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The speculative camera

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Abstract

What if we focused on different camera constellations in order to understand the future and history of photographies, instead of focusing on specific (photographic) representations? This realignment towards the camera would not only take into account the kinds of devices commonly considered to be cameras but also include alternative forms and methods of measurement and electromagnetic sensing – historical and contemporary – which are involved in developing our techno-visual imaginaries. The speculative camera, as described in this article, explicitly addresses the camera as an assemblage that includes not only particular photographic devices but also a range of other techniques, technologies and ways of being which form a backdrop for photographies. This assemblage is held steady via a constellation which may include tens or hundreds of devices. This article presents three cross sections exploring the relationships between *photographies and: (1) navigational abilities practised by members of the animal kingdom (notably bat echolocation), (2) human wayfinding, seafaring and astronomy and (3) volumetric mapping (like infrared sensing, Light Detection and Ranging [LIDAR] and photogrammetry). Common to all three is the articulation of temporality through observations, time-stamping and time-synchronicity, which, we suggest, is pivotal to all camera operations. The speculative character of these camera operations lies in the fact that they are all based on models or programmes, that need to be activated to make camera constellations work.*

> Why is it that telegraphers produce telegrams but photographers produce not photograms, but photography? […] Why do biographers write biographies instead of biograms, and how do electrocardiographers relate to electrocardiograms, autographers to autography, or holographers to holography and/or holograms? And finally: why do cinematographers make films instead of cinematographies or cinematograms?
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> (Flusser 1991: 45)

The word *photography* seems to have lost much of its thrust in recent decades. When still used, it is often preceded by the word *expanded* ('expanded photography'), followed by the word *and* ('photography and technology'), augmented by words like *imaging* and *visualization* or simply substituted by one of their morphological forms. If nothing else, it is presented in plural form (*photographies*). This article is less concerned with the question of why scholars have become uncomfortable with the word 'photography'. Rather, it will problematize the common perception that photography's past is necessarily misaligned with its present condition and seen as sets of seemingly unrelated imaging practices and visualization technologies. To recall: The Greek prefix *photo* (genitive of *phōs*) is associated with 'light' and the suffix *graphé* with 'writing' or 'inscribing'. Thus, the nineteenth-century English word photography was intended to articulate the notion of permanent inscription of light onto durable surfaces, and already at that time referred to numerous imaging techniques.

This etymological preamble, although brief, ought to, nowadays, make clear how limited an ontological definition of photography always was, especially as it seemed to favour very particular devices and practices (such as single-lens cameras, roll film or the use of photography for remembering that which has already 'been'). We posit that those traditional understandings of photography remain as unresolved as they have always been. We further suggest that forms of speculation have always been at the centre of many photographic practices, both old and new. In order to discuss the role of speculation for an understanding of expanded photographies, we focus on old and new epistemologies afforded by crossing the threshold of humanly enabled measurement and calculation, although not always stemming from light, nor from the desire to make it inscribable.

Thus, when speaking of photography, we might do well to consider Vilém Flusser's alternative etymology: Flusser argued that while it is true that the word *photo* does derive from the Greek word *phōs* it is equally true that it can be understood to have a different meaning, which should be translated as 'appear' or 'to appear' (1991: 45). Put differently, the prefix 'photo' can be understood to deny the suffix 'graphy' because, combined together, the two make up a 'photography' which is nothing but 'apparent writing'. With this alternative definition, photography can be taken to evoke phantoms, flights of fancy and phenomena such as spectres, delusions and illusions: a medium (or range of media) which induces the apparent, the possible, the tentative and not the necessary (Toister 2020). Photography is neither a surface without a core, nor is it durable by default. It is something else entirely. It is a provisional set of calls for action. It is media bred for speculation.

Instead of focusing on specific photographic representations, as the etymology of the word photography seems to necessitate, we therefore focus on different camera constellations, from which we hypothesize on the present and future of photographies. This focus on the camera not only takes into account the kinds of devices commonly exhibited and listed as cameras (e.g. Gustavson 2012), but also includes the alternative forms and methods of measurement and electromagnetic sensing – historical and contemporary – which are involved in developing our techno-visual imaginaries. The trajectories of our jointly undertaken research each explicitly addresses the camera as an assemblage that includes not only particular devices but also a range of other techniques, technologies and ways of being, all of which form a backdrop for the development of photographies.

Therefore, the camera considered here is not primarily understood as a photographic device or a technical apparatus, but rather, following its etymology, as a site for decision-making (Lehmuskallio 2020). Etymologically, the camera is connected to the Papal Curia (the administrative institutions of the Holy See) and particularly to the department dealing with finance. Consequently, a camera can be generally understood as 'a chamber in which a deliberative, judicial, or legislative body meets' (*OED* 2024; Lehmuskallio 2020). Hence, the term refers to the particular, situated assemblages required in order to use a photographic device in the first place. These include human and non-human elements and actants, whose role as agent or patient (or, in being active or passive) routinely change within particular setups of various cameras. These assemblages are held 'steady' in camera constellations which might include tens or hundreds of devices, as is the case in the functioning of satellite imaging systems.

