

Flocking Phones & Drones: Three-Dimensional, Real-Time, Mapping of Dense Urban
Environments Using Off-the-Shelf Microdrone, Smartphone, and Point-Cloud Technology

Alex Bitterman, M.Arch., Ph.D.

Chair and Professor

and

Richard Carlo, M.Arch.

Professor

Center for Architecture & Remote Sensing

Department of Architecture & Design

The State University of New York, Alfred State College of Technology

10 Upper College Drive

Alfred, New York 14802

Abstract

The use of microdrone technology and its collective abilities remains in relative infancy, and the current employ of microdrones is limited to a reasonably small number of visual surveillance and experimental uses. However, the unharnessed “swarm” potential of microdrones, particularly when used in “flocks” of multiple units in conjunction with open data intelligence provides a surfeit of opportunity, efficiency, and efficacy in observing and surveilling densely populated and built urban areas. While the U.S. Military and intelligence communities have, for years, used unmanned aerial vehicles (drones) of various sizes and capacities, these microdrones are smaller, stealthier, more precise, and more persistent than their larger counterparts. The efficacy of larger-scale drones and satellites in comparison is limited, especially in dense urban environments. This paper explores the basic feasibility and potential of using artificially intelligent microdrone “swarms” in dense urban environments as a means of intelligence gathering and dynamic surveillance.

Context and Problem

Small, commercially-available drones currently scan the horizontal plane (parallel to the earth) with great reliability resolution and accuracy. While this works well in sparsely populated regions and suburban areas, abilities and efficacy is decreased in more densely populated urban areas, multi-floor buildings, and skyscrapers. Smart phones—many of which come equipped with high resolution cameras and other sensors—can fill the void relaying information about buildings, their occupants, and activities. Together, these broadly available off-the-shelf technologies create a crowdsourced constant-stream dataswarm that provides a dynamic snapshot of a specific building, neighborhood or city.

Geocentric satellites in low-earth orbit, medium-earth orbit, geosynchronous orbit, and high-earth orbit have long been used for observation, remote sensing, measurement and signals intelligence (SIGINT) and geospatial intelligence (GEOINT). However these satellite technologies are costly to develop, deploy, and maintain. Despite American dominance of the satellite sphere, satellites are finite in their resources and a single satellite cannot easily—or cost effectively—surveil several physical locations simultaneously. Satellites are cumbersome (not to mention relatively slow) to reposition. Satellite locations are largely known or discernible, and therefore easily detected and observed by enemy entities.

Likewise, military-scale unmanned aerial vehicles (UAV), colloquially referred to as “drones” provide a more granular level of observational ability, but remain costly and are easily detectable. When disabled, drones provide enemy combatants with the opportunity to scavenge debris for greater understanding of our expert technology.

Neither UAV nor satellites are effective in three dimensional, dynamic modeling of buildings in dense urban environments or in rapidly changing conditions.

Solution

A fleet—or more precisely, a “flock”—of artificially intelligent microdrones (which we define as the size of an apple or smaller) could provide a constant stream of swarmdata about a specific building, neighborhood, or city. Exhibited by birds, fish, bacteria, and insects, flocking is best described as the collective motion of a large number of self-propelled entities notable because it typically does not involve any central coordination of the individual player entities.

The swarmdata feeds two main objectives:

1. Constructing a high-resolution digital model using high-resolution imagery.

Swarmdata in concert with archived photographic data sourced from open data sources (OSINT) available on the internet would provide the elements for a high-resolution point-cloud mesh that would quickly present the building blocks for creating a high-resolution three-dimensional model of a specific building, part of building, neighborhood, or city. The goal is to deploy the swarm, gather high-resolution imagery, and construct a high-resolution virtual model in less than 90 minutes.

2. Remote, virtual surveillance using remote sensors of the digital model in real-time.

Once “built” the digital model would become a living, breathing replica of the actual area of study (building, part of building, neighborhood, or city.) At this point, the surveilling microdrone swarm would (figuratively) switch gears and rather than relaying high-resolution image data, embedded sensors would provide measurement and signature intelligence (MASINT) necessary

to surveil the area of study. This virtual surveillance would be ongoing and, in theory, of unlimited duration.

Proof-of-Concept Experimentation

Over the past academic year, my colleagues and I have worked to establish the Center for Architecture and Remote Sensing at SUNY Alfred State. While the resources of the Center are modest, we have purchased two commercial drones (each about the size of a bread box) and two micro drones (each about the size of a large pad of Post-it notes). With these drones, we have conducted a number of “fly” tests on both terrain and buildings. We therefore are confident that with further experimentation that our 90-minute goal is attainable.

In our experiments with off-the-shelf components, we are able to achieve a significant level of detail both in surveilling and in physically re-rendering the built environment. Physical variations in the built environment of less than 3mm, surveilled at approximately 50m are discernible and been successfully printed on small-scale physical models. At this stage, however, gathering any substantial degree of MASINT data has been limited by availability of equipment.

Benefits and Potential

Flocks of artificially intelligent microdrones are significantly less costly, provide greater coverage, and less infrastructural output for gathering intelligence and surveilling targets in densely built and heavily populated urban areas. Moreover, the small size of microdrones would make their presence virtually undetectable. In comparison, the typical cost of developing, deploying, maintaining, and positioning one satellite would fund the development of a swarm of drones and three dimensional imaging equipment capable of keeping constant watch over each and every building in medium-size city.