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Drones for Foraging

Carl DiSalvo and Tom Jenkins

Georgia Institute of Technology
Digital Media Program
Atlanta, GA, 30332, USA

cdisalvo@gatech.edu
tom.jenkins@gatech.edu

Abstract: Drones for Foraging is a research through design project that explores the use of hobbyist drones in support of urban foraging. The underlying motivation for this project is to use design as a means of investigating future practices and to provide the basis for near-term innovation with hobbyist drones. Through this project we are developing use-cases that make strong claims around the current and future uses of drone technologies to aid bottom-up food finding, prototyping software and user interfaces for drone navigation, helping build a broader community of practice around these complex issues, and exploring the use of open-source technologies for image capture and analysis. Our work is intended to provide real-world rationales that move drones beyond being military hardware or simply a technological gizmo. Repurposing automation and monitoring technologies as partners in food-finding proposes a collaboration between the ecological, technical, and social that illustrates one way to generate new food infrastructures.

Keywords: Design; Drones; Agriculture; Foraging.

Introduction

Robotics and sensing technologies are common in industrial agriculture. Little attention, however, has been put towards the use of these technologies for small-scale or alternative forms of agricultural practice. Drones are a case in point—more and more drones are being used in industrial agriculture, but there is little design research exploring how drones might be used in other agricultural contexts. As DIY and hobbyist drones become increasingly accessible, they offer an ideal platform for experimentation in that vein.

Foraging is the activity of collecting edible fruit and vegetables from sites other than farms and orchards, such as collecting apples from trees planted in parks or mustard greens from abandoned lots. Foraging can be a way to supplement the local food supply by making use of fruits and vegetables that might otherwise go to waste. For instance, foraged apples can be donated to local food shelters to bolster the supply of fresh produce and contribute to the food security of a community.

The aims of the Drones for Foraging project is to imagine, investigate, and prototype uses of drones for foraging as an alternative agricultural practice, and to document and share that research-through-design so that it is available for others to build upon.

Figure 1. A drone searching an apple tree for ripe fruit.

Aims

Broad Aims

The broad aims of this project are to explore the practice and potentials of designing for new modes of civics. One aspect of these new modes of civics is new economies. In particular we are interested in exploring how to design for what economic geographers Gibson-Graham label post-capitalism (2006a, 2006b). The post-capitalism term denotes modes of labor and exchange that are often not captured in traditional discussions of capitalism and the market economy. For instance, discussions of post-capitalism include work such as undocumented care providers, migrant farmers, unregulated transportation services, and barter systems. Foraging is a post-capitalist practice because it operates outside traditional modes of agriculture but is dependent upon existing systems of providing food to the needy in order to function.

Foraging also exemplifies the relationship between economies and civics. Providing food to the needy, and more broadly, contributing the to the resiliency of the local food system to improve food security, is a civic endeavor. Foraging is an alternative way to do this—it operates in parallel to existing systems of food provisioning, intersecting at some points (such as distribution channels), while diverging at other points (such as how the fruit is collected). Foraging, then, is suggestive of a new kind of civics: a civics that operates in conjunction with governmental and non-governmental organizations and services, but is not in any official manner part of those systems.

Although economies are foundational to design, and increasingly design is engaging civic concerns and governments as clients, for the most part, work at the intersection of design, economics, and civics tends to engage common notions of governance and exchange. This is not meant as a critique. Rather simply to point out that our exploration of new modes of civics and domains such as post-capitalism contribute another perspective on contemporary design practice in an effort to broaden the field.

Narrow Aims

This research also has narrow aims directly concerned with the practice of foraging and drones as a technological platform. That is, we are interested in foraging as a distinctive practice: what is foraging and how is it done? This opens up other questions: How are fruit trees spotted? How does one obtain the rights to pick from a public tree or a tree in someone's yard? How are picks organized? How is the fruit distributed? As an unusual sort of agriculture for which there is little research, particularly design research, the specifics of the practice of foraging are worthy of elucidation.