Accounting for cameras as situated assemblages within operational chains connects this project not only to Flusser's (2000) questioning of the principal agency of a human photographer in photography, but also to a broader set of writing on technology which discusses the interrelationships between techniques of the body, material artefacts and various sorts of automatisms in operational chains (e.g. Mauss 1973; Leroi-Gourhan 1993; Latour 2000). By prioritising operational chains in analysis, instead of specific devices, we note that photographic devices have long been created and used for a wide variety of purposes. These include measurement (e.g. of human faces and bodies, of environments on earth and outside it), as aides-memoires (e.g. of countenances, of places, of measurement) and for representational purposes (e.g. in portraiture, as depiction of hallowed sites), to name but a few familiar practices. The images created with the help of cameras may temporarily result in photorealistic depictions on mobile phone screens, as maps in plotters, histograms in forensic studies of human atrocities, or remain invisible, as work on operative images has shown (Farocki 2000–03). The camera, from this perspective, is understood as a specific assemblage, a way of combining various technical elements together which vary across domains, relying on specific constellations of human and non-human actants to provide meaningful use.

This multitude and ubiquity in photographic practices are increasingly being probed to reveal novel notions of what the photographic might be or have been. For example, Joanna Zylinska has argued for a photographic condition in which environments photographed by humans are already in many ways formed by a 'photographic flow of things' (2017: 69). Michelle Henning (2019) has suggested that an environment can inscribe itself in the processing of film, exemplifying the London fog and its effects on the Ilford company and practices of photographic professionals based around it. Stephen Cornford (2023) has discussed how the chemicals needed for constructing satellite imaging are increasingly found with the help of satellite imaging itself, producing a recursive loop of imaging and extraction. And Jill Walker Rettberg (2023) has suggested that machine vision is tied to historical developments in lenses, devices and forms of electromagnetic sensing, including those by animals other than human beings. While this project is clearly connected to these (and other) literatures that call into question conventional and singular definitions of the term 'photography', we limit our focus to imaging practices that deal with decision-making. Such practices allow us to focus on particular kinds of camera constellations, as well as to foreground the role of operational chains relating to decision-making.

Speculation in decision-making

Many of today's camera assemblages – from surveillance and security cameras, to satellites, manufacturing robots and autonomous vehicles – are used for decision-making: when to set off an alarm, where to go or what to fire at. Such cameras are rarely used (or even designed to be used) for representational purposes. They are instead part of what Harun Farocki (2004) coined operative imaging: optical images captured to be fed into and analysed by semi-automated or fully automated electronic computing systems, providing the requisite information for deciding on the next task in an operational sequence. While public rituals when installing these systems in our streets, at border controls or in the skies above us demand that decisions made within automated operational chains and using operative imagery follow the rule of law (e.g. assure non-discrimination, suppose innocence, etc.), a wide range of scholarship, especially in recent years, has uncovered systematic biases encoded within these camera constellations (cf. Crawford 2021; Buolamwini 2023). The biases are due to either misleading training data (e.g. insufficient breadth of material gathered from image archives); faulty decision algorithms in operational chains (e.g. ignoring minority rights); or their main use cases being in fostering asymmetrical power relations (e.g. between occupiers and those occupied). While some of these uncovered biases are undoubtedly the product of short-sightedness (ethnocentric, ideological and other), and at times pure ill will, decision-making itself, being a fundamental part of operative imagery, is not only reliant on confirmed knowledge (whatever it may be) but also, and to an important extent, on speculation. In turn, such speculation relies on a range of means: probabilistic algorithms, culturally moulded understandings of 'good images' or notions about the kinds of data that customers might approve.

While a focus on photographic representations (or 'pictures') foregrounds the stabilization of photography (we can hold a print in our hands, carry it in our wallet or show it to others on liquid crystal displays), the focus on speculation allows us to foreground the inter- and intra-relations that make photography a sensible and useful task. From this perspective, photography is considered to deal less with what we already know but to partake in those kinds of practices within which we (and others) try to make sense of the world. Speculation is less concerned with past knowledge but rather with ways of predicting and making futures. Cameras are important here as they consolidate specific forms of speculation within the constellations that hold them steady for particular epistemological purposes.

Etymologically, the word speculation refers to the sense(s) of vision, the faculty of sight and to exercising one's vision and sight (e.g. for watching or observing). Hence, the speculative in discussing cameras as broader assemblages in vast image infrastructures and media environments places etymological emphasis on the interrelations between images made visible for humans to see and post-lenticular images that emerge from sensors sensing electromagnetisms which are not visual at all, as well as the various ways these merge in real-world practices when using sonar equipment in order to map one's immediate environment (Helmreich 2007). Such electromagnetic sensings are often available for viewing and analysis by humans, thus keeping them 'in the loop' (Seaver 2018), although automated analysis raises suspicion that when vision is fully integrated with automations, other loops may in the future make humans superfluous.

