Championing Design Knowledge in Human-Drone Interaction Research

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Figure 1: Drones pose challenges to design work, and are surrounded by a myriad of actors and factors to be considered.

ABSTRACT

There are current methodological and epistemological gaps and struggles between Human-Drone Interaction research and the field of design. We highlight five HDI design considerations and suggest a non-exhaustive list of design methods to approach them. We present an appeal to a more diverse and inclusive study of drones where current research can be balanced with a deeply qualitative and critical understanding of these flying robots through embracing design knowledge.

CCS CONCEPTS

• **Human-centered computing** → **Human computer interaction (HCI)**.

KEYWORDS

human-drone interaction, design knowledge

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1 HDI DESIGN CONSIDERATIONS

Drones are a technology profoundly integrated in society as tools in work practices such as mining, energy engineering, forestry, cinematography, and police work [31], and in leisure activities such as photography (e.g. [23]). This ongoing development suggests the need to understand a plurality of drone practices in society to guide future design, but also to be able to quickly incorporate a holistic framing of drones as robots with the capacity for a wide span of desirable and **undesirable** applications. This requires critical reflection on the epistemological foundations of HRI to consider potential limitations and opportunities. Initiatives such as critical robotics call for a more reflective approach to research [30, 41], including through designerly approaches [33]. Accordingly, our work is oriented towards design as a reflective practice [40] in order to incorporate more critical questions in research as complement to existing research approaches.

The dominance of experimental methods in HDI risks reducing the societal impact of the research. We propose research through the use of designerly methods and perspectives, and a reflective stance throughout the research [11]. The design of drones is identified below as a difficult endeavour, where experiential qualities should preferably be studied through interdisciplinary approaches.

Drones are Here Now. Drones are already used in society in many work practices and as a hobby. This suggests that ethnographic methods are a highly appropriate approach that could be used more extensively: only in the field can the intricate relationship between users, technology, weather conditions, legal frameworks, and other factors be understood in a critical manner. While interview studies are important, participatory observation is likely to bring a more qualitative, rich, and contextual understanding of the impact of drones. Unlike many other robots, drones can already be easily accessed in the real world. Cyberethnography [39] may be an appropriate and accessible method for capturing the already existing nuances in the intimate [13] relationships between drones and humans. Some examples of research using this method can already be found [21, 23]. Pometko et al. [36] illustrate examples

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of drone-based play potentials found on social media. The commercial availability of drones also allows the researchers to have first-person experiences with several types of drones and evoke more embodied perceptions of the research material. Gamboa [19] used autoethnography with such a drone to identify design opportunities for child-drone interaction, qualitatively researching children as a neglected user group.

Drones Resist Uncontrolled Studies. While frustration can be universal when developing robots, those associated with drones are of a different nature, including for example extremely limited battery power, fragile parts such as propellers, omnidirectionality, low payload, the need for offloading sensors, unpredictable flight paths, and more. Many of these limitations (along with ethical ones such as the physical risks for participants) result in the impossibility of conducting studies in uncontrolled environments. Drones cannot easily be directly implemented in their intended **context of use without massive technical considerations, which resists playful design explorations**. As a complement to studies in the wild, we find an viable opportunity for considering the showroom [28] as an alternative to the lab. Drawing from the context of art, the showroom can also be interpreted as a semi-controlled space where technology can be engaged with in ways that promote critical thinking rather than allowing for the strict measurement of variables. It combines the controlled technological context with the freedom of qualitative research. The "showroom relies on debate rather than statistics, like Lab, or precedents and replication, like Field. It questions the way in which people see and experience the material world and elicits change through debate" [28, p.94]. Openness to a showroom-like testing affords research with a wider user group. For example, Rubens et al. [38] do this by working together with the toy company LEGO®, to design and evaluate a "build and fly" experience with 240 children in a public exhibition. Such collaborations and settings are fortuitous to the study of drones.

