# Aberrant Patterns: Cataloguing the Visual Effects of Materialising the Hidden Patterns in Digital Imaging Systems

## Scanning Heritage: Qualitative Representations

The commercial imperatives behind promoting the contemporary city through the broad dissemination of its image have resulted in an escalation in the use of digital visioning systems. Importantly, these systems calibrate hard and soft technologies that aim to mimic the Human Visual System (HVS). To achieve this mimicry, patterns secreted in the camera's mechanisms and processing algorithms work to erase the aberrant visual behaviours inherent to these artificial visioning systems. Ironically, these immaterial patterns establish processes and protocols that clean up the image to present a city image that cannot be 'experienced' with the naked eye.

Past design-based research shows how embracing the aberrant behaviours native to the digital visioning system reveals the conceit behind attempting to construct the perfect city image. Specifically, this research indicates that it is possible to disrupt the clarity of such images by simply replicating these secreted patterns on a building facade. Significantly, the application of these patterns across a range of scales and in either two or three-dimensions, can be calibrated and then catalogued to link aberrant behaviours to various 'real-world' functions. However, the rejection of mimicry associated with the simple act of making the immaterial material does more than disturb the city image: the tectonic expression of the immaterial ruptures the political economy that currently governs the contemporary practices used to image the city.

The capacity to disrupt the city image allows for a critical assessment of the political economy of such representations. It is also apparent that the ability to catalogue the aberrant visual effects of digital imaging systems according to 'real-world' uses also brings with it a capacity to unpack and curate a range of political functions that accompany the deployment of the disparate effects of these patterns.

Keywords: architecture, urban images, digital imaging technologies, HVS model of vision.

### Introduction:

The proliferation of still and moving images within the public domain reflects how easy it is to produce and disseminate images digitally. Despite the technical transformations involved, digital image production still constructs images according to the Human Visual System (HVS). This model, which mimics how the human eye sees, uses a procedurally-based biological analogy to sublimate two fundamental shifts in digital image production. First, affordability prioritises a 'fit for purpose' design approach. As long as they achieve an adequate level of resolution without causing aberrant image artefacts, digital imaging systems (DIS) do not have to match the technical and operational sophistication of the human eye.[1] Second, the networked computer removes the discrete activities that previously typified emulsion photography. The transformation of images into data dematerialises past material and spatial boundaries, making it easier to integrate production and dissemination.

Designing digital cameras on a 'fit for purpose' basis introduces susceptibilities unique to digital visioning systems. Self-authored research shows that replicating the patterns used to process images onto a built surface disrupts how and what the camera sees.[2] Variations in pattern type, scale, colour and intensity assemble into a taxonomy of 'unnatural' visual effects. Importantly, the mathematical principles governing the optical performance of the hardware and the algorithms make these effects predictive. The ability to catalogue these effects is made more significant by the way in which visual data is used to coordinate the equipment used in image production and dissemination. Under these circumstances, this taxonomy of effects transforms into a rule book on how to intervene strategically in a host of new viewing scenarios. The possibility of strategically intervening in how images circulate speaks to a different type of political agency that goes beyond the meaning of an image. Therefore, the tectonic expression of the immaterial patterns within digital imaging takes the politics of the image somewhere closer towards a performative mode of intervention.

**The Human Visual System Model**

Irrespective of the differences between analogue and digital camera technology both steadfastly adhere to the Human Visual System (HVS) model of vision. The HVS model is biomimetic because it solicits images by functionally imitating the constituent components of the human eye. In effect, the HVS model biomimetically replicates the way in which the eye sees by processing the world according to colour, brightness (or light intensity) and shape. As Barbara Gillam argues, this model also attempts to stabilise representation. “The main function of perception is to decode the transient retinal image in order to achieve constancy: the perception of the external world in terms of its stable and intrinsic characteristics.” [3]Consequently, a mechanical aperture copies the iris and pupil to control light, a lens is used to focus the image, and a photosensitive surface replicates the image forming impulses triggered as light hits the retina. The model's rationale presupposes an instrumental and representational form of depiction when viewed from a purely technological standpoint. It is instrumental because image production relies on a mechanical depiction of the eye. It is representational because of the expectation that the resulting image faithfully indexes the captured scene. There is a clear interrelationship between these two forms of depiction given instrumental depiction exists only to convincingly re-present the world as it (apparently) appears to the eye. The prioritisation of the image in this interrelationship is representationally convincing enough to sublimate the technological mimesis governing image creation.

