

Unmanned Aerial Vehicles (UAVs) in environmental and chemical engineering

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Unmanned Aerial Vehicles (UAVs), commonly known as drones, are becoming increasingly popular in various industries (Figure 1), and piloting these devices has emerged as one of the fastest-growing professions. Recent years have witnessed significant developments in air logistics, showcasing the use of drones in fields such as advertising, photography, and film production. This foreshadows an imminent substantial expansion in the field of air logistics. Successes will undoubtedly be primarily celebrated in civilian logistics but also within the military sector (Ochowiak O. and Ochowiak M., 2023). Insurance companies are also expressing interest in drones, which can be utilized for inspecting sites where failures have occurred. Drones prove particularly useful in cases of toxic substance leaks, damaged infrastructure, and monitoring large areas, such as post-fire assessments. Aerial observation is more cost-effective, convenient, and efficient. Furthermore, drones find extensive application in rescue operations, search missions for missing individuals, nature observations, crop inspections, geodetic measurements, property protection, thermal assessments of buildings, and photogrammetry (biznesomania.com.pl, 2023; Szruba M., 2017).

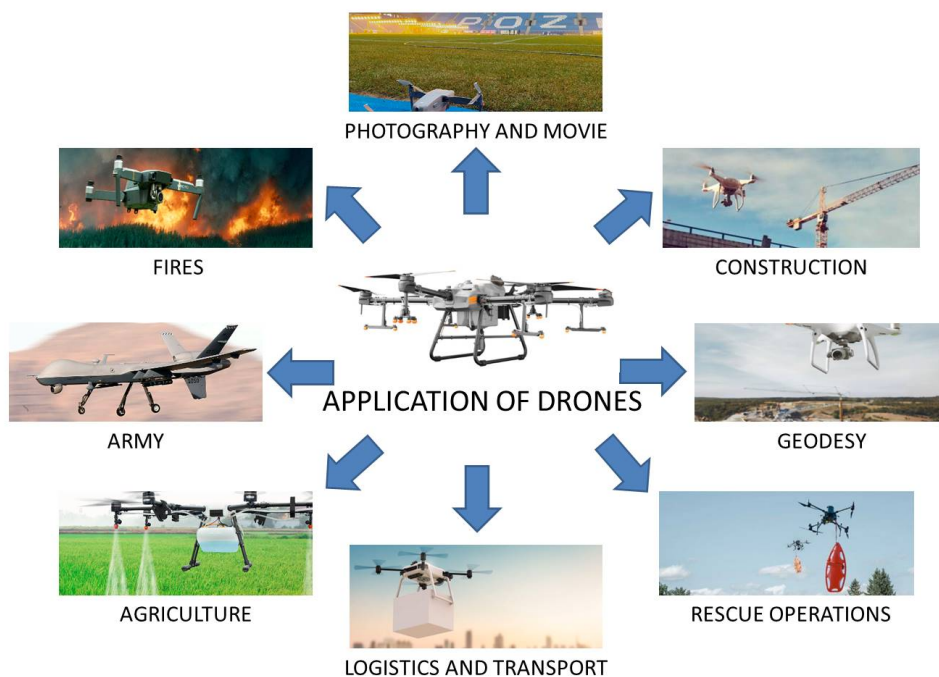


Figure 1. Applications of drones.

Drones have emerged as transformative tools across various industries, particularly in the domains of environmental engineering and chemical engineering. Their integration with high-resolution cameras, sensors, and advanced technologies has ushered in a new era of data collection, analysis, and visualization, fundamentally impacting these engineering disciplines. In the realm of environmental engineering, the utilization of drones has unfolded new possibilities. These aerial devices are pivotal in environmental monitoring, allowing engineers to acquire real-time data on diverse ecosystems, air quality, water bodies, and land usage. Such comprehensive data collection facilitates the assessment of environmental health, identification of pollution sources, and the continuous monitoring of changes occurring over time. Moreover, in precision agriculture, drones serve as indispensable allies. Their ability to assess crop health, detect pest infestations, and optimize the allocation of resources significantly enhances agricultural practices. Through detailed imagery and targeted applications of fertilizers and pesticides, drones contribute to minimizing the environmental impact of agricultural activities. During critical

environmental events such as floods, wildfires, or oil spills, drones prove their worth in disaster response and management. Their capability to access hard-to-reach or hazardous areas allows for efficient and accurate assessment of the damage, thereby aiding in the formulation and implementation of effective response strategies. By installing suitable equipment, such as a thermal infrared radiation camera on a drone, it becomes feasible to monitor animal populations. Additionally, a standard camera recording in the visible spectrum can document crop damage caused by these animals. Furthermore, coupling an infrared camera to the same drone allows for the mapping of the Normalized Differential Vegetation Index (NDVI), a plant health indicator, in challenging terrains like swamps and wetlands. Employing thermal, multi-, or hyperspectral cameras facilitates the early detection of disruptive signals, often imperceptible to the naked eye. This capability offers the opportunity for swift intervention and protection of specific areas, such as habitats of protected flora and fauna, against adverse changes. The thermal camera enables the measurement of plant surface temperatures, where higher temperatures indicate dried plants while lower temperatures signify undisturbed plant life processes (sozosfera.pl, 2023). The potential use and application of drones in monitoring and regulating the work environment are discussed by Kasperska (2019). The primary objective of employing drones is to enhance employee safety and efficiency. The study reviewed current legal regulations concerning drone use in the labor market and highlighted the benefits derived from their application. It emphasized the pivotal role of the drone operator profession and identified innovative technical solutions that can bolster occupational safety.

In the domain of chemical engineering, drones play crucial roles in ensuring safety and compliance. Equipped with specialized sensors, these aerial vehicles monitor chemical plants and industrial facilities, detecting leaks, assessing equipment conditions, and ensuring adherence to safety regulations. This proactive approach minimizes risks to both the environment and human health (Lewis et al., 2016). Additionally, drones significantly contribute to pipeline inspection, identifying leaks, corrosion, or structural weaknesses. By capturing high-resolution images and thermal data, they assist engineers in conducting proactive maintenance, thereby preventing potential environmental disasters.

The integration of drones with image visualization techniques marks a significant leap in data interpretation and analysis. Advanced visualization methods such as Geographic Information Systems (GIS) and 3D modeling enable engineers to comprehend and interpret complex environmental and chemical datasets more effectively. These techniques enhance decision-making processes by presenting clear, visually appealing representations of data, aiding in effective communication of findings to stakeholders. These technological innovations not only offer invaluable insights but also significantly enhance efficiency and contribute to sustainable practices. As engineers harness the power of drones and visualization technologies, they are empowered to make informed decisions, paving the way for a more promising and environmentally conscious future.

The use of drones is rapidly expanding its scope of applications, and drone regulations are continually evolving to accommodate their increasing presence in the airspace. The necessity to balance civil aviation security, safeguarding the privacy of businesses and individuals, and preventing unauthorized access to sensitive facilities has led to progressively stringent regulations. The most recent amendments are set to take effect in 2022. Concerning drones and EU legislation, there is a distinct trend towards harmonizing regulations across EU member states. The drone flying regulations for 2022 establish fresh parameters, this time broadening the scope of potential users who can leverage drone technology.

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