Starting from the sixteenth century, speculation increasingly denotes abstract concepts of intellectual observation – essentially, observing with the mind's eye rather than the physical eye. In English, the figurative meaning of speculation as 'conjecture' (or simply 'theory without firm evidence') first appears around the early seventeenth century. This usage emerged in conjunction with the rise of scientific inquiry, where speculation came to mean hypothesizing about unseen or unproven natural phenomena. By the eighteenth century, the term also started to be used in financial contexts, meaning taking risks or making predictions in markets based on uncertain future outcomes, mainly with the goal of short-term profit, usually without 'even residual lip-service to the welfare of humanity or planet' (Cubitt 2021: 29). Somewhat similarly, vast scale camera constellations are increasingly being created to facilitate volumetric spaces that become navigable on their own terms, often independent from (and at times apathetic to) the ground, local or traditional knowledges (e.g. GPS systems, digital twins, etc.). The diagrammatic mapping of space with the help of speculative cameras has been a *sine qua non* for large-scale imperial actions at a distance, including the immutable mobiles which Latour (1986) originally traced by referring to the emergence of specific visual technologies, including maps.

In design, speculation is considered as a way to imagine alternative futures, different modes of being, which are less interested in the probable and plausible but rather in possible futures. That these may take the various colourings of our affective responses has become painfully clear in war-ridden regions, during responses to a pandemic, during financial crises and in the inadequate responses to environmental crises. But a focus on speculative cameras allows us to also focus on possible futures that may take other forms.

Our respective exemplary studies draw attention to the role that modes of modelling and speculation take in imaging practices that are used to decide on elemental aspects of the everyday. We posit that modes of speculation tie the camera constellations we work with to epistemic practices of knowledge production, which, referring to the camera, are used to make decisions. The emphasis on speculation highlights the role played by uncertainty before cameras came into use, while this uncertainty at the same time informs the ways specific photographic devices are prepared, used and later modified in recursive loops. Therefore, a focus on speculation orients this work towards the discernment of imaging practices, considering not just the development and use of specific technical devices but also the roles that human rituals and symbolization processes play in this equation.

Active and passive sensing

Some theorists of photography and visual perception already offer an alternative epistemological framework that allows for the development of a new conceptual understanding of photography based on the speculative model of the camera outlined above. The sensory aptitudes of bats have been examined by a few analytic philosophers (notably Currie 1995; Gaut 2008), who aim to shed light on the murky associations between human vision and photography in the main. Specifically, bat echolocation, which augments vision using sound emitted at ultrasonic frequencies, has been metaphorically linked to photography. This process, which has been referred to as 'vision under heavy scare quotes' (Gaut 2008: 395), quasi-vision or, most fittingly for this discussion, para-vision, illustrates an innovative perspective on visual perception.

These references may either validate or refute the frequently made assertion that humans 'see' through photographs (Walton 1984), a process sometimes considered comparable to biological vision. However, what has remained unaddressed in this analytic photo-philosophical discourse is the *active* nature of bat echolocation, regardless of its voluntary or conscious execution. This characteristic of echolocation becomes increasingly relevant for the study of photography and its associated imaging techniques, especially since active sensing has extended beyond a characteristic unique to bats and other animals, as Walker Rettberg discusses in equating bat echolocation with forms of facial recognition (2023: 53). Rather, active sensing has become a fundamental component of various human approaches, tools and platforms for seeing and visualizing, such as in fields like archaeology, everyday transportation, law enforcement and space exploration. Consequently, it is now necessary to offer a concise explanation of the differences between 'passive' and 'active' sensing modalities.

Firstly, when one is susceptible to influences or interferences outside one's own body then one is often sensing electromagnetic radiations or emission signals. Put plainly, sensing is intended here as an abstract term to avoid the pitfalls of *phōs*, its morphology and its associations to imagery and ocularcentrism. Sensing incorporates not only visible light and the sense of vision but also hearing as well as other sensory abilities which humans do not possess but select members of the animal kingdom do (e.g. sensitivity to magnetism). Sensing is the utilization of *any* sensory ability or abilities for knowledge acquisition and decision-making.

Passive sensing is the act of receiving and/or collecting only ambient electromagnetisms for mapping one's environment. In most of its historical contexts, the photographic camera is only a passive sensing technology. Of course, numerous exceptions might be proposed, and these problematize this definition. One confusing problematization is the photographer's gesture(s) which Vilém Flusser (2011) famously theorized. As important as this exception may be, it articulates only the gestures (or attention) of the photographer as arguably active, and admittedly ignores 'complex electromagnetic, chemical and mechanical technologies' from analysis (2011: 386). In doing so it concedes that the photographic apparatus remains passive. Here we might mention flash photography as a more serious challenge to the passivity of the photographic apparatus. Crucially human vision is in a range of theories of vision rendered as a type of passive sensing (human vision as it is understood since the baroque, earlier theories of vision offered different conceptions of the operations of the human eye), although we also know that our selective attention actively filters (and in some theories is claimed to generate) that which we see (Seth and Bayne 2022; Alva Noë 2006). Although strict lines may be difficult to draw, active sensing is here understood as the act of receiving and/or collecting electromagnetic bands which are being purposely emitted or transmitted for the sake of mapping one's environment with a specific device.

