CHAPTER 2

Non-human Sensing: New Methodologies for the Drone Assemblage

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Our machines are disturbingly lively, and we ourselves frighteningly inert.
-Donna Haraway (Haraway 1991, p. 152).

Abstract Consideration of the drone as a component of an audio/visual methodological assemblage prompts post-phenomenological questions about how bodies act with technologies. Piloting a drone through a live video stream appears to create a sensory extension. Yet the increasing autonomy of the drone, facilitated by exponential innovation in sense-and-avoid technologies, point towards future amalgamations that are increasingly more-than-human. In the context of a plethora of work on the 'terror' of the drone, where operational autonomy is politically non-negotiable—for autonomous machines cannot yet be held to account—we suggest here that the non-human, multi- and extrasensory visuality of the drone are more plentiful than terrible, more evasive than invasive, and create practical and imaginative space for experimentation. Here,

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we first think through the relationships between bodies, ex-bodies and objects in the imaginaries and practices of drone piloting. Then, we suggest that where drones—as aerial avatars—are reshaping methodological imaginations through the unique sensual amalgamations they afford, future drone bodies will be less stringently tethered to the hand and the eye of a human host as the drone flies off on its own, in swarms or alone.

Keywords Drones · Bodies · Autonomy · Senses · Aerial · Non-human

2.1 Introduction

The drone is defined as much as a technology that can see as a technology that flies; where we find drones 'there is one feature we see in almost every situation—the presence of a camera' (Rothstein 2015, pp. 75–76). This seemingly leads to a simple slotting of the drone into an expanding digital methodology research toolkit. Yet, Phillip Vannini (2015, p. 232) suggests that 'if all that the camera is employed to do is to see something the naked eye can also see on its own, than what is its value?' We argue that drones take seeing and sensing to new heights and have the capacity to reform bodies and imaginations. As a culturally charged media device full of real and imagined significance, camera mounted drones have pushed McLuhan's (1964) idea of media as extension of perception as far as any device to date where the 'technology supplies the dominant basis for an understanding both of the world and ourselves' (Ihde 1983, p. 10). Drones allow us to occupy spaces never before occupiable, open new opportunities for sensing environments and create new sets of challenges around territorial sovereignty, law and privacy.

While much has been written about the 'terror' of the military drone (Chamayou 2015) and its imaging capacities (Gregory 2011), in some cases military drone technologies are actually being informed by faster-developing consumer-side research and development (Hsu 2017). Commercial off-the-shelf drones are now filled with advanced sensor technology far beyond the camera and are linked to high-powered computing via wireless terrestrial or satellite networks. This array of sensors, signal, processing and controls both tethers the drone within human and technical systems and produces an eerie kind of autonomy where the drone can override the decisions of the operator to accomplish tasks or to preserve its own body. Thus, where Urry (2003, p. 138) writes that all aerial technology is 'moored' to an infrastructure on the ground, we wonder *for how long*? It is this tension between assemblage and autonomy that we pursue in this chapter to complicate the 'put camera in sky and stir' methodological innovativeness of drone technologies.

In the context of audio/visual methodologies being deployed across the humanities and social sciences (Bates 2014; Pink 2007), we would like to consider the current sensory capacities of the drone and how they are changing the ways that we sense and the ways that we imagine we can sense. In short, we are concerned with how the body of the drone forms an assemblage with the environment and operator to create new bodies and imaginations. But further, we would like to consider what the non-human, multi- and extrasensory visuality of the drone have to offer, beyond the 'terror' associated with its sensuousness or increasing operational autonomy. If we speculate on drone assemblages or imagine future bodies in assemblages that have less or no need for the human, what then of drone theory and drone methodology, when the drone no longer remains tethered to the body and its modes of human sensory motor perception?

2.2 The Drone Body

What can drone bodies do? Current commercial drones such as those produced by DJI and 3D Robotics (3DR) are capable of recording still and video images but can also use those images to compile three dimensional volumetric models using LIDAR and photogrammetry, for instance. On most aircraft, basic obstacle-avoidance capabilities are now standard features, where ultrasonic (mimicking mammalian/cetacean sonar) and optical sensors maintain the aircraft's position in relation to objects and environments. Drone imaging systems or 'payloads' vary greatly. Large and small-scale models make use of video recording and streaming relayed to a ground control locations and monitoring systems via wireless radio frequency transmitters, in combination with satellite GPS tracking and location information. Small cameras are commonly used to transmit high-definition video imagery, often in wide-angle and taking a kind of spherical, orbital global image of ground activity below. The drone's bodily movements (and stability) constrain the function of the camera it often carries. This movable camera functions both as one of the primary purposes of drone operations in its aerial media production, and as its mode of remote visual control through streaming into a tablet, phone or first person view (FPV) goggles. Signal strength varies depending on the hardware and network systems, but for civilian drone systems usually ranges from around 1 to 6 km. As one might imagine, whizzing through the atmosphere at great distance from your body, relaying the video into immersive goggles, '…what you feel is not displacement but extension' (Wallace-Wells 2014), the extension of the human body into aerial or atmospheric assemblages.