Of the many reasons for producing images, surveillance and marketing reinforce the need for representational depiction. Monitoring and marketing require that images must be as 'natural' as possible. The need to present ‘natural’ images exploits the technological performance of the HVS model. In such circumstances, the value of the HVS model is its technical capacity to establish fidelity between the world and its representation. Surveillance and promotion use images differently. The former substitutes the eye for the camera to persuade the remote observer and the situated observed that the camera is a reliable proxy for the eye. The marketer's gaze fixes on the representational content of the image. It encourages the observer to project themselves into the scene as they are enticed into reading the image. Irrespective of these different viewing relationships, the logic of monitoring and marketing both need images that are akin to what is seen by the naked eye. The veracity of the image relies on being 'natural' enough to divert attention away from the technical mediation going on behind the scenes. The technology must be mute because any imperfection in the image registers a failure in the capacity to create a faithful depiction. Instrumental and representational forms of depiction require techniques that smooth out any subtle differences that may exist between the photographic image and human vision.

Numerous critiques of photography support the claim that photographic images are hardly natural. Like linear perspective, there are subtle but essential formal differences in the images produced by a single viewpoint and binocular vision. It is also correct to say that the embodied act of seeing is vastly different from photographic images. Photographs are static image-artefacts. They do not replicate the experience of seeing by ignoring behaviours like saccadic movement. If these discrepancies were not enough, commercial imperatives result in camera manufacturers using different proprietary colour range profiles. Collectively, these technical differences furnish a range of visual inconsistencies between images and the real world.

**Hard and Soft Patterns: Aberrant Behaviours in the digital HVS model**

The critical distinction between analogue and digital photography reflects the material differences in the photosensitive surfaces used to capture images. The inscription of the image onto a physical medium is very different from the electrical impulses generated by sensors. This material difference means that analogue photography tends to determine image quality at that moment when the light hits the film. In contrast, DIS technology processes the image elsewhere. The conversion of the image into transferrable packets of data overcomes the limits of emulsion film because image quality can be improved both as the sensors capture the scene and as software moves between data and image.

Compared to emulsion film, the use of electrical impulses to transform the image into data for processing elsewhere offers a far more accurate parallel to the interrelationship between the retina and brain. However, the DIS provides a far more basic version of human vision. The sensors are far less sophisticated than the retina because they do not match the density of cones in the fovea or each cone's capacity to register colour. This discrepancy in sensor density is an economical choice given digital camera performance uses a 'fit for purpose' approach to design. The economic advantage of the digital process is that the image’s dematerialisation can use algorithms as an affordable fix to the performative limits of the hardware.

The algorithms used in image processing respond to specific geometric patterns that occur in optics. Given the propensity of these patterns to occur throughout the image processing pipeline, different algorithms are used to capture and organise visual data and remove aberrant image artefacts. Over the last decade, numerous articles by the authors have revealed a susceptibility in the DIS caused by simply replicating these algorithmic patterns onto a building facade. It is important to note that the final facade panels are passive; any disruptive effects result from the way 'active' digital technologies 'see' the world. The patterns on these panels physically replicate the optical geometries that dictate the function of each algorithm. This physical, geometric expression of these algorithms replicate those used to capture the image, organise the visual data, and improve image quality. By extension, these patterns, which are 'printed' onto a solid substrate, also align with the performative categories of the HVS model-colour, light and shape. The first panel category copies one the most common Colour Filter Array (CFA) patterns, the Bayer Array. (Figure 1) These gridded structures, sitting above the sensors, capture colour information by filtering light according to the additive RGB colour model. However, an interpolation algorithm is used to fill the gap because the density of the filter is often insufficient to colour each pixel. (Figure 2) Sample points are taken from the original data array and the values of the unknown pixels in the projected larger array are effectively produced through programmed guesswork.[4] (Zeimbekis, 2012).

