The Reality of Unmanned Aerial Vehicles in Retail Delivery

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Unmanned Aerial Vehicles (UAVs) used in retail delivery are increasingly becoming a reality. It is no longer difficult to imagine that in a few years, UAVs would swarm city suburbs carrying everything from last-minute pizza orders and paper towels to crisp white dress shirts. With the Federal Aviation Administration's (FAA) roadmap for commercial drone integration into US airspace still yet to fully sink into public consciousness, and the unsettled reaction from the general populace to this possibility, bottlenecks are inevitable. The advent of this novel application of commercial drone technology raises fascinating questions about its risks and challenges. This paper explores some of these questions in detail and proposes feasible solutions based on recommendations from industry experts and meaningful research.

Introduction

An Unmanned Aerial Vehicle (UAV), otherwise known as drone, is an aircraft with no human pilots aboard. It uses aerodynamic forces to provide vehicle lift and by design, is either remote-controlled or flies autonomously. While the term 'UAV' loosely refers to the flying aircraft, a related term, UAS – Unmanned Aircraft System – encapsulates the physical aircraft as well as communication protocols between the drone and its base-station or ground controller. UAVs were allegedly invented in 1849 when Austria deployed bomb-filled hot air balloons to attack Venice, Italy. This typifies the most prevalent application of drone technology over the past few years – military combat.

However, drone technology has since been expanded to a wide variety of other applications apart from military warfare. Figure 1 below depicts a simplified environment for UAVs and most of these applications still employ similar protocols for their ecosystem of components. They include aerial cartography, aerial photography, bridge inspection, convoy protection, border patrol missions, among others. Advances in relatively nascent fields such as computer vision, robotics, image processing and aeronautics have thus led to the emergence of retail delivery applications for commercial drones. These systems are configured to autonomously deliver items of inventory to various destinations. Companies like Google, Amazon, Dominos have announced futuristic initiatives through which they plan to exploit this technology. Test flights have been embarked upon across the world, and physical delivery of items appears destined for a revamp.

