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Advances in Drone Technology Applications and Control

Introduction

Drone technology, both in application and control, has advanced rapidly over the past few decades. The structure, working mechanisms, technological features, and navigation technology have evolved tremendously. Because of these advances, drone technology has experienced increased adoption in a wide array of applications, including photography, search and rescue missions, pathfinding, defense, power line inspections, and civil infrastructure projects. This research explores recent advancements in drone technology, covering commercial and non-commercial applications of drone technology. The paper also examines recent developments in hardware and software specifications of drone technology.

Another promising application area for drone technology is in product deliveries for customers. This potential application is highly relevant in the increasing adoption of online shopping that omits the need for physical interactions between sellers and buyers. Amazon, one of the leading online stores has shown intentions to venture into drone-aided item delivery to customers (Muchiri & Kimathi, 2016). Drone technology has even better commercial potential in lightweight cooked food markets. Nonetheless, drone navigation systems still face significant challenges associated with the GPS-based navigation system currently in use. To make successful deliveries to a customer, a drone must detect and maneuver around objects to reach its goal position and back to the store using GPS. This navigation system requires significant amount of human interventions to complete the delivery cycle, which is counterintuitive of autonomous delivery. To overcome this challenge, this research introduces a navigation algorithm that implements course-over-ground data to facilitate autonomously navigated drone deliveries.

Related Works

Drones or Unmanned Aerial Vehicles (UAVs) are pilotless aircraft operated with advanced components comprising ground control stations (GCS), sensor technology, and modern communication tools to facilitate remote navigation and control. Previously, drone technologies were popular only in military operations, such as search, rescue, and mapping missions (Ul Hassan et al., 2017). However, with recent advances in computer technology and the Internet of Things, the application spectrum and control technology for drone systems has

exploded to include other unimagined deployments, such as emergency evacuations during disasters, for example, fires and floods (Song & Scaramuzza, 2022). Figure 1 shows the drone technology application array.

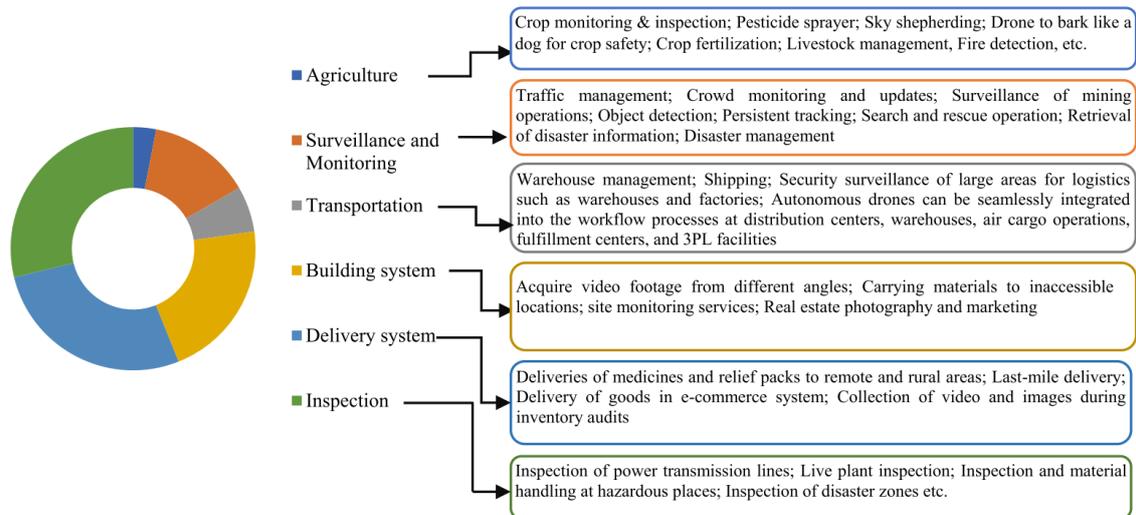


Figure 1: Application Array of drone technology. **Source:** (Ahmed et al., 2022)

A Brief History of Drone Technology

Drones were initially developed for military applications, but as the technology advanced, their application spectrum broadened. In 1986, drones were deployed for the first time in forest fire monitoring in Montana. By the mid-90s, drone technology use had expanded following the deployment of improved image resolution lenses (Muchiri & Kimathi, 2016). Since then, the rate at which drone technology has been embraced for civilian applications has accelerated unrelentingly. Recent studies have explored the potential deployment of drones in weather research (Mao et al., 2018), mineral exploration (Muchiri & Kimathi, 2016), and coastal surveillance and security (Octavian & Jatmiko, 2020), and marine resources management (Toonen & Bush, 2020). Drones applications in precision agriculture have also received tremendous research attention.

Research Overview

This research focuses on drone applications and control. It explores current and past applications of drone technology and examines the advancement trajectory of drone technology to reveal potential areas of research and alternative usage. This research forms a crucial inquiry as it may facilitate a more expanded use of drones and attract broader research, investments, and improved policy for their application to protect human wellbeing.