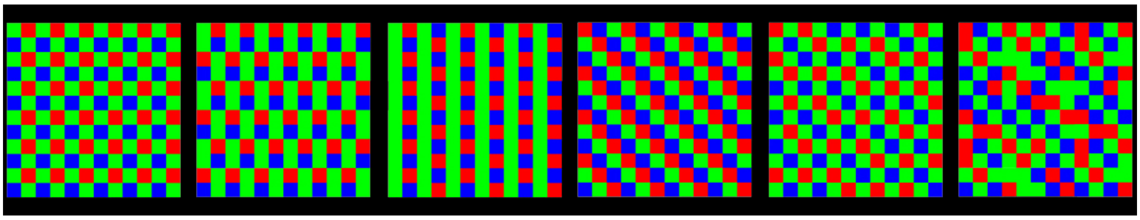

Figure 1. A sample of the more common CFA patterns. The Bayer CFA is the first pattern on the left. © Linda Matthews, 2016.

The second pattern category replicates the algorithms that target the cues for brightness used in the HVS model. These algorithms duplicate the pattern of aberrant visual effects caused by the diffraction of light. In such cases, algorithms are deliberately introduced by camera manufacturers to erase these ‘unnatural’ aberrant visible artefacts from the image. The authors have tested Fraunhofer diffraction patterns. Significantly, diffraction patterns are not a simple consequence of the pixel count or resolution. (Figure 3) Instead, they are parametric; they are a consequence of whether the wavelength of the diffracted light is large relative to the pixel size. Glare (which is translated by the camera as an artefact when light exceeds the range of luminance that can be accurately measured by it) is therefore image-dependent and cannot be rigorously removed by calculation.[5] In this case, the panels are translucent because of the need for these patterns to be backlit.

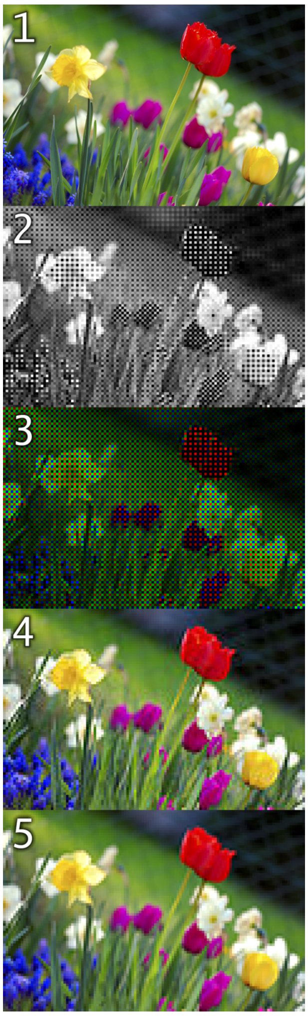


Figure 2. Colorful spring garden Bayer + RGB.png. © By Cmglee - https://commons.wikimedia.org/wiki/File:Colorful_spring_garden_Bayer.png, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=68063700, 2016.

“1. The original scene of a garden with some tulips and narcissus. 2. The response of a 120-pixel × 80-pixel sensor with a Bayer filter in a digital camera. 3. The response colour-coded with the Bayer filter colours. 4. The reconstructed image after interpolating the missing colour information.5. Full RGB version of 1, downscaled to 120x80 (then upscaled using nearest neighbor).”