Drones 'see' through a complicated array of sensors and machine vision software systems. The DJI Mavic, for example, incorporates a 4K high-definition movable camera for recording and FPV, in addition to two fixed forward-facing stereo vision cameras and a sonar system. In combination with computer vision, object recognition, and machine learning processing, these are used to track objects in 3D space, detect and avoid obstacles, and track and follow chosen subjects on the move. The sensing system at play in this device not only allows the drone to fly more autonomously, but introduces an intelligence that produces new tactical functionality in the machine's ability to visualise and process visual data. Driving this technological shift for the DJI Mavic is the Movidius Myriad 2 chip, which allows for high-powered visual processing at low energy input. For this device, the 'return to home function' and object or subject tracking introduces a new kind of intelligence into our visual extensions, and gives the camera-drone device a new level of visual reflexivity. In combination, these developments signal a giant step toward machine vision autonomy and as Illah Nourbaksh writes, these increasingly 'autonomous robots will displace our sense of control precisely because they are out of our control, but occupy the physical world and demand our attention' (Anab 2015, p. np).

Drones are clearly being outfitted with more-than-visual 'payloads' and many even grapple with things, picking up objects like chairs or working in swarms to build infrastructure like bridges.[1] No longer is the drone a simple cyclops eye that flies but rather part of a more-than-human sensorial assemblage. Where once the drone was considered an object looking out from its unique aerial position, it now more fully interacts with that position, more transparently altering its environment. This interactivity is possible because of the increasing range of sensors, and their integration with one another to solve flight control, stability, tracking and 'return to base' problems. But it is also because of the complex data processing that enables reactivity and adaptability to novel environments, obstacles, and even weather events.

As the drones 'exceeds' us, the body of the drone is also becoming less technological and more human-animal so that the line between either is increasingly unclear.[2] This is no surprise, given how drone designs take cues from the animal world, evolving through mimicry of anthropomorphic and zoomorphic features. The aerodynamics of bird and insect wings have occupied the minds of scientists and artists for millennia and drone design often mimics animal characteristics. Jordan Crandall (2011, p. 284) has referred to the drone as a 'winged fusion of human, beast and machine' and this is most evident in drone design inspired by the physiology of birds, where ornithopters simulate flapping wing flight of species including hummingbirds and seagulls and even jellyfish (using flotational air bursts). News reports suggest that ornithopters are already flying in Mogadishu, where in 2016, a 'mechanical bird' was found,

> …covered in dirt and grime, with signs of heavy wear, shoddy construction, or both. The bird-bodied drone looked tired, if it's possible for a machine to look tired. In that weary, mechanical body, we glimpse the art of hiding robots in plain sight (Atherton 2016, p. np).

There are also projects that have fitted microprocessors, batteries and radio receivers to living insects like beetles to allow external flight control using radio transmitters. The cyborg insect, 'a hybrid creature composed of organism and machine' (Haraway 1991, p. 1) can then be flown using oscillating electrical pulses that allow control of thrust and lift.[3] Dodd (2014, p. 153) explains that such creatures are then 'the outcome of social, as well as technological, conditions' and prompts recognition of the 'porous borders between human, animal and machine' (Whatmore 2002, p. 174). Expanding this further to consider future hybridised drones, and their role in future audio/visual methodology, photography specialists have already developed algorithms to convert photographs into data that represent how different animal species would sense the environment. There are great experiential possibilities to be explored in fixing such sensors to drones and exploring the environment through the eyes of an insect, bird or another animal.

Brian Massumi finds evidence of the fuzzy borders of human and non-human in his account of instinct and the 'supernormal' qualities of animals and insects, from 'the athletic grace of the pounce of the lynx', to the 'the architectural feats of the savanna termite', to 'the complex weave of the orb spider's web', and their 'automatic nature, or instinct' (Massumi 2015, p. 1). The link to media is made by Jussi Parikka in his study of the 'transposition between insects…and media technologies' (Parikka 2010: xiii). Massumi's point is that the supernormal quality we see in these instances 'is a force not of impulsion or compulsion, but of *affective propulsion*. This is why it is so necessary to say that instinct involves the inducement of an effect rather than the triggering of an automatism' (Massumi 2015: 9)—what Parikka (2010) refers to as the 'uncanny affect' of insects, robotic machines, and algorithmically controlled devices. If we take on board an expanded notion of the drone body, considering the above expansion of its sensory and physical bodily capacities, we wonder whether their instinct for acting and taking in the world through supernormal sensor capacities is the 'instrumentality of intelligence wrapped into reflex' (Massumi 2015: 1)?