We are also interested in drones as a platform. Drones are part of the cultural zeitgeist of the early 21st Century. The majority of our knowledge

Figure 2. Mushrooms in the wild.

Figure 3. Mushroom foraged.

of drones is as machines used for waging warfare or gathering intelligence. But the use of drones for other purposes, such as precision agriculture, is growing. So too is the use of DIY, "prosumer," and hobbyist drones, whether for real estate marketing, paparazzi, amateur and professional video, and photography. How do we design for the use of drones? What capabilities do drones have as a platform? And then, combining these two narrower aims together, what are the viable capacities and potentials at the intersection of foraging and hobbyist drones?

Process

Early in the research process we decided not to build a custom drone. We investigated the possibilities for doing so, and given the time and cost, we determined that using an off-the-shelf system would enable us to begin experimenting with a platform sooner. Of the many off-the-shelf systems available, we investigated two. The first of these was a pre-built hexacopter constructed on the ArduCopter platform. The ArduCopter platform is based on the Arduino and there is a significant community of developers and users for this platform. In addition, the platform supports autonomous

flight through an open software package and is capable of sensor integration. The second off-the-shelf system we investigated was the Parrot Drone 2.0. This hobbyist platform is ready to fly out-of-the-box. The drone is flown via an app for tablet or phone, and with an additional GPS unit autonomous flight is possible. There is an SDK for the control app, however there is limited opportunity to integrate sensors. Of these two platforms, the ArduCopter was significantly more powerful. However, it was also less reliable. The Parrot was less sophisticated, but easier to fly, and at 1/5th the cost, we would be able to purchase multiple drones to use and design with. So we chose the Parrot as our platform for research.

Mundane Interaction Design

Some of our research through design took the form of mundane interaction design. For instance, we drafted scenarios informed by our own experiences using the drone to spot fruit in the city, combined with desired functionality expressed by our colleagues in Concrete Jungle—a local foraging collective with whom we have been collaborating (www.concrete-jungle.org). Although scenarios are a banal sort of interaction design, given the novelty of the practice and the platform we found them to be useful for establishing and subsequently communicating basic use cases.

Perhaps less mundane than scenarios (but still standard fare for interaction design) we developed prototype software for drone control that approximated the functionality of the scenarios. A common function

Figure 4. Predator drone.

Figure 5. Hobbyist drone.

across the scenarios was setting waypoints on a map and having the drone fly to the various waypoints, take a picture, and then return. Using the Parrot development kit we implemented a version of this functionality and field-tested it (Figure 7). Another common function was the ability to recognize fruit on tree, using the built in camera on the drone. Object detection using computational vision is increasingly accessible, through packages such as OpenCV. However, identifying an object as fruit, either by color or shape, particularly when that object is surrounded by a multiplicity of similarly shaped and colored objects is still a formidable challenge. As a general proof of concept for the platform we implemented a feature in the flight app that would look for a red circle, and when one was identified, mark it with an orange circle. Although it fell far short of identifying an apple on a tree, the software did enable us to engage with the complexity of the problem and produce a working prototype that gestured toward the desired functionality.

Finally, extending both the scenarios and software, we designed a user interface toolkit. Following the standard of similar UI toolkits developed for mobile platforms, we designed a simple set of buttons, icons, etc. that would be useful for both prototyping and developing interfaces for drone controls. As with the software and scenarios, the UI toolkit was itself mundane interaction design activity, commonplace in technology development.

Designing Through Use

In order to support the activities of designing through making, we also engaged in ongoing use of the drone, taking it for test flights around the city to understand how it functioned, and experimenting with its utility in spotting fruit. In this way, part of the research through design took place through use, which we characterize as designing through use. With platforms that are more familiar, such simple use might not be necessary. After all, we generally know how a smartphone or tablet works and what it is like to carry such a device around, not to mention a laptop or desktop computer. But a drone is still a novel platform: a flying computer with media capabilities. Furthermore, under the best of conditions, it can fly for a mere 20 minutes. And without mastery, a gust of wind or a draft at 50 feet can send the device into a tree or wire or flip it and send it careening back to the earth. Before beginning to design for those computational and media capabilities we had to first learn how to fly the device. For the first several months, before writing scenarios, developing software or designing interfaces, we flew the drone on brief flights to master the control of the device well enough that we might use it to spot fruit. This learning took a material toll, as two drones were broken in the process, one beyond repair.