Examples include contemporary technologies like Light Detection and Ranging (LIDAR)[1] or older technologies like Sound Navigation and Ranging (SONAR) and Radio Detection and Ranging

1. LIDAR, an acronym for Light Detection and Ranging, is a remote sensing technology that uses laser light to measure distances to the Earth's surface, creating precise, 3D information about the shape and surface characteristics. Conceived in the mid-twentieth century, LIDAR has become an essential tool for a wide range of applications, including geology, seismology, forestry and atmospheric physics. Its ability to penetrate forest canopies, map terrain under vegetation and provide high-resolution elevation data has revolutionized environmental monitoring, urban planning and the study of climate change. LIDAR's development showcases the evolution from an experimental technique to a fundamental resource in scientific and commercial sectors.

(RADAR),[2] and indeed various capacities long known to exist in the animal kingdom. Notably, active sensing is a term with roots which run deep into theories of vision which predate the baroque. Nonetheless, when using it today, we must bear in mind that the form of speculation which it augments is the temporal activation of spatiality and the potentialities which it unleashes. After all, if bats were not able to perceive minute temporal differences of reflected sounds within one location, or between locations, they would never be able to process spaces and 'visualize' them (visualize under heavy scare-quotes …). They would similarly be unable to form mental maps of them and to navigate within them as efficiently as they clearly can. Put differently, active sensing is first and foremost the measurement of time and only later, consequent to speculation, becomes visual or spatial measurement which, for humans too, never occurs instantaneously. Active sensing, hence, is a form of temporal echolocation allowing the formation of a speculative model of whatever it is that one encounters. So what might we learn from the importance of temporality in practices of bat echolocation for human use of situated assemblages that rely on specific camera constellations?

The role of temporal observations

Early camera obscuras allowed real time 'internal' observations of 'external' scenes or situations, doubling or at times even multiplying the ability to see the unfolding of events at the same time. A fine example is the camera obscura located at the Royal Observatory, Greenwich in London, still offering a view towards the National Maritime Museum, the Old Royal Naval College and Island Gardens. Traditional histories of photography have been specifically interested in the aim of conserving these events, so that they could be shown again, after they have supposedly evaporated. The importance of this history has been told in Batchen's (1999) seminal book *Burning with Desire*, which recounts the various wishes, desires and fantasies of scholars, artists and businessmen to 'fix' fleeting images. Famously, this set of desires allowed later-day photographers to use photographs for studying that which 'has been' (Barthes 1980) or in other words, to focus on a transducted form of past (Helmreich 2007). A transducted form of the past does not 'show' the past as it was, but transforms and mediates it in photographic ways, providing a specific mode of perceiving that what 'has been'.

A focus on the importance of temporality in echolocation practices described above, or more generally an emphasis on the passive and active modes of registering which occur beyond photographic devices, allows us to turn our attention towards the ways in which several measurements of the past are made operational for an envisioned future. Here too, the Royal Observatory provides us with practices and devices to assist our thinking. The Observatory, established with the aim of finding a way to determine longitude at sea (as well as to provide for other astronomical observations), became a site for disciplining a scientific body (that of the Astronomer Royal) in a way that would confirm the speculations that astronomers had about the usefulness of astronomical observations, as

2. SONAR, an acronym for Sound Navigation and Ranging, uses sound waves to locate and identify objects underwater. Although the practical development of SONAR technology occurred in the early twentieth century, primarily for naval use during the First World War, its conceptual foundations can be traced back to Leonardo da Vinci. Da Vinci's sketches and notes hint at the idea of using sound waves for underwater exploration. Officially, SONAR technology was instrumental in naval operations for navigation, mapping and warfare, evolving into a vital tool for both military and civilian maritime endeavours, including underwater exploration and scientific research. RADAR technology (short for Radio Detection and Ranging), which utilizes radio waves for object detection and ranging, traces its theoretical underpinnings to the late nineteenth century, following Maxwell's electromagnetic theory and Hertz's radio wave experiments. However, its practical development and deployment occurred primarily in the early

twentieth century, with significant advancements during the 1930s and the Second World War. This period saw the transformation of radar from a theoretical concept to an essential military and navigational tool, marking its official inception and operational use.

these needed to be made regularly throughout the night, in a precise manner, and by recording the exact times and angles of each sighting. Following a complex layer of clockwork, including a precise pendulum clock, the so-called 'clock stars' (and an alarm clock to keep bodies on track timewise), the Astronomer Royal, and their assistants were part of an assemblage measuring time in order to help speculations about the future (cf. National Maritime Museum 2023). These sightings, for purposes of our argument, crucially relied on a camera constellation including a range of specifically crafted optical telescopes as a means to precisely align the sighting angles of telescopes. The constellation also included grids inserted into these telescopes for purposes of measurement, several clocks and the work of human computers to note down exact sighting angles and times. In addition, the institute of the Astronomer Royal served as a live guarantee of skilled, reliable and correct methods of observation and notation from moment to moment in time.

