IJRAME

INTERNATIONAL JOURNAL OF RESEARCH IN AERONAUTICAL AND MECHANICAL ENGINEERING

WWW.IJRAME.COM

ISSN (ONLINE): 2321-3051

Vol.10 Issue 2,

FEBRUARY 2022

Pg:- 34-45

A COMPREHENSIVE REVIEW OF DRONE TECHNOLOGY IN SURGICAL AND MEDICAL APPLICATIONS

Vinodh S[1], Prakathiswaran V[2], Irinjudy J[3], Stefina L[4], Mukeshmittoo M[5]

[1] Assistant Professor, Department of Aeronautical Engineering, Mahendra Engineering College, Namakkal

[2,3,4&5] UG Student, Department of Aeronautical Engineering, Mahendra Engineering College, Namakkal

Abstract

Drones have the ability to gather real time data cost effectively, to deliver payloads and have initiated the rapid evolution of many industrial, commercial, and recreational applications. Unfortunately, there has been a slower expansion in the field of medicine. This article provides a comprehensive review of current and future drone applications in medicine, in hopes of empowering and inspiring more aggressive investigation.

Key Words: Disaster planning, Delivery of healthcare, Epidemiological monitoring, Telecommunications, Tele- medicine.

I. INTRODUCTION

The more familiar public term “drone” was first coined because of the similarity of the loud and cadenced sound of old military unmanned target aircraft to that of a male bee. Despite its public popularity, the term has encountered strong opposition from aviation professionals and government regulators. The term unmanned aerial vehicle (UAV) was first coined in the 1980s to describe facilitate various applications. Although this technology is not new, it has only recently begun to meet conventional business applicability by providing a cheaper, faster, and better option than full-size aircraft. Through the development of microminiaturization and widespread production of underlying technology, including processors, micro- electrical mechanical systems (MEMS) sensors, and batteries produced for smart devices, drone designs have be- come more capable, affordable, and accessible.[4]

There are several distinct drone designs; in addition, further categorization is based on regulatory requirements of sizing and performance. The common configurations in- clude fixed-wing, rotary-wing, multicolor, and hybrid de- signs. These designs are typically modular and scalable in nature that feature reconfigurable payload and ground control options. Payloads can include remote sensing equipment, including electro-optical (E-O) with color, infrared, multispectral, and hyperspectral cameras. Others options are synthetic aperture radar (SAR), light detection and ranging radar (LiDAR), ground-penetrating radar, direct measurement sensors (gaseous, particulate matter, and meteorological), communications equipment (re- ceipt, transmission, and relay), and cargo. Designs can also be categorized based on (*1*) operational profiles, such as horizontal take-off and landing (HTOL; ie, conventional airplane launch and recovery) and vertical take- off and landing (VTOL)[5]; (*2*) regulatory categories, that include small UAS (under 55 pounds) and UAS (55 pounds or greater)[6]; (*3*) governmental convention, such as the Department of Defense group schema (groups 1–5),[7] based on weight and performance; (*4*) propulsion design composition (electric or internal combustion); or (*5*) application-specific configuration, including intelligence, surveillance, and reconnaissance (ISR); cargo de- livery and resupply; and communications relay.[8]

II. HISTORY

The development of drones is deeply rooted in military history. The U.S. Navy along with a team of British re- searchers at the Ordnance College of Woolwich first ex- perimented with aerial torpedoes in an effort to combat German U-boats in World War One

IJRAME

INTERNATIONAL JOURNAL OF RESEARCH IN AERONAUTICAL AND MECHANICAL ENGINEERING

WWW.IJRAME.COM

ISSN (ONLINE): 2321-3051

Vol.10 Issue 2,

FEBRUARY 2022

Pg:- 34-45

(WWI). These at- tempts fueled investigation into pilotless aircraft. From 1922 to 1925, the Navy tested radio control systems on the N-9 Aircraft. In 1924, the first successful radio-controlled flight was conducted from takeoff to landing. Drones had their initial use as targets for weapon accuracy practice in World War II. However, in 1942, the Navy developed a radio-controlled drone that carried a torpedo. These drones, designated TDR-1, were designed with television guidance systems and were controlled by a trailing aircraft.12 At the same time, the U.S. Air Force (USAF), through a similar operation named the Aphrodite Project, transformed old Boeing bomber planes into unmanned aircraft equipped with radio control systems, television cameras, and 18,000 pounds of explosives.

During the Korean War, Hellcat fighter aircraft were converted to drones and loaded with 1000 pounds of explosives. They were then deployed in an attempt to destroy North Korean power plants and railway lines. In the 1950s, the U.S. Navy developed the first operational un-manned helicopter created in an effort to counter the threat of the Soviet submarine forces. The QH-50 helicopter was remotely controlled from a destroyer deck and carried torpedoes, sonar devices, or nuclear charges. Concomitantly, the Ryan Aeronautical Company created a jet-propelled, subsonic unmanned aircraft called the Fire- bee. Initially, they were used for target practice.[12] In the 1960s, the company modified these aircraft into reconnaissance drones called Lightning Bugs, with a range of 2500 miles.[13] The Vietnam War became the first war in which the United States extensively used drone technology, with3435 UAV missions deployed between 1964 and 1975. These missions were flown by the Lightning Bugs, and were used primarily for reconnaissance and missile interception.[12] Drones received more widespread attention after their use during the Yom Kippur War in 1973. The Israeli Air Force deployed drones to provide crucial real- time images of enemy threats and targets. Increased co- operation between the United States and Israel led to the U.S. Navy’s acquiring Israeli Pioneer drones, which were used very effectively during the Persian Gulf War. By the end of the 1990s, drones had become a