Once we had developed a modicum of skill in piloting the drone— enough that we could maneuver it between trees, adjust the altitude in-flight, and bring it back, relatively close, with minimal damage to the drone or any trees—we began conducting test flights for fruit spotting. In the beginning, this involved locating a fruit tree ahead of time, taking the drone to the location, and then flying it a short distance to the tree. The basic experimentation in these flights was for positioning for image capture: how close did the drone need to be to a tree to capture an image in which the fruit were clearly discernable? This process also yielded multiple images of fruit that we were then able to use for later experimentation with computational imaging techniques for identifying and counting fruit. Subsequent flights added the complexity of actually using the drone to remotely look for fruit, that is, to engage in the fruit spotting that was core to the concept. This involved taking the drone to a location where we knew there was a fruit tree nearby (within ~35 meters) and then piloting the drone in a search for the fruit. Though perhaps seemingly simplistic, such experimentation and practice in use was not only necessary for subsequent design work, it was itself a mode of designing through appropriation and adaptation of an existing platform.

Drone Foraging as Speculation

To help consider the roles that drones may play in foraging in the future, we produced speculative concept sketches of drone and related technologies. These push consumer-technology-based concepts towards adapting existing military and industrial hardware and systems. For example, military drones that are no longer in service may be repurposed as command-and-control platforms that determine foraging locations

Figure 6. Mock drone UI derived from scenarios.

