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Optical Calculus

I.

In my talk today, I want to take a critical look at the concepts that we use to talk about the so-called "operational images".

I want to argue that "operational images" are "images", in a strict sense, only from a human perspective, and that in order to understand their shape, their functions, and their meanings beyond the limitations of human interpretation, we need a non-anthropological register of terms to talk about them.

Somewhat polemically we can say that, "human and machine only appear to be dealing with the same things;" in fact, they look at quite different things.

Paul Virilio has called this difference a form of "blindness", and the look of the technical apparatus he has called a "non-gaze". Similarly, Harun Farocki has emphasised that machine vision is based on a deliberate reduction, a disavowal, or denial, of most of what the human eye would see at the same moment. And Fabian Offert and Peter Bell have recently argued that the shape of machine perception, what they call its "perceptual topology", is radically different from, and irreconcilable with, human perception.

My talk today departs from the argument on operational images that I developed in the book on Machine Art. (Broeckmann 2016, 128–134)

I have decided not to show any images during this talk, in order to underscore the fact that the use of images and other forms of visualisation might actually be counter-productive to gaining a critical understanding of the "optical calculus" that manifests in these technical systems.

II.

A word about the notion of the "machine". Those of you who have read my book, or my text on the "myth of the machine (as artist)" will know that I try to use the word "machine" only sparingly, because it is a complicated concept that, if used carelessly, troubles any thought about technology, more than it clarifies. (Broeckmann 2019)

I cannot develop that argument here, but I want to hint at it, because it leads us to a differentiation in the understanding of technical systems that will be useful for the rest of my argument today.

It sounds a bit counter-intuitive, but I believe that "the machine" is not a technical system, or an apparatus, but the notion of "the machine" describes a particular type of relationship that humans have with such technical systems. It is a relationship characterised by antagonism: the machine is always considered as an adversarial other, potentially threatening, and as something to worry about.

The use of the word machine also marks the conviction that the speaker is a human, and not a technical being; the word machine marks the claim to an ontological difference which affirms the humanness of the speaker, and it renounces the possibility of a "posthuman" entanglement with one's technological environment.

III.

In the context of this conference, I don't need to spend much time explaining what we mean by "operational images". Around 2003, the German filmmaker Harun Farocki coined the term for, as he wrote, "images that are not simply meant to reproduce something, but instead are part of an operation." (Farocki 2005/2009, 107) He was particularly thinking of industrial and military contexts in which images are not used for humans to survey and control certain operational procedures, but the technical system itself analyses the images, for instance, directing a construction robot in a car factory to hit the head of a screw, or a computer vision system that enables a cruise missile to hit its target.

However, the "operational image" is an "image" only from a human perspective, while from a technical perspective, it is what I heuristically call an "optical calculus" – that is, an element in a technical procedure in which data are collected through optical devices, and thus made available to computations which are, in turn, used to take decisions about a specific task, like steering a car or a cruise missile.

Virilio affirmed this fundamental difference of technical visuality, or "visionics", from the way in which humans see: "Don't forget, though, that 'image' is just an empty word here since the machine's interpretation has nothing to do with normal vision (to put it mildly!). For the computer, the optically active electron image is merely a series of coded impulses whose configuration we cannot begin to imagine since, in this 'automation of perception', image feedback is no longer assured. That being, of course, the whole idea." (Virilio 1988/1994, 73)

Before I try to characterise the "optical calculus" further, let me suggest briefly what is an "image". An image, in my understanding, is some form of representation that is somehow distinct from its immediate surroundings. You can think of a canvas painting, perhaps even with a frame, but the same goes for an unframed cave painting, like the lioness drawn on the stone walls of a cave: this drawing manifests the virtual presence of the animal in a place where it is not, and it transforms that part of the wall into something that is, at the same time, drawing, lioness, and wall.

In order to describe this interlacing of visuality and materiality, the art historian Gottfried Boehm has introduced the notion of "iconic difference" (or *ikonische Differenz*) that points to both the semantic and the visual difference of the image from its surroundings. Boehm has suggested, as a minimal definition, that in an image the representation and the represented are perceivable simultaneously, that one can see both the iconic shaping and its medial premise. (Boehm 1999, 173)

IV.

The main claim of this talk is that, from a technical point of view, "operational images" aren't images at all.

Any useful notion of the "image" is close to what Boehm describes. The image is a way in which humans open up their environment for virtuality.

It is understandable that people have the desire to interpret the "optical calculus" as an image, and that they try to understand the technical process by looking at its visual output.