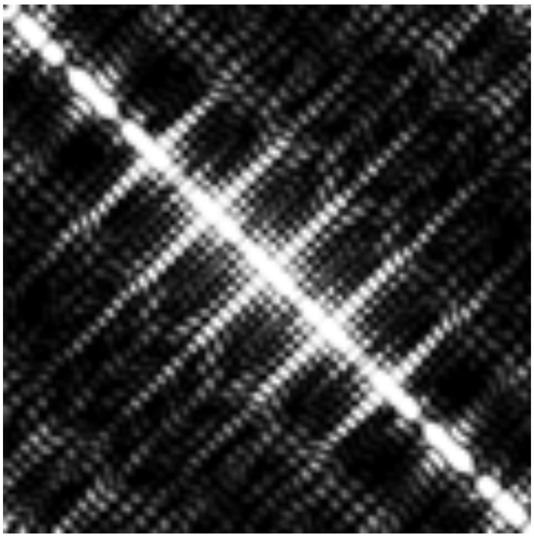

Figure 3. A sample of the more common CFA patterns. The Bayer CFA is the first pattern on the left. © Linda Matthews, 2016.

The third category of panels appropriated HVS cues used to determine shape or structure. The camera's image sensor uses various architectures to convert the analogue electrical light charge into a digital value, and all of these processes involve raster scanning patterns.[6] (Figure 4) The procedure of ordering pixels by rows is a highly strategic process. The direction and vertical retrace action operate according to a pre-determined algorithm programmed to prioritise the production of a smooth, moving image. Many variations of this scan-order code enable the process to isolate and privilege image regions of specific interest, thus enabling the production of a stable and highly curated image.[7] When applied to an image-captured surface, these structural patterns produce disruptive aliasing and moiré effects.

The visual and mechanical disruptions caused by the patterns highlight a paradox of the HVS model. The effort to produce images that mimic what the eye sees produces new disruptive artificial image artefacts that are unique to DIS. If "the limitations of the human visual system (HVS) can be exploited to improve the performance from a visual quality point of view" then it is equally true that this.[8] These panels challenge the authority of the instrumental and representational depiction by deliberately turning the technology against itself.

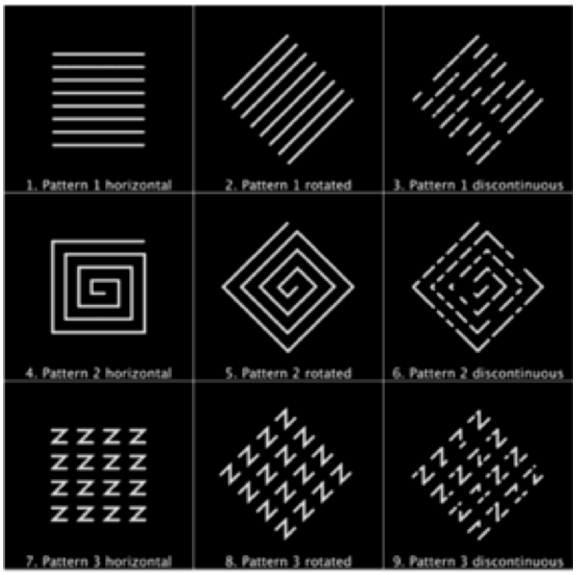


Figure 4. A range of different Raster Scan Order Patterns © Linda Matthews, 2016.

**Portability & Co-dependence**

The conversion of images into data gives digital imaging its unique social and cultural capital. The medium delimits analogue technologies by locking production and dissemination into a series of specialised and discrete of actions occurring in purpose-built spaces. In contrast, digital images are transferable. Digital cameras, personal computers and printers significantly remove the cost of labour, materials, space and equipment. They can be modified at the moment of being captured, transported and processed. The subsequent ease and affordability of producing images enable very different economic and social paradigms. These actions not only impact image making; they also free image-making from the need to produce image-artefacts because it makes just as much sense to transmit images as it does to print them. Consequently, digital technology makes image production highly portable.

Portability usefully describes both a general facility to move objects easily and the capacity in computing to work across different computers or operating systems with little or no translational disruption. This second definition is particularly relevant because data moves smoothly between different hardware platforms. In analogue photography, the interdependence between the darkroom, processing laboratory and the various professional and consumer outlets operate through a very different economy. Each technological step involved in the processing pipeline must wait for the previous technology. This need to wait reflects how the processing pipeline is sequential. The technology functions independently. In the digital imaging pipeline, portability makes it possible to use the same data set to impact on the operation of two discrete pieces of hardware. Computational portability anticipates the current trend for data to influence or direct a technological co-dependence between hardware.