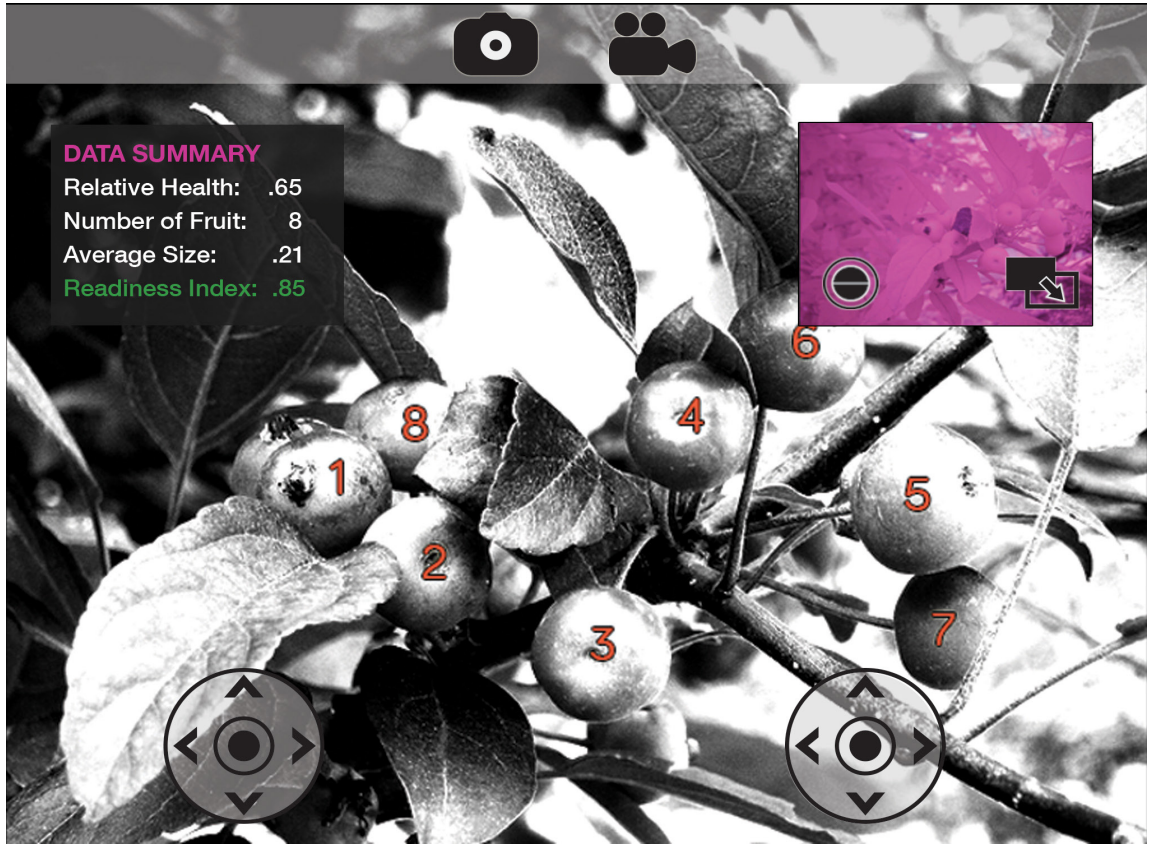
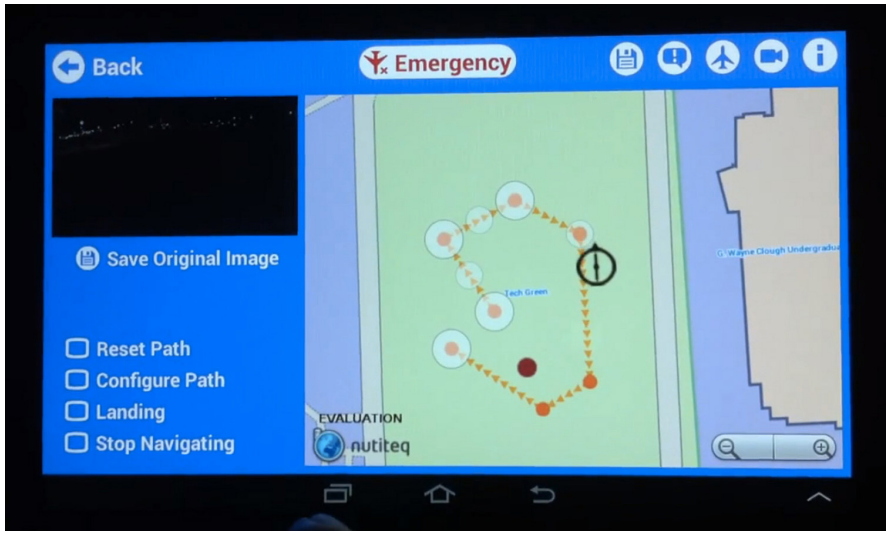


Figure 7. Custom flight application.



for swarms of inexpensive foraging drones nearer to the ground. Another concept applies automated robotic monitoring systems to regional crops, creating specific automated sensing tools for harvesting. In the example here, a member of a pair of ground-based drones shake trees, causing nuts to fall, allowing its conspirator robot to vacuum up the spoils.

Drones are a rich topic for speculation in design applications right now. Drone technologies occupy a zeitgeist so completely that speculation about the their role in enforcing the contemporary surveillance state and their application in warfare is implicit in any concept. Conceptual work that is centered in the material of autonomous sensing platforms become part of larger, ongoing conversations around these issues even as their mundane technical abilities can be harnessed to help solve real problems in real communities.