Fabian Offert and Daniel Bell have, in a paper that they published just last month, pointed to this deferral from calculation to image in relation to "feature visualisations", that is, visualisations that are supposed to show to human eyes the workings of, in their case, neural networks. The authors observe the fundamental difference between technical functionality and its visualisation for the human eye, and highlight the paradox that, "the more legible a feature visualization image is, the less it actually represents the perceptual topology of a specific machine vision system." (Offert and Bell 2020, 2)

This is not a problem so long as it is clear that, in a given discourse, there is an acknowledgement that "images" are an anthropological category in the first place. This is, for instance, the case in Vilém Flusser's conceptualisation of the technical image. For Flusser, the image is always something that humans look at. For him, the introduction of electronic images provides a medial extension of what humans can imagine. There are considerations in Flusser's theory of technical images that acknowledge the fact that they are closer to concepts than to other pictures. He writes that technical images "do not mean scenes, but concepts. Ontologically they are on a completely different level than all other pictures and have a completely different genesis than them." (Flusser 1996, cit. Irrgang 2017, 38) But the "operations" Flusser associates with such technical images are the human faculties of thinking, of reflexion, imagination, and communication.

For another example, we can turn to Inge Hinterwaldner's book on the "Systemic Image" (2010/2017), where the operations in which images are implicated are based on such an anthropological understanding of the image. In her discourse on the iconicity of synthetic images, Hinterwaldner analyses the way in which simulations work as interfaces of analysis and comprehension, and as interfaces of interaction, viewing the image as an interactive matrix for human computer users to engage with.

There is of course nothing wrong with such an anthropological concept of the technical image. However, it diverts us from the specific "perceptual topology" of optically based data collection and computation.

V.

How can we distinguish the "optical calculus", with its specific "perceptual topology" of optically based data collection and computation, from such an anthropological conception of the "image"?

An important aspect is that of the contextual periphery, what in our perception of images is happening outside the frame, outside the image field. This *hors champ* is spatial, i.e. the physical things that are beside and, importantly, behind the image medium, the picture. And it is semiotic, in the sense of the associations and references that we may connect with whatever the image shows.

What, in the case of images, is a necessarily vague and ultimately uncodifiable contextual periphery, is in the case of the "optical calculus", a precise and comprehensively described, closed world.

The programmation of the technical system requires a definition of what information should be taken into account. The same definition describes reversely what should not be taken into account. Even when it is programmed to observe contextual elements, these will, ontologically, only exist in this particular "world" in so far as they are integrated. The "optical calculus" recognises no *hors champ*, it registers no "outside the frame".

In contrast, the image, in Boehm's sense, is characterised by the very fact that it is distinct from its physical and semantic context; the meaning of an image is derived from that difference, a difference that has to be excluded from the calculation in order for the "optical calculus" to become operational – what Farocki calls the necessary disavowal.

Tom Holert seconds this arguments when he pleads for an expanded conception of "pictorialities" (*Bildlichkeiten*) that takes the consequences of their algorithmic state as operational images into account and that may, as Holert suggests, be more suitably expressed mathematically, than visually. A current sense of visuality requires a reflection on such images that takes the particular aesthetics of their algorithmic dimension into account, and that considers them, I quote, "as complex interfaces of human-machine interaction, [...] in order to stop expecting them to tell the truth about reality." (Holert 2014, 31)

The "optical calculus" is an unthinking, mindless mechanism. It is a calculation based on optically derived input data, abstracted into calculable values, which can become part of computational procedures and "operations".

(It feels a bit hard to speak of mindlessness, and I feel some sort of sympathy for the devices that, if they were animate, would no doubt develop some sort of desire for such interpretive faculties. Science fiction literature is full of such emergent desires – the feeling of love among the robots in Capek's story is a good example. But in order to get our head around the "optical calculus", we have to free ourselves from such animistic sympathy for "machines".)

From the perspective of the technical system, the visual input data are a purely instrumental element in a sequence of programmed steps; an object crafted according to the rules of information theory.

VI.

From this perspective, it is interesting to look again at the programmatic claim in the title of this conference, "Images Beyond Control"; of course there is always a nonhuman, I would say technical dimension to images that is determined by the material and technical affordances of the medium used; but otherwise the data sets and computations used in operational contexts are always as much under, or out of, control as any correct mathematical calculation is.

How much "control" is there in arithmetics? And how much control can one desire to gain over numbers and equations in algebra?

I don't know whether it is possible to write a human-readable text about the production, analysis and meaning of optical data sets from the perspective of a nonhuman technical system. I would suggest though that some of the urgent questions asked in the call for proposals to this conference, about the possibility of resistance and the regaining of control, will pose themselves differently, when the data objects in those questions are not, somewhat misleadingly, called "images". The critical agency would then have to be shifted towards the field of technical development and application.

VII.

To conclude, I would like to make some comments on a remarkable new research paper by Fabian Offert and Daniel Bell that addresses my topic from a slightly different angle. (Offert and Bell 2020) The authors provide a critical analysis of "feature visualizations", a visualization technique used to illustrate the operations of convolutional neural networks, CNNs, deployed in machine vision systems. Feature visualisations are based on "noisy" images which get processed by a CNN in a way that, what the CNN detects as recurring patterns, gets amplified, step by step. Thus the originally grey, neutral and redundant images begin to show visual features which CNNs attribute to a specific image class, such as a banana or a pair of sunglasses. Offert and Bell introduce the notion of the "perceptual topology" of such systems, to describe the shape and structure in which perceptual information is received and processed. The authors point to the critical difference between the visualisations and the systems they are supposed to elucidate, and argue that these visualisations displace the perceptual topology of the technical system in favour of a presumed legibility for humans.

