'analysis ready' by partly atomized workflows of stitching images together, applying filters and removing clouds and shadows (Planet, 2018b). The eye in the orbit has also pushed for techniques to hide. The satellite images *Queryable Earth* analyses are composite images that allows for in betweenness and we have to be aware that those gaps, deliberately or not cover the all-seeing gods eye view. When we automate the interpretation of images, translate them to measurable numbers and present them as an answer it is crucial to understand what gaps exists and the possibilities that nuances of the reality disappear in them.

## 4. ENDURING ASSUMPTIONS OF OBJECTIVITY

Imagery obtained through satellite and aerial reconnaissance was among the first to be processed by pattern recognition and change detection algorithms (Bousquet, 2018). The ideas and technologies *Queryable Earth* is intended to operate on are available and aerial images of large surfaces that have been surveyed and analysed by algorithms in order to forecast behaviour. Hence it seems like Planet's mission is to quantify and capitalize on it. When *Queryable Earth* is promoted as "Satellites + AI" (Planet, 2018a), one can argue that it is more accurate to call it machine learning than AI. In the past years, machine learning technologies have made rapid advances in accuracy (Lee, 2018). The reasons for current developments are: the revival of neural networks enabling machine learning from observing data, access to massive amounts of data to train neural networks, and increased processing power (Jones, 2014; Nielsen, 2015; Lee, 2018; Patrizio, 2018). Even if general 'artificial intelligence' is not applied to *Queryable Earth*, automatization using machine learning combined with satellite images, emphasizes the sense of scientific objectivity already linked to the 'technical image'. However, the objectivity of photographs has been widely contested. Among others Vilém Flusser (2000) states that "the 'objectivity' of technical images is an illusion" (p 15.). Furthermore, in the past years there have been several reports of how machine learning emphasizes existing biases (Buolamwini & Gebru, 2018; Courtland, 2018; Zou & Schiebinger, 2018) and there is an increasing awareness of how AI tools "are shaped by the environments in which they are built and the people that build them." (Myers West, Whittaker, & Crawford, 2019, p.6) Why are then predictions based on object recognition presented as neutral?

Objectivity as we know it is a relatively new concept from the mid nineteenth century. Lorraine Datson and Peter Galison (2010) have been writing on the history of objectivity using image production for scientific atlases as their case. They argue that objectivity requires suppression of some aspect of the self. Atlas maker sought for techniques to create images seemingly untouched by the human hand. Automatization, removing the human from the loop of interpreting and processing a vast amount of satellite images, may therefore seem to create a more objective tool. However, working with machine learning might require more human labour than we think. The object recognition *Queryable Earth* is to rely on involves machine learning models such as artificial neural networks, hence I will briefly discuss how artists have been working with neural networks to move towards an understanding of how human and technical cognition is weaved together in an assemblage such as *Queryable Earth*.

Since the launch of *DeepDream* in 2015 and the "machine learning for art" residency program at Google's Cultural Institute in Paris, starting the same year with artists such as Mario Klingemann, interest and ability amongst artists to work with neural networks has increased. Gene Kogan with *Machine Learning for Artists* (2016) shares knowledge and code, training artists to learn more about machine learning. For example the exhibition *sensu lato :: im weiteren Sinne* ("sensu lato :: im weiteren Sinne," 2018) at Akademie Graz guided the visitor through a collaborative learning process

of experimenting with DCGANs (Deep Convolutional Generative Adversarial Networks). Artworks generated from neural networks play with biases and it becomes evident that machines only see what they are trained to see. For example, Trevor Paglen's *Comet (Corpus: Omens and Portents) Adversarially Evolved Hallucination* (2017) is an image generated with a neural network which was trained to only see things associated with omens throughout history such as comets, eclipses, rainbows, black cats or a face in the sky. People training neural networks decide what is non-relevant "dirty data" and what type of images the machine should learn to see. The machine is trained to recognize objects, but the network can also be run in reverse to generate something we can recognize as an image. These images can tell us something about the main features the network has learned. This is what *DeepDream* computer vision program creators Alexander Mordvintsev, Christopher Olah and Mike Tyka at Google are describing: "The results are intriguing—even a relatively simple neural network can be used to over-interpret an image, just like as children we enjoyed watching clouds and interpreting the random shapes. This network was trained mostly on images of animals, so naturally it tends to interpret shapes as animals. But because the data is stored at such a high abstraction, the results are an interesting remix of these learned features." (Mordvintsev, Olah, & Tyka, 2015) To learn features pattern recognition filter signals out of noise. This process is also referred to as discrimination in machine learning. Hito Steyerl argues that pattern recognition is fundamentally a political operation (Apprich, Chun, Cramer, & Steyerl, 2019). What effect will inference and over-interpretation have on *Queryable Earth's* predictions. As described by Deep Dream creators in the process of adjusting or tuning the so called weights of a neural network determines how accurate object recognition will be.