Outcomes: Two kinds of things made

In the near future, drones will not be used for foraging. Through our research through design we discovered a number of obstacles. First, there are technical obstacles. These can mostly be reduced to issues with batteries and GPS: the batteries do not provide enough power for extended flights and the GPS is not accurate enough to locate trees as needed. Second, there are policy obstacles. At the time of writing the Federal Aviation Agency (USA) has banned the use of drones for commercial purposes. Notably, foraging seems to escape the definition of

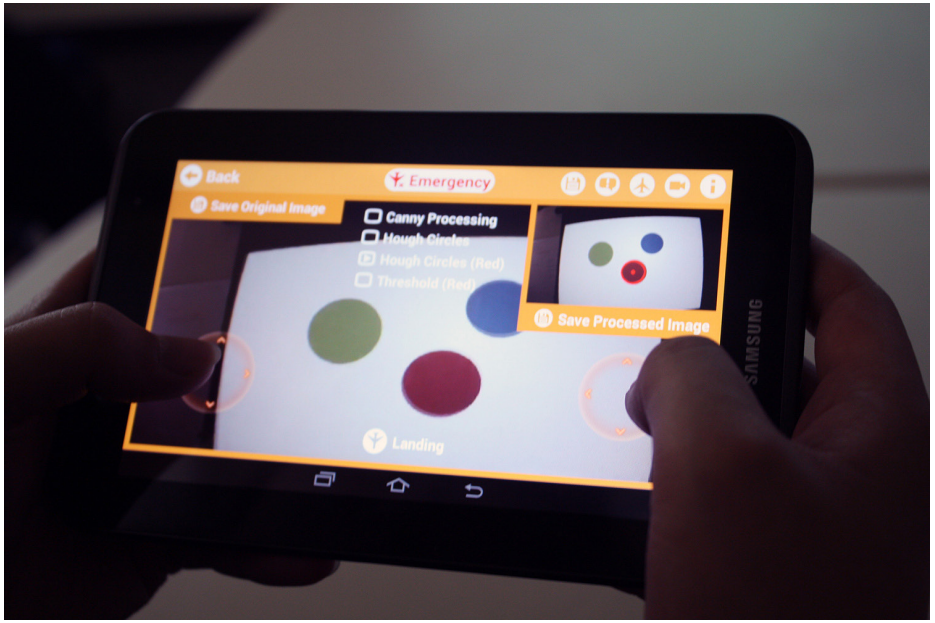
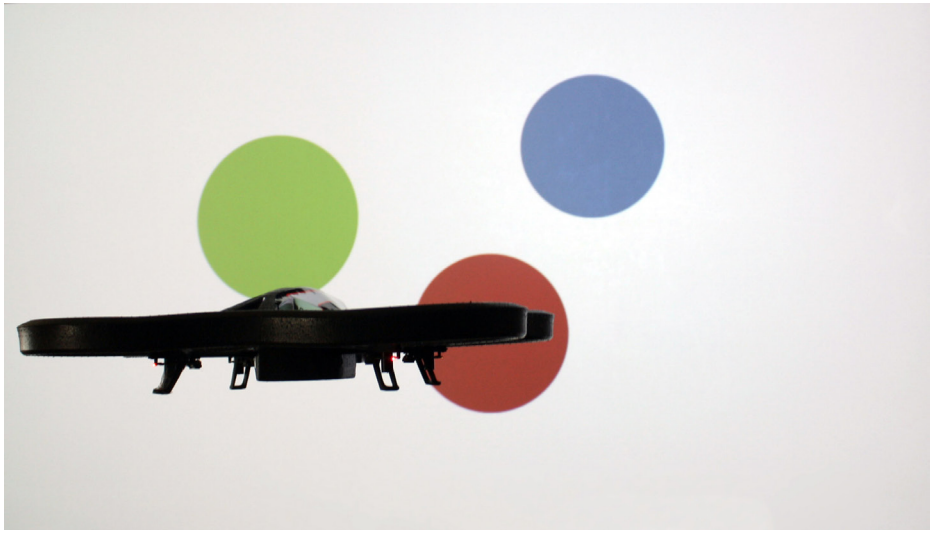


Figure 8 (above). Object detection UI.
Figure 9 (below). Object detection test flight.



a commercial purpose, but the regulations are currently still too prohibitive for drones to be used for foraging on a regular basis. Nevertheless, things of value were made from the research.