Offert and Bell write that, "feature visualization [...] exemplifies an essential dilemma: the representational capacity of feature visualization images is inverse proportional to their legibility. Feature visualizations that show “something” are further removed from the actual perceptual topology of the machine vision system than feature visualizations that show “nothing” (i.e. illegible noise)." (Offert and Bell 2020, 7)

While I agree with the general line of this argument, I would like to raise three critical points that also pertain to our discussion here today.

Firstly, the question of academic disciplines, and research methodologies. The authors make an effort to keep their own field of Visual Studies in the game, even though the evidence which they present seems to contradict that. Of course, aspects of the non-visual can be significant subjects of Visual Studies. However, the very fact that the neural networks are looked at with regard to their visuality, seems to undermine Offert and Bell's important insight that their functionality is likely to be misunderstood if approached from that perspective. For the sake of consistency, the authors then limit their argument to a critique of feature visualisations, rather than addressing the more urgent question of the perceptual topology of neural networks.

Secondly, and more problematically, their text is rife with unnecessary anthropomorphisms. In their presentation, the technical system "sees", it "learns", it "deals with"; concepts like "meaning", "image", and "machine", derive from a humanistic register that may get deployed in order to make the argument more easily human-readable, but its usage undermines Bell and Offert's core effort to develop a critique of the perceptual topology of "computer vision systems." They describe these systems with an anthropomorphic register and thus fall victim to the very mechanism that they so elegantly identified as the flaw of feature visualisations.

Thirdly, the authors link the concept of a "perceptual topology" with the notion of a "perceptual bias", a somewhat moralising term here used to describe some sort of inappropriate (or inaccurate, non-realistic) functionality. This "perceptual bias" is associated with a lack of the systems to be "intuitively" understandable. A recurring sub-theme in the text is a longing for explainability, interpretability, understandability of such technical systems, and for their "intuitive" accessibility. The authors remain opaque on the question what motivates the desire for such "intuitiveness", and where such (presumably human) intuition might be sourced from, – which may be understandable from the perspective of enlightened and humanistic curiosity, but which seems inadequate in the face of technical systems whose very function is to be inhumanly complex and fast. Of course, the question of explainability arises because this is not simply a set of mathematical and informational models, but they get computationally implemented and used in societally relevant contexts. Yet, on this "path of explainability", the mathematical abstraction germane to these systems is replaced by anthropomorphisms (which, by the way, themselves become the kernel of an unrecognised "bias" – aka functionality – of the desire for "interpretable machine learning"). The human desire to understand such processes is commendable, but it appears incompatible with the technical and physical reality of such systems.

VIII.

It is possible to frame such a "desire for understanding" by an insistence on a political reading of such systems. Offert and Bell don't make that connection, but they would be in good company: authors like Allan Sekula, Harun Farocki, Thomas Keenan, or Tom Holert have framed their own treatments of operational images by the sociopolitical contexts from which the technologies emerge, and in which they are deployed.

With regard to the "optical calculus", we could then ask what role the human crafted visual media play in the process of optical data collection. How does this "derivative visuality" inform the data and the computation? Should we speak, in these cases, about an optical calculus based on a visual media apparatus? And how do systems using, for instance, video cameras with rectangular frames and two-dimensional reception sensors, compare to a "machine vision" system like radar which has no immediate equivalence in the range of human perceptual faculties?

From a technical perspective, this might be regarded as a problem of inadequate, imprecise tools for data collection, which generate "noisy" data sets. In that sense we could imagine the "operational images" as human-tainted data sets, with an abundance of unnecessary detail and an inverted logic, since humans can often understand "images" only by considering what is not there, what is outside of the frame; whereas from the perspective of the technical system, whatever is collected as data represents the whole world.

The optical calculus is therefore not only ontologically and epistemologically different, but also cosmologically different from the "operational images" of which humans dream.

IX.

In his study of historical methods of scientific visualisation, *Image and Logic* (1997), Peter Galison distinguishes between two traditions, "the image tradition" and "the logic tradition." The latter, Galison maintains, is based on mathematics and on statistics, and it thus falls into a different register and has recourse to a different set of academic disciplines than the other, the "image tradition".

I believe that we have to recognise that the subjects of study in our engagement with so-called "operational images" are mathematical and computational objects whose sensibility for optical phenomena begins and ends with more or less advanced forms of pattern recognition – an observation that I take from Leipzig-based artist and scholar Francis Hunger (2017). The related systems don't "see", and they certainly don't see images, but they perform calculations on optically derived data sets.

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