The problem with this embodied time, in the form of the Astronomer Royal as the official marker of time, was that the body of the Astronomer Royal could not be duplicated, but had to remain in place in order to continue the disciplined observations night after night. While these time observations were used to calculate and speculate on astronomical movements, various time movement devices were created in order to relay time over a distance. These included those relying on vision (e.g. a time ball on top of the Observatory, marking the 'exact' time of noon each day), those relying on the ability to hear (e.g. shooting a cannon ball at a specific pre-agreed time) or those relying on the ability of other human and non-human actants to 'deliver' time across distance (e.g. those setting their watches at Greenwich to the correct time and later selling this information in the centre of London, or the sending of time signals via telegraph cables, radio waves or later GPS systems). With the help of these relays, time could be mapped onto one's representations of space, plotting one's self or vessel into a virtual model.

For a considerably long period, measured times within given locales could not be communicated over wider distances, making it difficult for anyone removed from the location of measurement to locate themselves within the virtual grid of latitude and longitude. Within this model, latitude was relatively easy to establish through studying changes in one's environment, particularly the sun at noon and the angles of particular stars in the firmament. Longitude, however, could not be established in the same way, especially not at sea where environmental conditions and the rocking of the vessel made it difficult to make exact measurements. This changed only when time from one location could be carried along with a separate clock, so that local time based on observing the environment could be compared to the time in another known location (e.g. the Royal Observatory in Greenwich). Once time could be compared while one was traversing oceanic space, the virtual, volumetric model of the Earth as lines of latitude and longitude could be filled with plotted positions in a virtual, speculative model of the Earth. Plotting was carried out with the help of a clock showing time elsewhere, a clock which is still called a chronometer, which is used both for measuring time and space in order to locate oneself in the here (i.e. space) and now (i.e. time).

The practice or cultural technique of measuring time in order to understand one's whereabouts within a speculative model of space is centrally based on a clear and concise understanding of time (i.e. the ability to answer the question: 'What time is it now?').[3] Importantly, this temporal form of sensing one's environment was important for creating representational models which could be depicted (either on globes or on two dimensional charts), and both virtually and actually inhabited. Forms of temporal sensing provided means to move within a model, as well as in a recursive loop to correct misaligned parts of the model.

This historical example is of interest because of the centrality of measuring time for fixing representations of one's location in a model of space. It continues to be a *sine qua non* of visual practices that use more recent visual technologies, such as those relying on satellite imaging. Also here, the different sensor readings that satellites collect are ordered and 'fixed' by reference to a specific marker of time, which today relies on atomic clocks and the related procedures for knowing time, and no longer on the disciplined body of the Astronomer Royal. Temporal observations conducted with the help of electromagnetic technologies, including highly specialized optical devices, form a backdrop for a range of cultural practices of visualizations which are highly influential today.

3. For a longer cultural history, see Galison (2000) or Siegert (2015), including actual difficulties in these measurements even at sites such as Greenwich and the Paris Observatory as well as competing techniques such as the lunar-distance method.

Planar and volumetric mapping

The purpose behind forms of temporal echolocation is the production of speculative models of space that may become operational and can assist in forms of decision-making. While the Greenwich Observatory was important for advancing the ability to map one's self into a virtual model of longitude and latitude in order to facilitate future travels within this planetary model, other forms of planar and volumetric mapping are pertinent for speculative cameras too.

On 3 October 1864, the first British surveying expedition to Palestine started work on establishing a level plane from which to draw the baseline for their triangulation map of the environs of Jerusalem. Its original aim was to establish accurate measurements of the ground level from the Mediterranean to the Dead Sea, measurements that would facilitate the construction of a new water system for the Old City of Jerusalem. With the use of chain and theodolite, the surveyors were able to spatially transcode the physical terrain. This mode of cartographic abstraction stripped out all but the bare topography of the surface. Structures and vegetation were removed from the image, creating a clean slate – an analogue version of what was to be later called a Digital Terrain Model. The spatial amalgam of physical elements on the ground, levels of terrain and sub-terrain, vegetation, water, land use, structures, names and technical data all appeared as layers on top of the original mapping system, which was now based on the new three-dimensional (3D) method of surveying employed by the Royal Engineers.

This process of capturing an environment, in optical, cartographic and material senses, resulted not only in the registration and archiving of numerous compressed flat 'views' but also in a set of

4. For a critique of the point and line method, see Ingold (2017).

experiments into the possibility of capturing volume by combinatory processes of recording and projection. In the mid-1860s, around the same time that the Jerusalem survey expeditions were being carried out by the British (as well as the Transit of Venus expeditions important for measuring the Earth's distance to the sun), a different yet logically identical project was underway in mainland Europe: the devising of a shift from single to multi-viewpoint ground-based survey. Photogrammetry (also known as Photometrographie and Iconometry) was a process developed almost simultaneously by Sebastian Finsterwalder, Albrecht Meydenbauer and Aimé Laussedat. It allowed for measurements of scale and volume to be derived from planar optical imagery by way of calculated projection. The key to this was the amalgamation of a large format camera (a representational device) as well as a theodolite (a survey device) into the *Messbildkamera*: a calibrated camera that augmented the flattened visible attributes of a scene, with the marking of distance, scale and height information as part of the image metadata. This assemblage into a *Messbildkamera* provided a means of 'holding still' that was similar to the means employed by the telescope with a clearly aligned grid used by the Royal Observatory.