For Jane Bennett vitality can be found in the 'nomadism' of matter, in the spreading of cracks or the self-transformations of metal, which is not a sequential movement from one fixed point to another, but a tumbling of continuous variations with fuzzy borders (Bennett 2010, p. 59). As Gregory Bateson once put it, emphasising the imbrication of human in nature and vice versa, in an ecological framework of social and historical effects, 'the generic we can know, but the specific eludes us' (Bateson 1979, p. 50). While drone bodies may be programmable, or controlled, algorithmic adjustments mediate every aspect of this control to accommodate trees, buildings, mountains, gusts of wind and automate return to home trajectories or camera tracking. Perhaps framing the drone calls for thinking 'not so much on drones as objects, but as [socio-technical] assemblages of the vertical' (Crampton 2016, p. 2).

2.3 Drone Piloting and the Wayward Object

Sensing and thinking are modes of processing and in this section, we would like to consider the drone a thinking object to probe its potential for *experimentation*, a potential that is ironically best illustrated by the accident. A popular part of the DJI Phantom Forums is called 'Lost and Found'. The simple stated premise is this: 'Lost or Found a Phantom or other Quadcopter? We'll help you reunite with your device!' The discussions there paint a picture of the wayward drone object, the intelligent device that has slipped out of the control of its 'owner', prompting us to think of the drone as an escapee. Unruly devices 'last seen' heading north east over 'dense brush' amidst gusty winds. One drone was found dormant 'in the middle of a pasture in St Cloud Florida', for instance, cut adrift from an owner, lifeless.[4] Feelings of loss and regret or surprise at an unexpected finding are palpable in the posts. But there is another direction that the drone's wayward capacity can be taken. We will illustrate with a story.

At Landeyjarsandur in Iceland, the landing site of the DANICE and Greenland Connect undersea fibre optic cable that author one was tracing with a drone, the machine sped away from the site at an alarming speed and seemed to wilfully ignore the 500 m distance limitations programmed into the manufacturer software. The environment, an expanse of low-slung black granular basalt dunes, seemed to create the potential for a breakage of limits, extending our proxy sensations into the realm of the uncomfortable and even the uncanny. Perhaps it was the topographical spread of the black sand beach, the anti-conductivity of the basalt in the black sand, or had something to do with the way the drone and the high electric field of the cable landing site interacted. This is all speculation but resulted in a seemingly limitless extensionality as the drone unshackled itself.

In these moments, the body of the pilot often contorts into unlikely empathetic permutations. These gestures are what James Ash refers to as a technological 'envelope' where the relationship between a technological interface environment and a user's body meet (Ash 2015). Janet Vertesi, in relation to the human inhabitation of the Mars Rovers' bodies by Nasa Jet Propulsion Laboratory Teams, argues that this possession is 'a *technomorphic* move in which team members take on the robot's body and experiences as part of their practice and narrative of their work' (Vertesi 2012, p. 400). Given the critical role of collective and individual gesture and movement here within and between bodies, both human and non-human, clearly these technomorphic shifts are more-than-imaginary and correlate with what Ash describes as 'ways of thinking that can attend to these inter-object relations and how they shape human capacities outside of the phenomenal realms of the subject' (Ash 2015, p. 8). Importantly, the errant capabilities and affective involvement of drone and human bodies suggest neither that the technology is deterministic nor that the technology is obedient, but rather that 'envelopes are homeomorphic, which means that they require engagement from a user to exist at all. Instead of trying to determine what users do or think, interface envelopes productively draw upon the contingency of the indetermination of users' actions in order to create envelope power' (Ash 2015, p. 16). If, however, we consider the increasing autonomy of drones, in light or their growing multisensorial capacities outlined above, what do we make of technomorphic or technological envelopes where objects condition objects?