Recent research has examined the effects of using a recursive figuring of these patterns. This decision builds on previous observations where select patterns prevented the camera from focusing on the surface at specific f-stops. In this earlier work, the tests simulated the operation of a promotional Internet Webcam. In such cases the webcam fixes the camera to a specific location. The only operability available to the 'virtual' tourist is the capacity to pan across and zoom in and out of the scene. The simulation of this viewing scenario revealed how the interaction between 'passive' patterned facades and the 'active' hardware disrupted the camera’s smooth operation. The tests revealed two types of disruption- the ability to blur the image or modify the brightness of the surface relative to its context. Both effects modified the image enough to highlight the discrepancy between what one sees in the world to what one sees on the screen. The multi-scaled recursive pattern design used this knowledge to disrupt the operation of the algorithms across the entirety of the camera’s zoom trajectory.

The fouling of the camera’s movement or the image quality registers the relationship between pattern size, resolution and distance. While resolution indicates distance as the determining factor, distance itself reflects the more fundamental interrelationship between the relative size of the physical pattern to the resolution of the camera. Thus, the co-dependence between the 'passive' surface and 'active' hardware results in a calibrated, predictive set of effects. The calibration of these effects measures a parametric relationship between pattern type and camera resolution. Ultimately, it is the f-stop, and not spatial distance, that calibrates the type of effects that occur between surface and camera. (Figure 5)

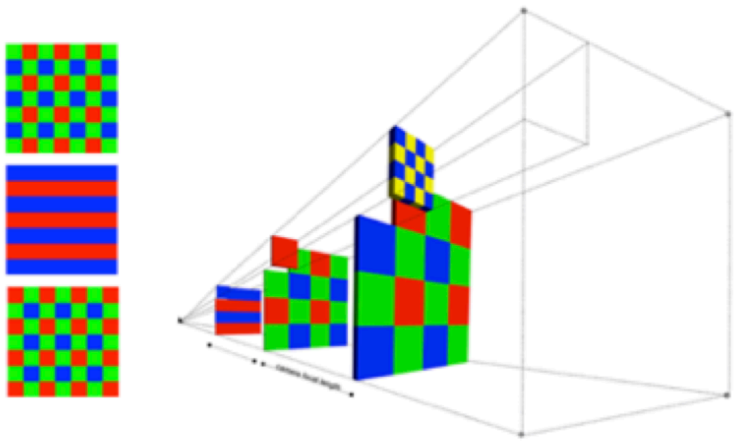

Figure 5. Recursion in CFA Pattern © Linda Matthews, 2017

The simulation of the webcam viewing scenario identifies camera trajectory as another critical determinant in calibrating the visual effects of these patterns. City authorities are drawn to promotional webcams because they give offer a limited type of interactivity. While the curational concerns of the webcam require a certain degree of fixity, the politics of surveillance places operability back into the hands of authority. Drones are the perfect instruments for surveillance because they are free to transverse territories. This different viewing scenario establishes introduces an altered type of co-dependence. For instance, a low-level consumer drone can be piloted using GPS or optical tracking. Optical tracking fixes the drone's movement to the visual data provided by the onboard camera through shape recognition algorithms. The self-similarity found within the recursive pattern is attractive precisely because it prevents the camera from discriminating between objects across an extensive viewing trajectory. The ability to foul the image across a wide viewing range can holt the drone's movement. (Figure 6) This capacity to interrupt the drone indexes the co-dependence between a passive panel and an active camera. This primary co-dependence leads to a second co-dependence that operates between two separate pieces of hardware. The example of the drone also confirms the critical correlation between the type of viewing scenario and panel design.