Meydenbauer used the compact design of the camera and a fixed focus for defining an optical constant to determine the dimensions of the photographed object after its recording. The first *Messbildkamera* was equipped with a wide-angle lens, a 30 cm × 30 cm photo plate of polished mirror glass and a crosshair as a coordinate system. By mounting the camera on a tripod, both camera axis and image plane could be adjusted. The focal point facilitated the calculation of distance, and the frame dimensions facilitated measurement of the length of objects in the scene along the rectified axes. From the single survey-photograph, Meydenbauer soon expanded into multiperspectival analogue photo reconstruction. Multiple individual viewpoints were used to process, analyse and collectively extract data to produce cartographic maps, first successfully achieved in his map of Freyburg in 1867.

Photogrammetry (etymologically: light-writing-measurement) is a process by which distance and movement measurements are extracted by comparing multiple still photographs of a single object or environment recorded from different points of view. Analysis of the inter-viewpoint parallax, together with information about the camera lens, allows one to triangulate the positions of both the source cameras and the scene information within virtual 3D space. This process, also termed 'Structure from Motion photogrammetry' (not to be confused with Stereoscopic Photogrammetry), permits free roaming of the camera (or cameras) in relation to the environment being scanned. Thus, the perspectival optical image, down to its granular level, becomes positionable in real-world 3D space.[4]

If measuring time in order to know one's whereabouts became a common practice informing today's expanded photographies, so did the ways in which photographic imaging became itself entwined with various measuring techniques for spatial modelling. Light-based measurement was pushed further with the development of atomic clocks that could register the time and therefore distance it took light itself to travel from one location to another. Time of Flight Measurement, as this was then named, used the constancy of the speed of light as a basis for a new level of fine grain, point by point registration of, and in, space and time. Timestamping became a constitutive part of spatial positioning, and therefore became the foundation that underlies the positioning and holding of computational camera constellations as they move in physical space, and the spatializing of virtual 3D cartographies. And so, structure from motion and time of flight both contributed to the formation of a camera and image space combination based on a computational, multi-chrono-spatial node. Continuing from the charting work of astronomers and cartographers, but also inverting it, the recording of space is done not only by triangulating the position of moving celestial bodies but also by introducing new sensory assemblages. These can be embodied in stationary combinations or heavenly constellations, from the underground and into deep space, providing a diverse set of camera constellations used for varying purposes.

From its outset then, the camera has been more than mono-perspectival and required multiple forms of time registration. We contend – following Schröter (2014), Steyerl (2017) and Caine (2019) – that the familiar photographic traditions of the mid-nineteenth century and onwards were paralleled by continuous developments of another type of camera apparatus and another kind of photographic image. The speculative camera, as termed here, is a framework from which to think of these computation-driven multi-perspectival and multi-chronal camera assemblages, arranged and held in various shifting constellations, to 'operate' on that which is now made 'known', and to be acted upon in the future.

Synchronicity

Even when considered as hardware or software only, without accounting for their human actants such as the Astronomer Royal, all camera assemblages embody spatial distribution. This is due to the simple fact that electromagnetic 'capture' devices (usually lens, but not always) are rarely (if ever) connected to the facility or immediate environment wherein the eventual image is subsequently produced. Put differently, photographic imaging depends on a spatial split between images to be captured (cf. the camera obscura discussed above) and images to be processed (be it dependent on chemistry, computer processing or another technology) (Benovsky 2014; Toister 2020). But spatial distribution is, by default, part and parcel of temporal distribution as well. A sheet of film never becomes a C-41 negative or an E-6 chrome (reversal film) at the same time as it is being exposed (at least not in the strict sense of developing). A print can almost never be made at the same time as a sheet of film is developed (except in certain extinct Polaroid technologies). As is well known, digital photography vastly decreases these time-lapse constants, or more accurately latencies, required for the eventual production of images. However, it cannot annihilate them completely, as even signals within electronic systems have the inherent latencies which plague all modern-day technologies, camera assemblages included. Crucially, such latencies remain unknown to most users (image makers and image consumers alike). Thus, not only the scope or magnitude of such latencies but also their influence remains little understood when studying images in their own right, without accounting for the camera apparatuses and constellations which brought them into being.

