Towards Affective Drone Swarms in Public Spaces

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ABSTRACT
Drones are an exciting kind of robot having recently found their way into the commercial mainstream. The idea of using drones in public spaces has gained momentum and been implemented in some recent public events, such as the 2018 Winter Olympics’ opening ceremonies. As drones are designed to be directly observed and possibly interacted with by an ordinary audience, some fundamental challenges remain for such interactions to be carried out successfully. Our work focuses on bridging the psychological gap between front-end technologies (drones) and the human observers’ emotional perceptions. For interactions to be effective, the observers need to feel safe and empathized with the artificial entities. To that end, we identify and discuss some open technical challenges to address this gap.

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Multi-drone, drone swarm, affective motions, affective drone swarms.

ACM Classification Keywords
• Computer systems organization–Robotic control  
• Human-centered computing–Empirical studies in HCI

INTRODUCTION
Drones are unmanned aerial vehicles that have increasingly found their way into commercial mainstream robotics, being featured both for personal use and in public spaces. A recent high-profile examples of their appearance in front of the public audience is during the opening ceremonies of the 2018 Winter Olympics in Pyeongchang, South Korea, when a drone swarm was used to display light animations in the sky [1]. Due to their epic appearance, the drones received high acclaim from the audience, solidifying the idea of using drones as performers in a public arena, capable of carrying out emotion-filled acts.

This drone show is an excellent example for our research’s vision in utilizing drones in the public spaces. Our work focuses on building drone swarms that are capable of not only participating in theatrical performances, but also operating as a collective entity that can communicate and interact meaningfully with ordinary people in daily life activities. Our thesis is that drone swarms can be more expressive when imparting emotive communication than solo drones do, due to their added degree of freedom: volume. Example applications of drone swarms used in the public include being tour guides at attractions or museums, to bring tourists on a trip through the most notable points at the site. In emergency situations that require evacuation of large crowds, drone swarms can help guide and coordinate the movement of survivors towards safe areas, as well as signaling first responders towards areas where help is needed the most.

EXPRESSIVITY ADVANTAGES OF DRONE SWARMS
The main advantages of drone swarms over solo drones are the added dimensions of freedom. More specifically, with multiple drones, we can

• Harness the 3D space in the form of occupancy volume. Drones can be commanded to spread apart or come close to one another, as well as hover in space at specific relative positions to one another, to depict different shapes of varying volume.

• Express group-based dynamic properties such as coordination or synchronization, similar to team dance with human dancers.

• Depict emotional states with collective group-based motions. Specifically, the movement velocity of individual drones in a swarm, either relative to each other or as absolute values, can be tweaked to depict internal states of emotions. For instance, while keeping the collective velocity zero, agitation can be expressed by fast moving drones, while calmness can be depicted by constant and slow motions, causing a therapeutic effect.

• Convey metaphorical messages in the form of sketches that involve more than one entities. For instance, depicting the notions of reciprocal love or fighting is much easier done using two or more drones than with single ones.

MOTIVATING APPLICATIONS
Equipped with the ability to impart emotive messages, drone swarms could be used for crowd control and guidance, e.g.,

• Shepherding groups of visitors around a site such as tourists visiting a location, or school groups visiting a museum or zoo. In this scenario, the drone swarm form boundaries around the group and shepherd them around. In addition, the swarm can behave in a manner to elicit emotions, such as excitement, as particular stations on the tour or landmarks are encountered.

• Controlling crowds in a large gathering such as a music concert or a large community meeting. In this scenario, the drone swarm needs to keep the crowd within the confines of the meeting and patrol the crowd boundaries to prevent access to prohibited areas. Emergencies happening in such large crowds, e.g., a person feeling ill or a fight breaking out, can pose challenges.
were originally created and tested for reporting one’s affect such as PANAS [3] or SAM scales [4]. The PANAS scales
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TC 2: A new means for emotion measurement

- Advertising produces and stores to passing crowds of potential customers. In this scenario, the swarm can be deployed at the entrance of shops or attractions, attracting customers to products or stores in a non-invasive way. For example, they can spell out the names or the shapes of the products being sold. Since the drones are airborne and do not occupy any ground space, they will not interfere with uninterested passers-by.

TECHNICAL CHALLENGES

There are many hurdles to overcome before drone swarms can engage in bilateral interactions with the public audience. However, before addressing the more complex problems of human-drone interactions, we need to learn how to completely harness the expressivity of drone motions in non-verbal communications, as well as understand their effects on observers’ emotional states. To that end, we identify the follow technical challenges to tackle in our research.

TC1 (Technical Challenge 1): Motions with emotions

Multi-agent algorithms have been used to effectively control the coordination of drones within a team. Now that the target of interaction is the general public, it is important that coordination algorithms take into account the psychological effects that may incur when the humans observe the swarm in action. This is to avoid a potential adverse reaction similar to, for example, the phenomenon of the Uncanny Valley [2]. The Uncanny Valley depicts a hypothesized relationship between the degree of resemblance to human form of a non-human entity and the emotion it may invoke on observers. As the entity approaches the true human form but is not quite there yet, there is a dip (valley) in the relationship, signifying a feeling of eeriness, effectively making the entity appear spooky, rather than friendliness to the observer. Avoiding this valley is one major challenge in creating artificial entities that directly interface with human audience.

In creating robots for the public space, practitioners will need to account for at least three kinds of emotions: (1) perceived emotion, (2) felt emotion, and (3) felt safeness. As depicted in Figure 1, perceived emotion refers to the emotion viewers attribute to the robot group, while felt emotion and safeness refer to the emotions invoked internally on the viewer’s part. The Uncanny Valley phenomenon is related to the felt emotion observers may have when watching the drones.

TC 2: A new means for emotion measurement

To measure affects, researchers often use validated measures such as PANAS [3] or SAM scales [4]. The PANAS scales were originally created and tested for reporting ones’ affect feelings. It comprises of 20 descriptive words representing positive and negative feelings, 10 for positive and 10 for negative. Sample positive words include interested, excited, strong, enthusiastic, proud, active, attentive, inspired, etc., while negative ones include afraid, irritable, scared, distressed, ashamed, etc. In PANAS scale, participants are asked to rate, on 5-point Likert scales, their feelings. In our preliminary study [5], it was found that most of these descriptors were insufficient to describe perceived emotions. This signifies the need for a different set of descriptors that can better represent the interpretation of emotions.

TC3: A language to encode drone swarms’ motions

Recent research looked at how to encode emotions in drones’ motions and took different approaches [6], [7]. Cauchard et al. [6] detailed a design process to encode personalities in drones’ flight paths, so that viewers can infer their personalities from the way they move. They map such vocabulary on to dimensions of drone movements such as altitude, direction, speed, angles (toward the user), and reaction time and compliance to basic commands. Szafir et al. [7] devised a formalism defining a set of flight motion primitives, the combination of which form flightpaths capable of communicating intents to viewers.

While previous works have looked at single drones’ motions, it is unclear whether or how such approaches apply to drone swarms’ motions. More research is therefore needed to construct vocabulary sets in the form of emotive motion motifs, to act as the building blocks for more complex drone swarms’ behaviors.

REFERENCES