Was this extended flight at Landeyjarsandur a failure or an opening? As Stephen Graham writes, '…moments of stasis and disrupted flow [can be] a powerful means of revealing the politics of the normal circulations of globalizing urban life' (Graham 2009, p. 3). In this light, the cause of the momentary autonomy at Landeyjarsandur is less fascinating than our imaginations that the drone became an agent and, in effect, usurped us as pilots, causing us to sympathise with it, to anthropomorphise it, to want to care for it. As Ian Bogost writes (Bogost 2012, p. 9), 'Anyone who has ever had to…operate on a computational apparatus knows that a strange and unique world does stir within such a device. A tiny private universe rattles behind its…exoskeleton'. All this leads us to consider that 'technical objects relate to one another and to human beings outside of human consciousness or intentionality' (Ash 2015, p. 20). This recognition creates a methodological opening. If a machine consciousness is in operation here, it is characterised by new mental relations set in train by the drone's capacity to provoke, question, grapple, act and otherwise intervene in the world (McCosker 2015).

The methodological intervention here arrives almost by accident, through the same processes that aim to stabilise and simplify the control of a remotely piloted device and extend its sensing capacities. For scholars looking to find a new angle on their research subjects, drones offer a break with a grounded perception and hence a chance for experimentation. The non-human vitality of the drone body, its movement or motility (self-propulsion), intelligent tracking and automated adjustments, its sensory feedback loops, ecological responsiveness and perceptual nimbleness brings into play a machine awareness that operates in two distinct directions. We see in this first a capacity to sense that characterises the drone's intelligence (and perhaps its terror), and second the practical or experimental applications that this makes possible. The implications for methodology centre on the disconnection that shifts the ontological frames through which we might see, sense, map and otherwise probe the world around us. The result is, as Jamie Lorimer describes, an 'affective micropolitics of curiosity in which we can remain unsure as to what bodies and images might yet become' (Lorimer 2010, p. 252).

This methodological opening can be recognised in relation to the wayward or 'accidental point of view' that drones bring into play. In other words, the drone's ability to find its own path also underlies its propensity to overshoot. Wallace-Wells (2014) calls upon a case study from Cupertino, California, where a teenager used a drone to explore his neighbourhood from above. In doing so, he discovered an electrical substation that he never knew was there—just a couple of blocks from his home. As the technology think-tank Superflux writes,

> Whatever the pros and cons, once you have this air-minded vantage point, you enter a position of strategic advantage and strength. A position that eludes to the magical effect of the pale blue dot, the overview effect and the change in cognitive ability. (Anab 2015, p. np).

2.4 Conclusions

Consideration of visual methods presumes a more or less complete sense of agency on the part of the human actant, where these methods are 'deployed' for investigative purposes. Approaching the drone in this way, however, leads to frustration since 'the drone was the first robot that obviously surpassed us' (Rothstein 2015, p. 86). Drones represent the hyper-agency of an aerial extension to sight and sensing beyond human capacity (including human sensory spectrums). Drone vision is linked to visual sensations—hence the post-phenomenological nod, but when the drone moves, or looks, like neither a human or non-human body, it terrorises us. Terror is the drone as an autonomous body—we are desperate to keep it 'tethered', 'moored' and bound in some way. But theoretically, and perhaps methodologically, we need to 'let it go', to take its semi-subjectivity seriously as a method for achieving new forms of non-human visuality and vision-enabled remote activity.

Exploring drones as a site for 'research, design, hacking, building and testing', Anab attempts to articulate the sense of excess that lies just beyond the affective entanglement of device and human body:

> As soon as they start flying, there is a complete and total collapse of the distance between us and the airspace surrounding us, as the drone becomes a new kind of disembodied prosthetic… standing with your feet on the ground, the tips of your body push up and high into the sky, entering a state of temporary amaranthine. (Anab 2015, p. np).

Pushing beyond this hyper-extension of human perception, as a response to the fitting of AI and powerful visual processing technology, we find a degree of autonomy, of instinct, characterised by an affective propulsion through an often accidental point of view. Superseding the terror that may result from both the loss of control, there is also an opportunity.

Adey understands this opportunity in the aerial gaze where he suggests 'it is multiplied and situated in different contexts. It is also a vision that is practised and touched. It is not simply ocular or visual, but an assembly of practices and materials' (Adey 2010, p. 145). What we are left with is a call to experiment, to invent new drone sensing practices to match the unfolding material developments of the machines.

Notes

1. Here a drone picks up a chair: https://www.youtube.com/watch?v=JNIs5_SdfTw and here drones work together to build a bridge humans can cross: https://www.youtube.com/watch?v=CCDIuZUfETc (both accessed 22nd February 2016).
2. Indeed future drones may be grown in vats and be comprised of more tissue and tendon than chips and circuits: http://www.popsci.com/bae-wants-to-grow-drones-in-vats-on-demand (accessed 22nd February 2016).
3. A depiction of this can be seen in the 2015 film *Eye in the Sky*.
4. DJI Phantom Pilots' Forums: (http://www.phantompilots.com/threads/drone-found-in-st-cloud-florida.97868/) accessed 14/02/2017.

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