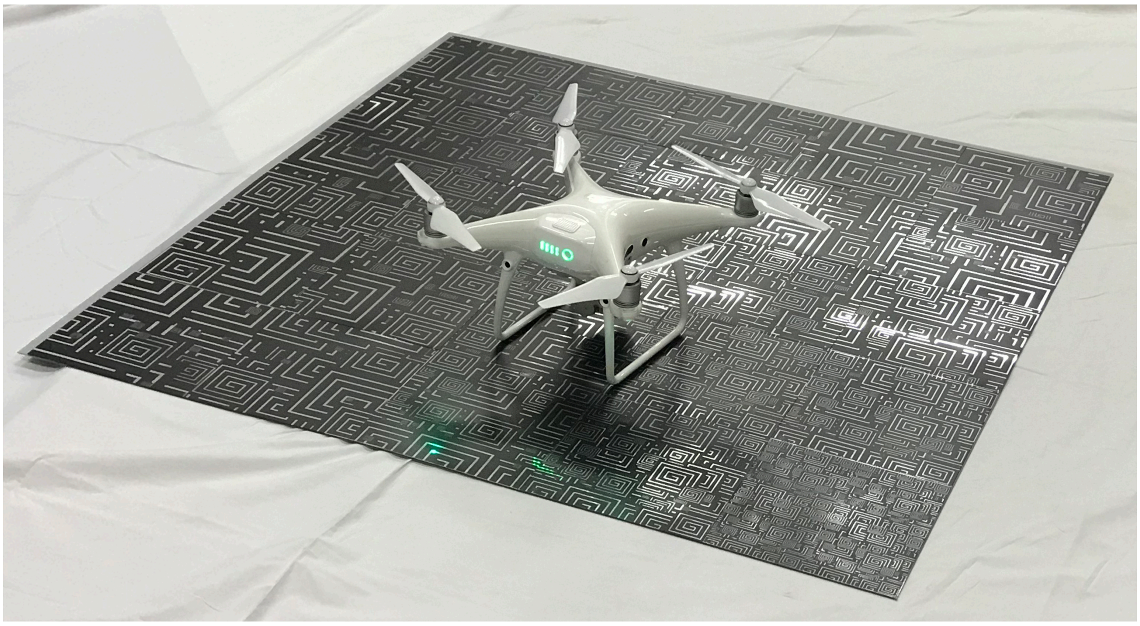

Figure 6. Image of Drone Forced Landing © Linda Matthews, 2018

The term design is vital because surveillance must consider the optimal range for the size of the panel and the density of the pattern. For example, the ability to confuse a military drone presents two alternative viewing scenarios. One scenario removes the human observer. Here shape recognition algorithms would be used to scrutinise large amounts of video footage. A pattern could camouflage on an object by producing a visual signature that sits outside the catalogue of known object-image signals. A second scenario would involve a high-altitude drone. Superficially, this scenario would echo that seen with the webcam. However, the drone's height could radically increase the size of the pattern. Operating now at an urban scale, the drone would address very different programmatic circumstances and require very different tectonic solutions and fabrication processes.

**Conclusion**

The proliferation of still and moving images within the public domain testifies to the affordability that comes with producing and disseminating images digitally. Irrespective of the digital transformation the image economy reinforces the idea that images should faithfully render the world. Architecturally, digital practice has strengthened this circumstance by prioritizing the formal potential offered by the new digital toolset.[9] The concern with novelty has resulted in iconic formal production.

The lie of the truthful image is exposed once the observer aware of how mediated the view is. These vulnerabilities contain an alternative formal logic that replaces the semblance of the real with a new set of … The immaterial tectonics of these vulnerabilities express themselves through a series of patterns that are used to make sense (or reproduce) the image. Applied through a range of scales in two or three-dimensions, the aberrant behaviours caused by duplicating these patterns can be calibrated and catalogued according to various 'real-world' effects.

The physical manifestation of the immaterial protocols operating within the digital imaging process provides new real-world tectonic. Ultimately, the formal, spatial, programmatic and constructional decisions that come with the digital image can challenge the politics of the view.

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**Endnotes**

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4 John Zeimbekis. "Digital Pictures, Sampling, and Vagueness: The Ontology of Digital Pictures." *The Journal of Aesthetics and Art Criticism*, 70 (2012)

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