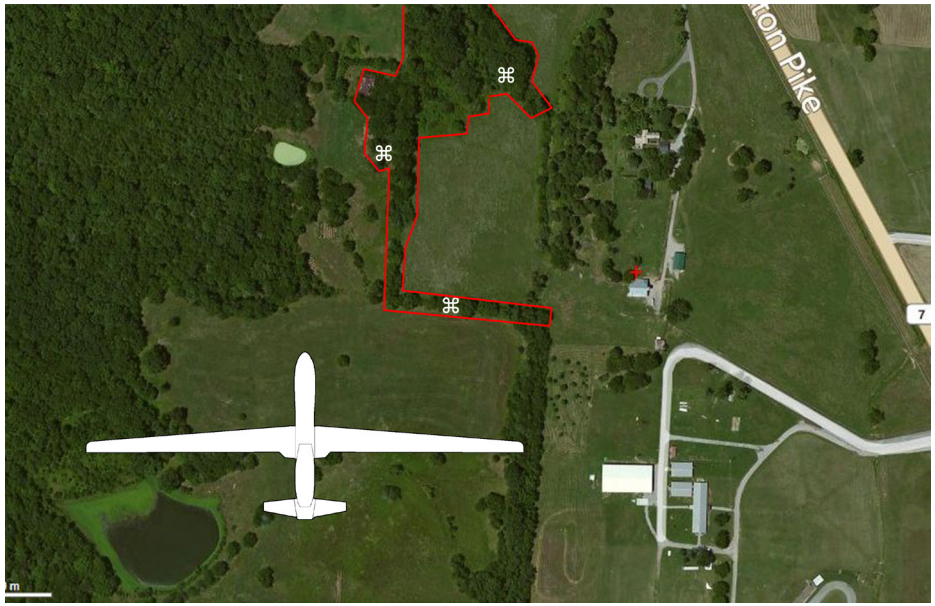


Figure 10. Drone pairs shake trees and vacuum up fallen nuts.

We can speak about two kinds of things made in the drones for foraging research. The first of these are the material products of the research—the design artifacts made in support of the research, that is, the design-based exploration of use. As mentioned, these include scenarios, software, interface elements (buttons, icons, etc.), and diagrams of future contexts. The second kind of things made is a so-called design thing itself.

Binder et al use the term design thing to refer to a kind of making in design that emphasizes design as means or mode of engaging is-sues and publics (2011). In this respect, the thing is different from a typical design project because the thing does not necessarily have the final purpose of a product or service, but rather, the thing does the work of gathering together the factors and condition of an issue, and exploring and expressing them. Related to discussions of design things, other researchers have spoken of the role of design in constituting publics and expressing matters of concern (see Björgvinsson, et al 2010, Ehn 2008, DiSalvo, et al 2014, Halse et al 2010, Olander et al 2011). The drones foraging project created a thing out of the combination of drones and foraging—a collection of design actions and representations that begins to articulate the factors of designing for foraging, while also expressing the possibilities and limitations of the use of drones in such contexts.

So, although there is functional code available on Github, scenarios for distribution, and a UI toolkit available for use, one could argue that the more important thing made by this research through design endeavor is the expression of a set of potentials, or a cultural imaginary of a novel use of drones in support of a novel mode of civics. This design thing does not obviate the importance of material objects made or activities of designing through use. In fact, it is dependent upon on those objects and activities as a kind of infrastructuring for the design thing (Björgvinsson, et al 2010, Ehn 2008). It is only through the making of those objects and the undertaking of those design activities that the potentials and limitations of using drones for foraging are encountered and documented.

As a design thing, Drones for Foraging suggests how collectives of people and objects, or rather humans and nonhumans, might come together in inventive ways to address an issue and its conditions. This issue and these conditions are specific: it is the issue of fostering and maintaining resilient food systems within the conditions of cities and their abundance. Through the practice of design, this issue and conditions are then brought together with a technological platform and its affordances: hobbyist drone technologies that provide semi-autonomous remote media capabilities. The purpose is not to make the use of drone for foraging possible, but rather to articulate the potential, and to have that articulation serve as the basis for a considered reflection. As a design thing this reflection includes the proposed product or service, and it extends to also include a consideration of the social and political context in which this product or service might exist (see Halse et al 2010).