Conversely, the speculative cameras which inform this research demonstrate an internal synchronicity which stems from practices of time-measurement. An echolocating bat can possibly be thought of as a camera assemblage, as even one individual bat emits multiple transmissions from multiple spatial locations, for measuring and synchronising the return times, in order to orient themselves within these surroundings. The seafarers and astronomers measuring time in order to position themselves in space also used a form of echolocation, arguably a more technically complex one, relying on a range of human and non-human collaborators to accomplish their tasks. These collaborators included observatories, astronomers, calculations of models, navigational tables as well as techniques in order to read from the environment both local time and latitude. Further, the surveying systems of today, augmented by new forms of triangulation and measurement systems, predominantly conducted through digital theodolites, remote-sensing satellites and airborne LIDAR to perform tasks of spatial mapping by temporal synchronizing, are also forms of human echolocation. The advent of computation and computer vision in the late 1970s clearly accelerated the development of such capabilities, as well as the possibility of subsequently distributing this information in near real time around the planet. With the introduction of atomic clocks, time measurement (including the registration of movement) enabled the synchronization of constellations in space to be independent of the human scale or a single planetary one. Once again, the meaning of time, position and now even the properties of light itself can be recalibrated with the advent of active sensing systems.

Provisional conclusions

This article provided selected cross sections with which to understand the speculative character of different camera assemblages used for decision-making and, perhaps more importantly, their future potentialities. These were active sensing, temporality of observations, multi-perspectivism and volumetric mapping. Active sensing refers to a perceived change in the capabilities of photographic technologies, which are increasingly equipped with means for 'actively sensing', or scanning, the environment (such as LIDAR or the implementation of GPS). Multiperspectivism relates to the increasingly important role that constellations of cameras have for expanded photographies (e.g. arrays of satellites for imaging sections of the Earth). It also relates to volumetric mapping and the role that models of volume play in imaging (e.g. in the spherical latitude/longitude model and in structure-from-motion models).

Common to the examples discussed is the articulation of temporality as pivotal to all camera operations, through observations, time-stamping and time-synchronicity (or lack thereof). In this context, two distinctions ought to be made. Firstly, that successful time measurement is, in and of itself, only a provider of information in photographs, not its guarantor. In other words, although Eadweard Muybridge's *Sallie Gardner* (1878) provided visual information through time measurement, its contextualization and potential is necessarily partial in the absence of temporal anchoring techniques.[5] Secondly, changes in time measurement are indeed the driver of photography's evolution since the nineteenth century, as well as its continued epistemological importance, but measurement is always incomplete without a scale – both relating to sets of standards (numbers, amounts and resolution) and more so to ways of comparing and relating (e.g. closer to and bigger than), as discussed with the importance of the grid in astronomical telescopes and the *Messbildkamera*. This temporal shift in the literature on photography is rarely studied.[6] However, since multi-perspectivism always implies movement which, in a non-quantum universe, must happen in time as well as in space, all imaging can potentially be augmented with temporal synchronicity (and not only temporal manipulation). Our analysis emphasizes the centrality of particular methods (e.g. active sensing, volumetric mapping, multiperspectivism) in order to speculate about spatial models. More importantly, it also foregrounds the role of measuring temporality as a cultural technique through which most images and practices of image making become sensible.

5. We could, following Cohen and Meskin (2004), argue that non-anchored time measurements always yield temporally agnostic visual informants.

6. Jimena Canales (2010) discusses the historical importance of being able to record a tenth of a second and its epistemological underpinnings. Also Andrew Fisher's article (2016) is a notable exception, but one which is primarily focused on spatial scales and scalings, not temporal ones.

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References

Barthes, R. (1980), *Camera Lucida*, New York: Hill and Wang.

Batchen, G. (1999), *Burning With Desire: The Conception of Photography*, Cambridge, MA: The MIT Press.

Benovsky, J. (2014), 'The limits of photography', *International Journal of Philosophical Studies*, 22:5, pp. 716–33, https://doi.org/10.1080/09672559.2014.923015.

Boulamwini, J. (2023), *Unmasking AI: My Mission to Protect What Is Human in a World of Machines*, New York: Random House.

Caine, A. (2019), 'Granular realism: Ontology and counter-dominant practices of spatial photography', Ph.D. thesis, London: Goldsmiths University of London.

Canales, J. (2010), *A Tenth of a Second: A History*, Chicago, IL: University of Chicago Press.

'camera' (2024), *OED Online*, 3rd ed., Oxford: Oxford University Press, https://doi.org/10.1093/OED/1020163718.

Cohen, J. and Meskin, A. (2004), 'On the epistemic value of photographs', *The Journal of Aesthetics and Art Criticism*, 62:2, pp. 197–210, https://doi.org/10.1111/j.1540-594x.2004.00152.x.

Cornford, S. (2023), 'Inverting resolution: Accounting for the planetary cost of earth observation', *Journal of Visual Culture*, 22:1, pp. 93–110, https://doi.org/10.1177/14704129231161947.

Crawford, K. (2021), *Atlas of AI: Power, Politics, and the Planetary Costs of Artificial Intelligence*, New Haven, CT: Yale University Press.

Cubitt, S. (2021), 'Mass image, Anthropocene image, image commons', in J. Parikka and T. Dvorák (eds), *Photography Off the Scale: Technologies and Theories of the Mass Image*, Edinburgh: Edinburgh University Press, pp. 25–40.