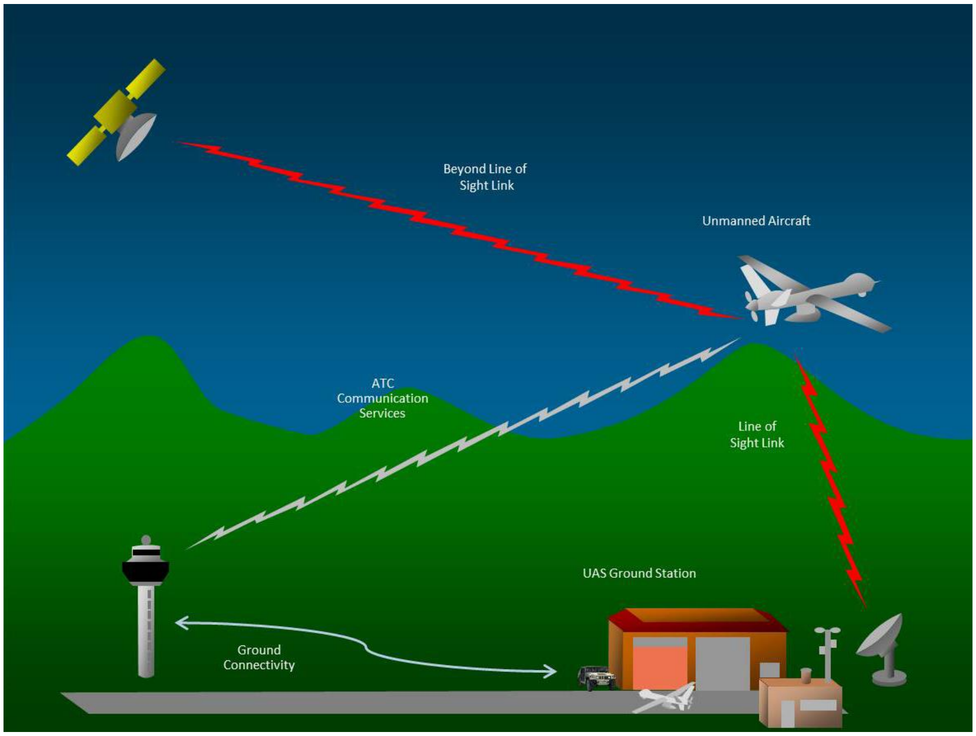

Figure 1: Simplified unmanned aerial vehicle (UAV) environment. This figure shows a graphic representing a UAV's interaction with other components of its ecosystem, including GPS satellite and ground station. *Image credit*: NASA

There are however multiple hurdles to cross if the goal of deploying UAVs to deliver items faster and more efficiently over short distances is to be achieved. These range from government regulations and licensing issues to high-profile social skeptics as well as the persistent anxiety within sections of the American society about the dangers of drones. Millions of people picture drones as they are depicted in documentaries on military unrest, that is, pint-sized aircraft delivering long-range missiles in warfare, not parcels filled with glossy white A4 printing paper. It is thus imperative to put into perspective the risks and challenges of retail delivery drone technology. There is a persistent question of whether the potential problems such as battery life and adverse weather conditions which may arise during deployments, as well as concerns within the public could be averted. For proposed solutions to be successful, these concerns need to be addressed. As such, it is critical to employ quality consumer research, novel navigation techniques such as sense-and-avoid systems (to prevent collisions with birds and streetlights), efficient power management and traffic management systems to ensure that retail delivery drones become a reality.

Theory / Background

Over the past few years, well-established companies have demonstrated strong commitment to developing delivery drone technologies. For instance, Amazon Inc. announced, months ago, that its future service, Amazon Prime Air, ‘will deliver packages up to five pounds in 30 minutes or less using small drones.’ (Amazon) These low-altitude unmanned aircraft systems are expected to provide the company’s massive customer base with rapid parcel delivery over short distances and Amazon anticipates that deployments would begin in a few years. This followed widespread media coverage on the Australian test flight for Google X’s ambitious delivery-drone program, Project Wing. Google X is Alphabet Inc.’s moonshot factory where ideas like the Google Glass, wireless hot-air balloons and self-driving car projects have been incubated over the last few years.

Determining the feasibility of widespread retail delivery drone deployment is one thing; calming the nerves of millions of Americans about the possibility of low-flying quadcopters buzzing past their second-floor windows is another. Developing a strategy for earning public trust for such a seemingly invasive technology takes time and effort. It does not get any easier given the society’s blanket unease over privacy violations and safety concerns. In his New York Times article, ‘What Our Paranoia About Drones Says About Us’ Jelani Cobbs captures this in succinct terms. Cobbs, a professor of journalism at Columbia University, successfully highlights the anxiety that has accompanied the ‘democratization of aviation’. This is obviously in the form of established FAA rules and the widespread availability of unmanned aircraft systems among hobbyists in the United States. Cobbs approaches the subject from the occasionally-overlooked perspective of someone who is neither a remote-control enthusiast nor drone expert, but a college professor who views himself as a dilettante drone owner. He narrates his experience flying a DJI Phantom 2 Vision quadcopter one morning in Morningside Park, New York, and describes the shocked reaction from passers-by – mostly men – who stopped in their tracks to question its use in public or simply ridiculed him outright.

The sustained anxiety within the populace to the sight of commercial drones is due to various factors. “In a Reuters/Ipsos poll…”, Cobbs writes, “42 percent of more than 2,000 respondents said they opposed private ownership of drones and expressed concerns about safety and privacy.” (Cobbs, 2015) It is conceivable that a similar percentage of respondents would oppose retail delivery drones for the same reasons: safety and privacy. The possibility of unwarranted surveillance of neighborhoods using generated data is equally plausible. In fact, the prospect of pedestrian remote control hobbyists landing UAVs on strangers’ windows is not entirely far-fetched, after all, a brave soul once crash-landed his quadcopter on the White House Lawn in Washington D.C. in broad daylight.