*Portrait of Edmond Belamy* (2018) generated by a GAN (Generative Adversarial Network) and created by the Obvious collective was not the first of its kind, nonetheless it was the first one to be auctioned by the art market creating a lot of fuss about AI's capability to create art ("Is artificial intelligence set to become art's next medium?" 2018). Even if the aspect of machines creating art is fascinating, my intension is rather to look at how human and machine agency intertwine in these processes. It might seem like the machine is capable of autonomously creating unique artworks. However, artists and computer scientists working with machine learning techniques emphasize how much work goes into scraping, collecting, cleaning and labeling data as well as how the outcome is shaped by tweaking various parameters. In her blog artist Hanna Davis (Davis, n.d.) explains how she used Crowd Flower workers to tag emotions on 4000 Landscape images, in the process of preparing training data for an ongoing project. Trevor Paglen describes how creating a training set involves an "extraordinary amount of labour" (Smithsonian American Art Museum, 2018) and in Hito Steyerl's lecture performance *The Language of Broken Glass* (2019), a video clip illustrates how engineers conduct hard physical labour smashing windows in the creation of a data set to train an 'AI' to recognize the sound of broken windows. In *Towards a Queryable Earth* Chris Holmes, Product Architect at Planet, demonstrates in his roadmap a hefty workload ahead: to extract and process open geospatial imagery and make it analysis ready, and then optimized, labelled and verified data, making it available in standardized forms so it can be used to train neural networks (Planet, 2018b). He admits that the workload is too great for one company and calls out to the geospatial community for open data and open infrastructure. When he describes how image labels will be flagged by algorithms and validated by humans, he adds: "it is about the people and the machines together" (Planet, 2018b, 37:17). As I have earlier specified *Queryable Earth* as Hayles points out has 'punctuated agency'. There are longer periods when these systems are designed and built, that human agency is crucial. Humans also need to supply the machines with power and maintain them so they can perform without human intervention for shorter periods of time. The often uncanny yet intriguing neural network images artist create are often results of queer taxonomies and "dirty data", however, the image is a result of selecting, categorizing, labelling, composing, adjusting and curating, hence the artist has a degree of control of the outcome. Likewise, the predictions of *Queryable Earth* is tied to human agency and will only see what it has been trained to see.

## 5. CONCLUSION

*Geocinema* (2019) a project by Asia Bazdyrieva, Alexey Orlov and Solveig Suess, introduces planetary-scale sensory networks including cell phones, surveillance cameras, satellites and geosensors "as a vastly distributed cinematic apparatus" (Bazdyrieva, Orlov, & Suess, 2018). The project website with currently four video episodes show fragments of how Earth has been and is sensed, and made sense of. The videos show glimpses of infrastructures and systems used to measure, calibrate, synchronize, calculate and translate data, technology enabling representations of Earth. There is a lot falling in between, not captured, not seen. However, both *Queryable Earth* and the *Digital Belt and Road Programme* ("Background - The Digital Belt and Road (DBAR)," n.d.), Chinas initiative of sensing, survey and

analyse the Earth referenced in *Geocinema* project, aim for a near totalitarian view to cast predictions and guide future environmental decision making. Climate change provides an urgency to develop such systems. Planet's Product Architect, Chris Holmes, expresses the anxiety that they may miss something: "I fear for the world's survival if we are not able to get an accurate pulse, MIR scans, x-ray and sonogram for what is happening." (Planet, 2018b, 42:23) In his statement he draws parallels between the Earth and the human body which can be scanned with medical machine vision to locate diseases. Following his logic, there is a need to locate the disease before we can attempt to create a cure. At its best such machine vision can be used to locate and identify, however, it is not part of the cure. In the Trevor Paglen: Sites Unseen Exhibition Panel Discussion (Smithsonian American Art Museum, 2018), Artist Trevor Paglen, AI experts Kate Crawford and Wendy Hui Kyong Chun, and law professor Alvaro Bedoy conceptualize machine learning systems as very expensive diagnostic models. Chun describes how these models are built upon repetition, and how new data is verified against historical data embedded in these algorithms, therefore, the past, the present and the future are genetically similar. Following this line of thought the future cannot be radically different. To summarize the discussion: when the past is reproduced in predictions, such systems are more likely to foreclose the way we are thinking than help us think radically about the future. We are not able to know what 'AI' will be able to do in the future, however, we know that geospatial analysis is used for collecting intelligence and governing the extraction of natural resources. Efficiency and profitability are driving forces to monitor the Earth, helping us calculate the 'perfect' balance of how we can continue the extraction of resources as long as possible. Art can provide counter narratives, revealing limits and in-betweens, and furthermore predict radical futures different from those rendered by the machines. Technical limitations of machine vision might be breakable and one day the gaze from the orbit may penetrate through surfaces. In the quest for achieving scientifically objective machine vision the human becomes an unbreakable limit. Florian Cramer concludes in the book *Pattern Discrimination,* "subjectivity is destined to remain hard-coded into this analytics, even after humanity is literally (and not just figuratively) dead and gone." (Apprich, Chun, Cramer, & Steyerl, 2019, p.52) What we need to strive for is that the hard-coded subjectivity of such enhanced vision is ethical and responsible.

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