Currie, G. (1995), *Image and Mind: Film, Philosophy and Cognitive Science*, Cambridge: Cambridge University Press.

Farocki, H. (2000–03), *Eye/Machine I–III*, video installation, https://www.harunfarocki.de/installations/2000s/2003/eye-machine-iii.html. Accessed 10 April 2025.

Farocki, H. (2004), 'Phantom images', *Public*, 29, pp. 12–22, https://public.journals.yorku.ca/index.php/public/article/view/30354. Accessed 10 April 2025.

Fisher, A. (2016), 'On the scale of photographic abstraction', *Photographies*, 9:2, pp. 203–15, https://doi.org/10.1080/17540763.2016.1181100.

Flusser, V. (1991), 'What is the literal meaning of "photography"?', *European Photography*, 12, pp. 44–45.

Flusser, V. (2000), *Towards a Philosophy of Photography*, London: Reaktion.

Flusser, V. (2011), 'The gesture of photographing', *Journal of Visual Culture*, 10:3, pp. 279–93, https://doi.org/10.1177/1470412911419742.

Galison, P. (2000), 'Einstein's clocks: The place of time', *Critical Inquiry*, 26:2, pp. 355–89, https://doi.org/10.1086/448970.

Gaut, B. (2008), 'Opaque pictures', *Revue Internationale de Philosophie*, 246:4, pp. 381–96, https://doi.org/10.3917/rip.246.0381.

Gustavson, T. (2012), *Camera: A History of Photography from Daguerreotype to Digital*, New York: Union Square & Co.
Helmreich, S. (2007), 'An anthropologist underwater: Immersive soundscapes, submarine cyborgs, and transductive ethnography', *American Ethnologist*, 34:4, pp. 621–41, https://doi.org/10.1525/ae.2007.34.4.621.
Henning, M. (2019), *Photography: The Unfettered Image*, London: Routledge.
Ingold, T. (2017), 'Surface visions', *Theory, Culture & Society*, 34:7&8, pp. 99–108, https://doi.org/10.1177/0263276417730601.
Latour, B. (1986), 'Visualisation and cognition: Drawing things together', in A. Kuklick (ed.), *Knowledge and Society: Studies in the Sociology of Culture Past and Present*, vol. 6, Chicago, IL: Northwestern University, pp. 1–40.
Latour, B. (2000), 'When things strike back: A possible contribution of "science studies" to the social sciences', *The British Journal of Sociology*, 51:1, pp. 107–23, https://doi.org/10.1080/000713100358453.
Lehmuskallio, A. (2020), 'The camera as a meeting place for decision making', in A. Hall (ed.), *The Camera as Actor*, London: Routledge, pp. 17–28.
Leroi-Gourhan, A. (1993), *Gesture and Speech*, Cambridge, MA: MIT Press.
Mauss, M. (1973), 'Techniques of the body', *Economy and Society*, 2:1, pp. 70–88, https://doi.org/10.1080/03085147300000003.
National Maritime Museum (2023), Flamsteed House, Royal Observatory, Greenwich, UK, 14 May.
Noë, A. (2006), *Action in Perception*, Cambridge, MA: The MIT Press.
Schröter, J. (2014), *3D: History, Theory, and Aesthetics of the Transplane Image*, London: Bloomsbury Academic.
Seaver, N. (2018), 'What should an anthropology of algorithms do?', *Cultural Anthropology*, 33:3, pp. 375–85, https://doi.org/10.14506/ca33.3.04.
Seth, A. K. and Bayne, T. (2022), 'Theories of consciousness', *Nature Reviews Neuroscience*, 23:7, pp. 439–52, https://doi.org/10.1038/s41583-022-00587-4.
Siegert, B. (2015), 'Longitude and simultaneity in philosophy, physics, and empires', *Configurations*, 23:2, pp. 145–63, https://doi.org/10.1353/con.2015.0011.
Steyerl, H. (2017), 'Ripping reality: Blind spots and wrecked data in 3D', in H. Steyerl (ed.), *Duty Free Art*, London: Verso, pp. 191–206.
Toister, Y. (2020), *Photography from the Turin Shroud to the Turing Machine*, Bristol and Chicago, IL: Intellect and University of Chicago Press.
Walker Rettberg, J. (2023), *Machine Vision: How Algorithms Are Changing the Way We See the World*, Cambridge: Polity Press.
Walton, Kendall L. (1984), 'Transparent pictures: On the nature of photographic realism', *Critical Inquiry*, 11:2, pp. 246–77.
Zylinska, J. (2017), *Nonhuman Photography*, Cambridge, MA: The MIT Press.

Further reading

Daston, L. and Galison, P. (1992), 'The image of objectivity', *Representations*, 40, pp. 81–128, https://doi.org/10.2307/2928741.

Grimm, A. (2007), 'The origin of the term photogrammetry', *Photogrammetric Week 2007*, Stuttgart, Germany.

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