As earlier alluded to in this paper, the race to win the delivery drone wars among companies like Google, Amazon and DHL cannot be understated. In his interview with the Atlantic, Ryan Calo, a law professor at the University of Washington and ‘leading authority on the ethical and policy implications of emerging technologies’ mentions that these companies are developing drone-delivery networks in a bid to ensure customer gratification. (Madrigal, 2013) Per Calo, implementing such technologies is not only an opportunity to play catch-up with China in terms of state of the art delivery services, but also a “business model … to attract talent and investment,” after all, “there is no denying that innovation is a currency in the tech world today.”

In fact, while the physical delivery of items over variable distances has vastly improved to ‘same-day delivery schemes’ and express mail, the industry recognizes that there is still room for improvement, hence the advent of delivery drones. While there are multiple designs possibilities for describing the implementation of retail delivery drones, the general idea is essentially the same. When a delivery request is made, a UAV is selected from its fleet based on the package’s dimensions and weight; a flight plan is automatically generated with respect to its destination. Inventory and operational checks take place, after which the package is loaded onto the UAV. It is deployed for delivery and autonomously routes its way to its destination, delivers the package on a designated landing area and follows a pre-configured route on its return to the base station.

In Google’s case, a tail-sitter drone configuration was in development two years ago. At the point of delivery, as the UAV hovers, a hi-grade fishing line spools out holding the “egg”, which is a little contraption lowered with the package to detect whether it has reached the ground. It releases the package at 2 meters per second for a soft landing and the fishing line is wound back into its winch. (Bensinger, 2016) This however abstracts away the complex mechanisms responsible for inventory engagement, communication protocols, routing and navigation algorithms as well as the autonomous operation of the drone.

Results and Discussion

When the FAA announced new regulations for the use of commercial drones in mid-2016, this was viewed as a positive step forward within the industry, despite its shortcomings. Dubbed ‘Part 107’ and aimed at small unmanned aircraft systems, these rules stipulate that such aircraft (including payload and cargo) weigh less than 55 lbs. and are operated in daylight or civil twilight (with anti-collision lighting mechanisms installed). What is more striking, however, is the Visual line-of-sight (VLOS) mandate. The drone must “remain within the line of sight of the remote pilot in command and the person manipulating the flight controls of the small UAS.” (FAA, 2016) This presents a major challenge to initiatives such as Google X’s and Amazon’s. It is debatable, nonetheless, whether this visual line-of-sight requirement is agnostic to the physical distance between the drone and the operator. The question is: if a delivery service utilizes a network of security cameras to keep the drone within the line of sight of someone monitoring the video feeds, does this violate the rule? Telescopes situated at a strategic base-stations across a city might be a step too far, hence the foreseeable problem this limitation presents.

In addition to lobbying the FAA using well-researched proposals and white papers, this limitation can be averted through various means. The backing of industry experts is a crucial step in creating an atmosphere conducive to delivery drone initiatives. In fact, Gur Kimchi, one of the pioneers of Amazon’s Prime Air unit spoke at the NASA-AUVSI Unmanned Traffic Management Convention in 2015, expounding on the company’s aspirations for this futuristic platform. The Association for Unmanned Vehicle Systems International (AUVSI) is a non-profit organization devoted to advancing the unmanned systems and robotic technology community, and is home to companies across the defense, civil and commercial sectors.

In his speech, Kimchi delved into the technical details of Amazon’s initiative for unmanned aircraft systems configured to autonomously deliver items of inventory to various destinations. He especially differentiated Amazon’s technology from the FAA’s satellite-based NextGen traffic management system whose initial development involved geofencing (creating no-fly zones) and scheduling vehicle trajectories. (AUVSI, 2015).

