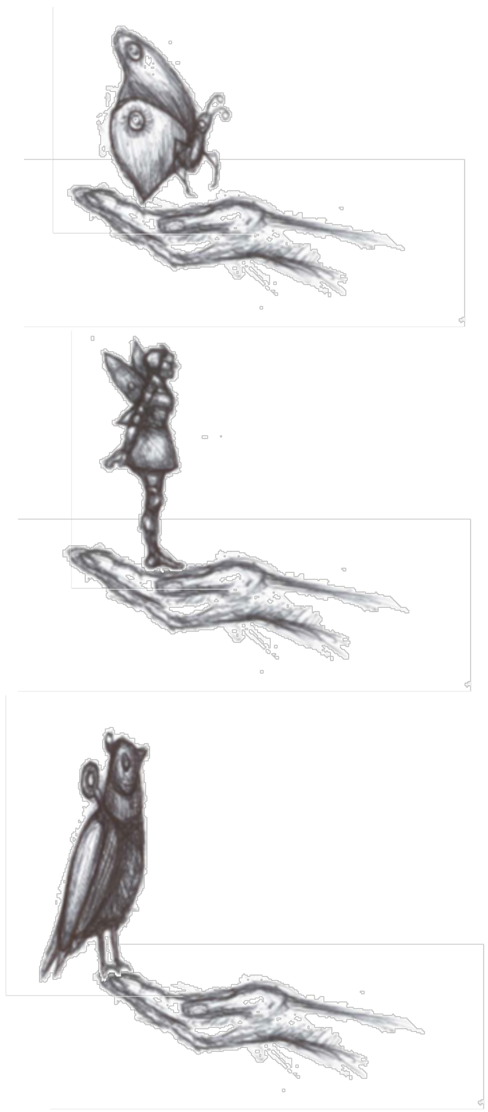

Figure 1: artist's rendition of drone form in collocated HDI (sketches courtesy of *Norm*)

"Come To Me Nice Butterfly" Drone Form in Collocated HDI

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ABSTRACT

Recent human-drone interaction (HDI) research is shifting away from the remote-control paradigm and increasingly exploring collocated interaction between people and drones. We are interested in intimate aspects of this new design space: in collocated interaction that affords tactile interaction and emotive touch. In this position paper, we briefly motivate emotive collocated HDI, present preliminary design ideation, and propose a research outline for further exploration using immersive collocated HDI simulations.

KEYWORDS

collocated human-drone interaction, natural interfaces, intimate interaction with drones

INTRODUCTION

Humans have an established set of interactions with volant (flying and gliding) animals, which has previously inspired human-drone interaction (HDI) design [3]. A small subset of these includes collocated interactions, for examples, dealing with flying insects, petting bats, or falconeering. With

"Come to me, nice butterfly.
Sit with me,
in the palm of my hand.
Sit, rest, don't fear.
and fly away again."

From: "Come to Me Nice Butterfly", by Fania Bergstein (translated from Hebrew [6])

Figure 2: From the cover of Fania Bergstein's "Come to Me Nice Butterfly" [6]

few exceptions, collocated interaction between people and flying animals is awkward, bothersome, and undesirable. On the other hand, cultural context can provide positive perspective, for example when interacting with pet birds [5], butterflies (Figure 2, [6]), or fairies.

We expect collocated HDI to emerge in both domestic and work environments, for functional uses, such as delivery of goods, or search-and rescue, and for fun and leisure, such as in photo and videography. When considering this new design space we see the realistic negative context of interacting with volant animals as a design challenge, and turn to the much more positive, and unrealistic, cultural contexts for inspiration. We envision future drones that will share space with people, providing functionality and playing social, emotive and intimate roles, taking physical forms that convey positive relationship, inspired by cultural contexts (Figure 1).

Such interactions are often seen in the popular culture, in movies and anime. For example, in Grave of the Fireflies [7], we see the main character, within a cloud of fireflies, trying to catch and hold them, later using the fireflies for light when needed. We envision similar behaviors with swarms of drones, where people could catch one in their hand before releasing it to the swarm.