The specific research objectives of the study are:

1. To identify the various drone applications.
2. To explain the major technologies used in the development of drones
3. To identify some of the opportunities and challenges associated with the drone technology

4. To develop a more efficient drone navigation system based on Global Navigation Satellite System to facilitate item deliveries to customers

Current Outcomes

Drone Application Areas

1. **Application in agriculture:** Drone application spectrums have expanded to include farming, especially crop behavior and abnormality assessments. They are helpful in largescale farming, where manual crop examination is costly and inefficient. Drone application in farming is a core component of precision agriculture, especially for data-driven cultivation practices (Muchiri & Kimathi, 2016). Drone use in precision farming replaces manned airborne tools, saving operational complexity and costs. Drones achieve high-efficiency levels in operational efficiency and costs, time-saving, and spatial operations.
2. **Application in remote sensing:** Remote sensing refers to the science of gathering information about an object, area, or phenomenon by analyzing data obtained using a device that is not in contact with the subject of the investigation. The advancement in drone technology has rendered them a useful tool for remote sensing applications. The low operating altitude allows them to collect ultra-high definition spatial data over a relatively small spatial extent.
3. **Long-range environmental monitoring:** Drone technology applications areas include meteorological surveillance in weather research. Their application in weather research is a relatively new area that has gathered pace upon the revelation of the potential of drone technology.
4. **Aero Robotics in agricultural applications:** Agricultural activities, such as spraying, benefit from recent advancements in drone technology. Recent developments in drone structures have facilitated unmanned airborne loads of up to 20 kilos, making UAVs practical, economical, and environmental-friendly agricultural devices.
5. **Application in defense:** Drones have provided leeway for effective first-response in civil defense, especially in emergency cases. Current drones are fitted with robotic arms and high-definition thermal sensing cameras, making it easy to locate targets and drop emergency kits and packages. Producers have also invested in research to develop communication technologies that will help civil defense officers in coordinating their response efforts.
6. **Application in power line inspection:** Power lines are overly thin and sometimes located in inaccessible areas, making it difficult to conduct the regular manual inspection. However, drones

have emerged with sophisticated visual technologies, and they are regularly flown over power lines to determine minor issues which need to be fixed as a means of ensuring that there is an uninterrupted power supply. Circuit overloads and sags in power can be fixed quickly with the help of drones, and this reduces power downtime, especially in areas with problematic terrain.

7. ***Application in road traffic monitoring:*** The most recent application of drones is in the monitoring of road transport, and this has enhanced the management of traffic. These non-invasive technologies do not require installation and besides, and the inclusion of modern sensing technologies implies that it is possible to record vehicle counts at a particular point or even traffic flow over a specific road stretch to facilitate the planning of traffic flow in a major metropolis.

A GNSS-Based Drone Navigation System for Item Deliveries

The system architecture of the proposed drone navigation system will implement Erle-Brain 3 hardware, which comprises a Linux-based embedded computer, an ROS system and a preinstalled Autopilot software. The system sparingly depends on a GPS to collect information about the current location of the Drone in the navigation path. Precise positional data is required to facilitate autonomous navigation. For this purpose, the proposed system implements GNSS to supplement the positional data from GPS system. Based on this data, the system schedules a navigation trajectory between the selling store and the customer using bearing. Course-over-ground data is used to enhance the navigation data. It is obtained using the bearing calculated between two geodetic coordinates as the drone proceeds along the trajectory. The algorithm for the proposed navigation system is shown in Figure 2.

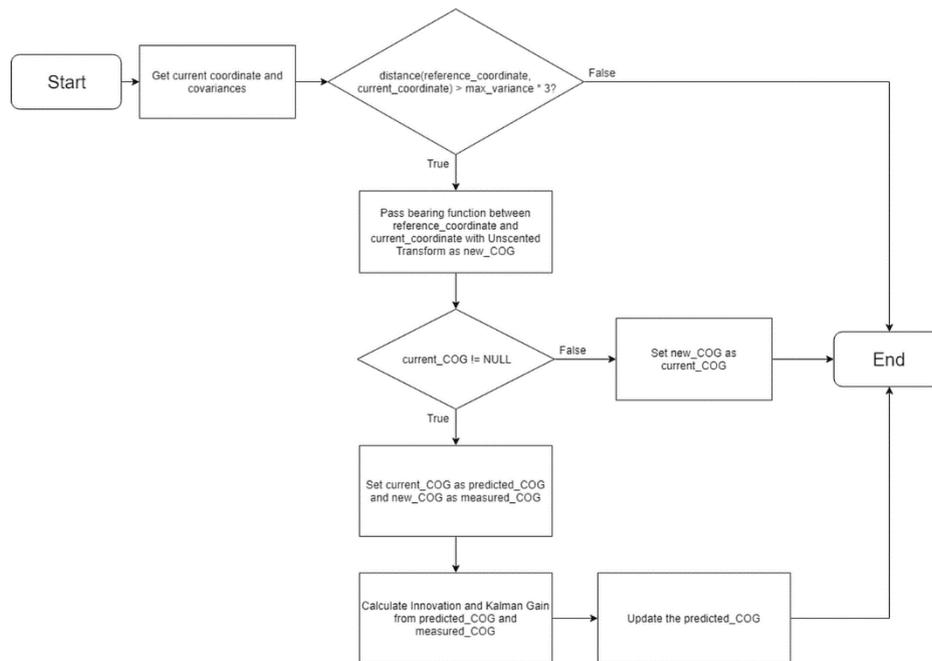


Figure 2: Algorithm for GNSS-based drone navigation system for item deliveries

Research Contribution

It is expected that the proposed system will outperform the existing state-of-the-art drone navigation system to make autonomous item delivery to customers realizable. The study realizes the benefits of deep learning, especially in object localization and detection. The research will contribute to the growing drone technology literature, and facilitate further commercialization of UAVs.

Conclusion

The application scenarios discussed above show the practical viability of drone technology. Precision agriculture is among the key practical areas of drone technology so far. Compared to conventional aircraft, drone technology fills a previously unexplored niche because of its unique characteristics in terms of operational complexity and cost. They can navigate areas with narrow spatial extents, extending human capabilities to unexplored limits. Consequently, their commercial applications have expanded and there are great opportunities for further development in the future. The proposed drone navigation system catalyzes further commercialization of drone technology, especially in autonomous item delivery to customers making online purchases.