The need to develop enough autonomy to enable delivery drones avoid hitting birds and streetlights midflight ties into the safety concerns within the American society. However, academic and industry researchers have explored advanced systems to tackle this challenge. Kimchi highlighted the Sense-and-Avoid capability of Amazon's retail delivery drone technology, that is automatic detection of 'non-collaborative' objects like birds and balloons as shown in Figure 2. The drone's Sense-and-Avoid system detects and avoids aerial objects on a potential collision path. (Nussberger, 2014) In fact, it can be equipped to algorithmically predict the flight paths of other flying objects within the its proximity. Researchers at ETH Zurich have explored this possibility using aerial object tracking mechanisms. Figure 3 shows a visual representation of two base scenarios utilized in test flights to determine the functionality of such obstacle avoidance mechanisms.

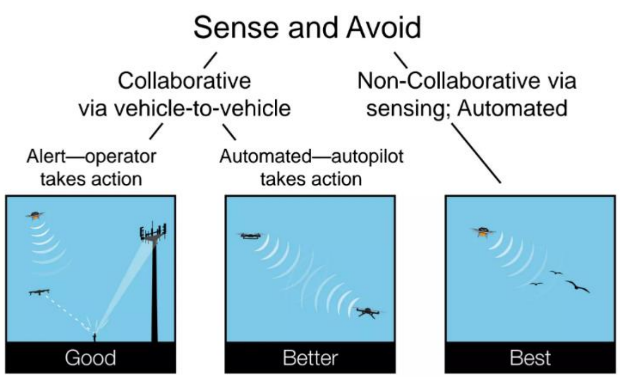

Figure 2: Sense and Avoid System Demonstration. This shows three classes of sense-and-avoid capabilities in retail delivery drones. The best scenario involves automatic detection of non-collaborative self-flying objects like birds in the drone's collision path. (Propper, 2016)

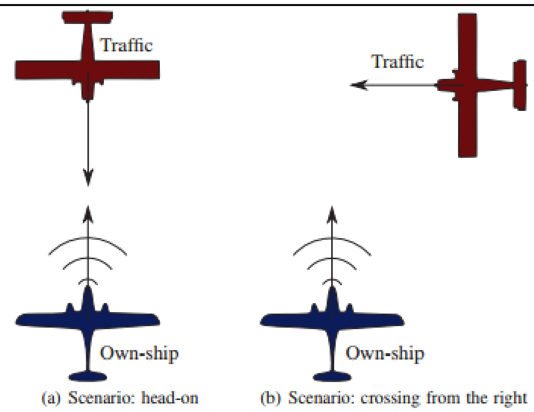

Figure 3: Aerial Object Tracking Scenarios. This shows two base scenarios used during test flights for an experimental aerial object tracking system developed at ETH Zurich. These are applicable to advanced UAV Sense-and-Avoid Systems. (Nussberger, 2014)

A large percentage of low-end commercial UAVs currently on the market rely entirely on GPS coordinates for their autonomy during flight and thus, are devoid of mechanisms with which to sense their environment. They are prone to GPS spoofing attacks (which generate counterfeit communication signals) as well as signal jamming during flight. This underlines an urgent need to safeguard UAVs during flight. Retail delivery drones can circumvent this problem using state-estimation and packet validation algorithms. These alternatives will vastly improve navigation in tight spaces and enhance drone lifespan. In the previously mentioned speech, Gur Kimchi emphasizes capabilities such as a geospatial database of known hazards as well as online real-time flight planning and management tools. These details are elaborated upon in a United States Patent Application filed by Amazon in April 2015 titled 'Unmanned Aerial Vehicle Delivery System' and Figure 4 shows a top-level view of the UAV traffic management system intended for development.