Critical Reflections

In addition to producing insights specific to both the practices of foraging and the drones as a platform, the research also produced insights of value to the broader research through design community.

Appropriation and Adaptation Collapses The Space Between Design and Use in Design Research

Since we were not designing and engineering a custom drone, a significant aspect of the Drones for Foraging research was an exploration of the appropriation and adaptation of hobbyist drone technology. Although there is a literature in the fields of design and human-computer interaction on appropriation and adaptation, much of that research focuses on appropriation and adaptation by end users (e.g. Dix 2006). There seems to be less on appropriation and adaptation as a design research method or process. As briefly mentioned earlier, with new platforms there is a need to understand how these platforms work, sometimes in the most basic sense of simply operating them without failure. Only then, once a level of competency has been developed, the second stage is to explore the use of the platform in the new context, to engage in those activities

of appropriation and adaptation. Though nothing materially is being made, this is still, we argue, a process of research through design. In such circumstances, research through design happens by research through use as one tries to first develop competency in a platform and then transfer the capabilities of technology across domains or contexts. This perspective, which collapses use and design, provides another way of approaching research through design as a method. Further inquiry into this collapsing of design and use might find support in some aspects of participatory design that call into question distinctions between design-before-use, design-during-use, and design-after-use (Ehn 2008).

The Value of Ordinary Artifacts for Extraordinary Contexts

Oftentimes, it seems we are fascinated by spectacular artifacts and strive to create such artifacts through our design research. There is also a value to attending to the ordinary artifacts and practices of interaction design. Indeed, these are not in conflict with one another, but rather support one another. Drones certainly are spectacular objects. Moreover, there is a quality of spectacle to the endeavor of using drones for urban foraging—there is nothing commonplace about seeing a small flying machine hovering in front of an apple tree in the median of a city street. But much was learned, and our research furthered, by attending to and taking on the common artifacts and activities of interaction design. Scenarios, software, UI toolkits, as well as the innumerable sketches, clusters of post-it notes, wireframes; these serve important purposes in research through design. Most significantly the common artifacts and activities of interaction design orient the design researcher toward understanding a given practice and platform as a product or service. Tools such as scenarios are used in professional practice to set the stage for a new product or service. Using such tools in research through design is one way to keep the research grounded. This is worthwhile especially if one is engaging the research as a thing, rather than a project. Even if the ends are not a viable product or service, constantly returning to practice and platform as if it were to be a product or service keeps a designerly perspective to research. If we approach design things and infrastructuring reflexively, we could consider the common artifacts and activities of interaction design as themselves providing infrastructure to the process of constructing things. These design processes and material artifacts support and give a particular shape to the endeavor of inquiry, which establishes and maintains the research as design inquiry. Moreover, it is the very ordinariness of the artifacts—that we do not have to interpret their formats—which provides stability in the context of the extraordinary.

Conclusion

In this paper we have presented the Drones for Foraging project as an example of research through design that simultaneously points to inventive opportunities for the use of hobbyist drones while also producing critical reflections on the processes of research through design. With regard to the inventive uses of hobbyist drones, foraging is just one of many domains where the capacities of drones as semi-autonomous remote media devices might be used to augment the practices of individuals and grounds. Foraging provides a venue for investigating how mundane technologies can be used in unusual situations to generate new modes of civics, Beyond small-scale and alternative agriculture, other, similar, domains might include various forms of citizen science and journalism.

With regard to the processes of research through design we discussed how appropriation and adaptation collapses the space between design and use in design research, and the value of ordinary objects for extraordinary contexts. Emphasizing the mundane practice of the design process in these extraordinary contexts produces specific, grounded design interventions that serve to interrogate a design space without losing sight of creating something that has utility or is practical.

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