Drones Engage the Body. May of the studied applications for drones in the literature open up design spaces between sports, games and art, for example employing drones designed for engaging body movements (e.g. [17, 20, 26, 29]), or as sports companions [5, 35]. There is a trend to identify bodily interactions with drones; using either hand gestures, foot gestures, proxemics, facial expressions or a combination of these. Such embodied interactions, beyond being user-friendly and intuitive. However, they can also result in even more conflict when different bodies are not considered. Spiel [43] found through a review of work in HCI "a fairly constrained set of represented bodies, generally normativising tendencies on expected embodiments, an implicitly imagined body ideal that is never made explicit". While we did not analyse the literature in search for norms, we could not find great variance in the bodies considered as the humans in HDI – in this case, we must consider if research is incorporating an inclusive and comprehensive view of the bodies (i.e. young, old, disabled, non-human) involved in the interaction. The trend to engage the body with drones brings methodological difficulties which also require their own research – **most methods do not acknowledge the multiplicities of the human body.** The theoretical framing of the aforementioned research seldom builds on existing theory and practice on embodied interaction, although these resources are widely spread within HCI [12, 25, 45]. Considering the human body in the interactions with drones is a valuable starting point to bridge this gap. Body Maps [2](or body sheets) are one example of a qualitative method that is successfully used in combination with drones by [29] (see the example of a filled in body map by a participant on page 6). This method offers a visual support for participants in the research, including the researchers themselves, to report on felt embodied experiences by drawing on paper.

Drones are More-Than-Human. The free flight capacity of most commercial drones means they can reach areas personal technology very often does not reach. Drones navigate the skies, but also occasionally collapse into the sea or crash into remote obstacles. This unique capacity causes encounters with more than just humans – similarly to what we have already seen with other robots in the wild such as lawnmowers and vacuum cleaners. From birds to sea creatures, the stakeholders in the development of drones goes beyond just human-drone interaction. In HCI, the attention given to these more-than-human actors and the entangled nature of post-humanist theories, i.e. how natural phenomena and other beings need to be taken into consideration in research, is in definite growth [10, 18, 24, 46], and HRI will certainly follow. Within design research, an important approach is called critical design [3, 6, 14, 34], focusing on critical and societal implications rather than applications. It already has a history of use within HRI, serving for example to promote children's critical thinking [32]. This approach connects to art and there are examples of drones being developed outside of academic research for the purpose of provoking discussion [16, 44]. This type of work opens up for critical, norm-creative, and innovative understandings of drones.

Drones are Framed by Law. The use of drones already encompasses a tight legal framing. Laws and regulations often struggle to keep up with the technical development. However, laws have an undeniable impact on the design of drones – a clear example is how many drones are purposely designed to weigh less than 250 grams. This is a constraint led by international legislation requiring specific licences to fly robots heavier than 250 grams. Legislation and public opinion go hand in hand, and drones potentially carry their fair share of negative attitudes due to, among others, military associations [7]. It is noteworthy that there are helpful user-centred surveys within HDI exploring users' existing perceptions of drones and their attitude towards possible applications [4, 8, 15, 15, 22, 27, 42]. In these surveys, a nuanced perspective of drones is offered, with space for negative impressions on the technology, and the opportunity to poise critical questions on the use of drones in society and which design values should be considered. It is necessary for researchers in HDI to incorporate these user-centred perspectives into their design work by **acknowledging the non-positivist stance often seen in society**.

Probing professional drone pilots raises questions which research could otherwise miss [31]. In this interview study, many issues with legal grounding were lifted. Beyond interviews, researchers could also consider engaging in more designerly ways through applied design work. One particularly helpful approach for creating connections between different stakeholders is participatory design: Wojciechowska et al. [47] ran a co-design study with experts from

sub-Saharan countries. Similarly, Agrawal et al. [1] presented an interesting example where they engaged with emergency responders in a series of sessions constructing scenarios grounded in real-life challenges. We suggest that participatory design with applied design tasks involving a diversity of participants is a strong resource for HDI, purposely involving participants with informed negative attitudes towards drones along with those with deep knowledge of the technology and encouraging serendipitous encounters with opinions and laws.

2 ENCOURAGING DESIGN KNOWLEDGE

We call for the opportunity to further include design knowledge as a critical robotics approach in HDI, and presented suggestions of methods for involving design knowledge in HDI in relation to previous work.**This list is but an example of what can be done throughout the design process, and is a non-exhaustive list of design methods.** Each research process brings different wicked problems [37] to the table, which must be tackled in a bespoke manner. There are several ways of achieving a more reflective and design oriented research practice, and one central gap is the unrecognised importance of design epistemology within HRI [9, 33]. We seek to encourage HDI researchers to conduct interdisciplinary research, explore further design methods, prioritise the explicit communication of design as a process, and incorporate complementary design knowledge into HRI.

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