Our vision is hindered by the current technical boundaries of flying machines. Drone technology, while advancing by leaps and bounds, still accounts for entities that become smaller in size but are still noisy, mechanical looking, and even dangerous. In order to explore the benefits and limitations of intimate collocated interaction with drones we propose the use of immersive simulations, and argue that the first challenge should be the exploration of drone form. In the following sections we provide a brief reflection on the state of the art of collocated HDI, describe our current low-fidelity ideation, present an exploration methodology and our proposal for an immersive simulation testbed.

RELATED WORK

Prior work on interaction with small-sized drones explored control mechanisms for collocated interactions including voice [8,9], gestures [2,3,10,11,12], gaze [13], and touch [4, 14]. Several feedback mechanisms have been proposed such as using a screen, a projector, or using the flight path to convey affect and emotions [1, 15]. Affect and emotion have been specifically investigated as a first step towards integrating drones into humans' social environments. In their preliminary results, Arroyo et al. [15] show that different emotional states can be recognized and suggest that HDI can be improved if the drone conveys different emotional states. Cauchard, et al. [1] explored how a drone's emotions could be conveyed through different behaviors and flying paths. They showed that people can accurately associate emotional states to a drone. Recently, researchers have been working towards design guidelines for social drones suitable for interaction and companionship. Kim et al.'s ideal companion drone [16] presents "adorability" features. Yeh et al. [17] proposed a blue oval shaped drone and discussed how a tablet can be used to display a "friendly face". Karjalainen et. al. [18] investigated several features and found that emotional characteristics were desirable, and they also suggest that the drone appearance should be a round shape with a face. The above literature shows that appearance and behavior is a central aspect of designing social drones intended to interact with people. We propose an investigation of this new HDI design space by liberally exploring unrealistic cultural contexts of interaction with collocated flying entities. We further suggest that this early design exploration should be unhindered by current drone technology, and instead conducted first within immersive simulations.

EXPLORING FORM IN IMMERSIVE COLLOCATED HDI

We are planning to design and implement a collocated HDI immersive simulator that would allow users to perform various simple tasks while interacting with a collocated drone. The simulator will be implemented in VR, though an AR iteration is also possible. The simulator will include 3D visual features relating to the drone, the setting (e.g. domestic environment, or a workplace) and the task. The testbed will include haptic feedback supporting intimate interactions: touching the drone, sensing its landing on a palm or taking off (note that others proposed the use of physical drones to provide such haptic feedback [20,21]), and possibly synchronized air flow device (e.g. fan [19]), enabling sensation of the drone rotors in proximity. The simulator will allow iteration of various collocated HDI form and behavior approaches, ranging from interaction with drones that look, for example, like butterflies, fairies, and birds (see Figure 1 for artist renditions of some of our current design ideas). The drones rendered in the simulator can take a range of forms, rendered as naïve entities, or as mechanical looking and moving flying machines. The simulator will support different drone behavior and varying flight characteristics (speed, acceleration and jerk) and proxemics behaviors. The simulator will support single drone as well as a group of drones moving individually or as a flock or swarm. The simulated drones will be sensitive to the user’s pose and gestures, as well as their voice and gaze. The testbed will also allow the simulated drones to express themselves, using body and wings gestures, gaze, “facial” expression, chirping, and voice.

LIMITATIONS

Our proposed collocated HDI simulator stops short of practical reflections on the many potential technical limitations and bottlenecks derived from some of our design ideas. Implementing drones for collocated interaction is a hard technical challenge, and it is questionable how many of our simulated design ideas could be scaled to the physical realm and implemented as collocated drones, in the short-term.

CONCLUSION

Realistic interaction between people and collocated volant animals is very limited at best, and undesirable in most practical cases. However, collocated interaction with flying entities in cultural contexts, in literature, film, media and the arts, while often unrealistic, can be quite positive. We suggest an exploration of the realm of purposely unrealistic collocated HDI metaphors, starting from drone form and behavior. We propose an immersive simulation testbed that would allow people to interact with different forms of collocated drones in various settings and tasks. Lessons drawn from the testbed could inform the design of the form and behavior of future drones, and be used in the design of more natural HDI.

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