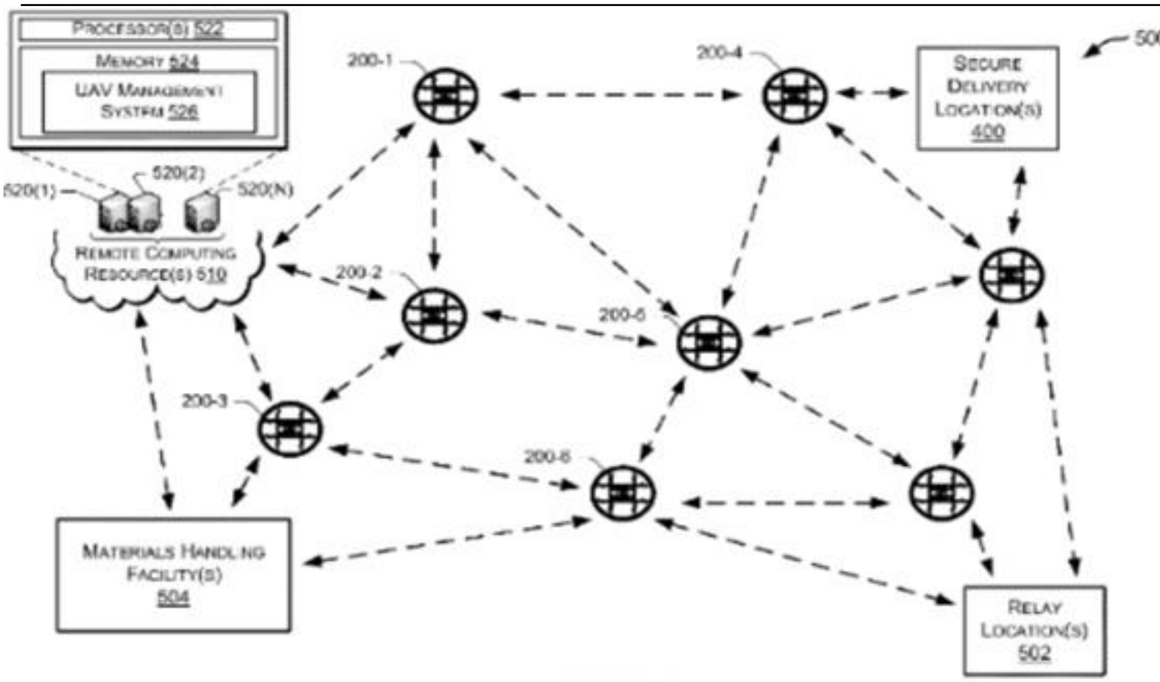

Figure 4: UAV traffic management system for retail delivery. This shows the UAV traffic management system proposed in Amazon's 2015 patent application. Each eight-propeller delivery drone is represented as a circular node in the diagram. (Kimchi, 2015)

The need to address privacy concerns is equally pertinent to this discussion, and even applies to my Senior Design Project, '3D Synthetic Aperture Radar (SAR) on a UAV'. Similar to Google Maps' tendency to blur out vehicle license plates on its platform, humans captured in delivery drone footage should be automatically de-identified. Not only does this help stave off an onslaught of privacy lawsuits during deployment, but it also reduces the possibility of perverting delivery drone technology for use in illegal surveillance.

Conclusion

While technologies that employ unmanned aerial vehicles in retail delivery have great potential, they have been met with arguments that question their feasibility and raise pertinent concerns about privacy and safety. There is therefore a responsibility to address these concerns by proposing solutions which affect the design of aircraft systems utilized in retail delivery. UAV autonomy comes at the cost of complex traffic management, navigation, routing and operational systems. Advanced inventory engagement mechanisms enable smooth package pick-up and delivery to final destinations. While there is room for improvement especially with regards to privacy and physical design, the results of current research into this application of drone technology show promise of a brighter future where retail delivery latency is narrowed to as little as 30 minutes from the time of request. The capabilities mentioned in this report only solidify the premise that there is a future for unmanned aerial vehicles in retail delivery.

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