IJRAME

INTERNATIONAL JOURNAL OF RESEARCH IN AERONAUTICAL AND MECHANICAL ENGINEERING

WWW.IJRAME.COM

ISSN (ONLINE): 2321-3051

Vol.10 Issue 2,

FEBRUARY 2022

Pg:- 34-45

crucial component of most prominent national militaries.[14]

In response to a request from the U.S. Department of Defense in 1996, the USAF developed the Predator drone, an unmanned remote-operated aircraft with reconnaissance, intelligence, and surveillance capabilities. After the September 11, 2001, attacks on the World Trade Center, the Predators were equipped with Hellfire missiles and were used to fight the War on Terror declared by the Bush administration. Thereafter, the U.S. military developed the MQ-9 Reaper, which can carry 8 Hellfire missile and flies twice as high and fast as the Predator. It also has improved imaging capabilities, enabling it to better distinguish ob- jects on the ground, such as explosive packages and foot soldiers. The Reaper is still one of the most potent military drones in use and one of the most controversial weapons of war.[15]

III. LITERATURE SURVEY

A systemic literature search was performed to assess scientific work involving current medical applications of drones. The EBSCO (Elton B. Stephens Company) Discovery Service was used as the search engine. An advanced search was performed to identify sources that contained the phrases “drones,” “UAV,” “unmanned aerial vehicles,” “UAS,” and “unmanned aerial systems” as subject terms. The sources were arranged chronologically, and their titles were screened for relevance and selected if deemed applicable. Source types included magazines, academic journals, news articles, trade publications, and electronic resources. All sources published in the English language through April 2017 were included. Duplicate search results were excluded.

Next, sources were selected that discussed the application of drones in civilian sectors and were grouped into 7 broad categories: agriculture, environment and conservation, law enforcement and traffic, education, construction and industry, commercial shipping, and medicine (Figure 1). Both academic and nonacademic sources were accepted. Academic sources were defined as sources published in scholarly journals or proceedings from national conferences. Nonacademic sources were included in an effort to capture the latest information in reporting on how drone technology is currently being used. Sources that discussed the same application were included. From these articles, relevant literature was extracted.

An additional search was used to identify sources that contained the term “drone” in either the subject terms or title, and the word “medicine” in any aspect of the text. The purpose of this search was to isolate medical sources that may have been missed in the initial search. The paradigm used to process the sources from the initial search was applied, including magazines, academic jour- nals, news articles, trade publications, and electronic sources in English up through April 2017. Search results were arranged in chronological order. Duplicate search results or articles that were found in the initial search were excluded. The sources pertaining to medical applications were further indexed into 3 major categories: public health/disaster relief, telemedicine, and medical transport (Figure 2).

Major themes within public health/disaster relief included mass casualty care, data collection, infectious disease, disaster relief, and emergency medicine. Within the category of telemedicine, descriptions included drones assisting in surgical procedures in simulated harsh environ- ments, including the battlefield, and use of drones as telemedical devices in emergency settings. Medical supply and transport articles involved several subcategories, including delivery of medical goods, evacuation of patients, and commercial applications for infrastructure. This organizational framework is depicted in Figure 3.

The initial search in the EBSCO database yielded 60,260 results. After titles and abstracts and irrelevant material were filtered, 1296 sources remained applicable. Within our first tier of major themes, there were 339 agricultural sources, 436 sources pertaining to environment and

IJRAME

INTERNATIONAL JOURNAL OF RESEARCH IN AERONAUTICAL AND MECHANICAL ENGINEERING

WWW.IJRAME.COM

ISSN (ONLINE): 2321-3051

Vol.10 Issue 2,

FEBRUARY 2022

Pg:- 34-45

conservation, 130 sources to construction and industry, 50 sources to law enforcement and traffic, 28 sources in education, 87 sources in commercial shipping, and 159 sources within the medical literature (Figure 1).

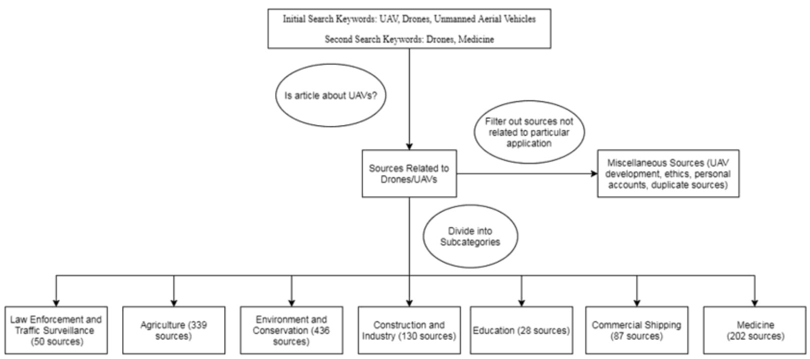

Figure 1. Initial literature search.

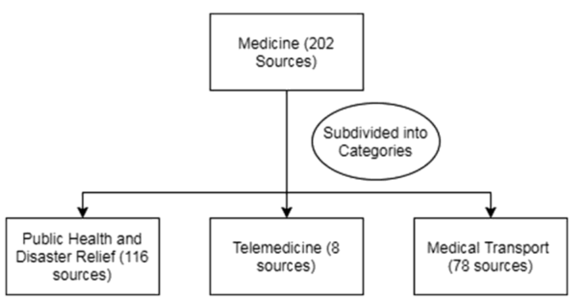

Figure 2. Medical literature search.

IJRAME

INTERNATIONAL JOURNAL OF RESEARCH IN AERONAUTICAL AND MECHANICAL ENGINEERING

WWW.IJRAME.COM

ISSN (ONLINE): 2321-3051

Vol.10 Issue 2,

FEBRUARY 2022

Pg:- 34-45

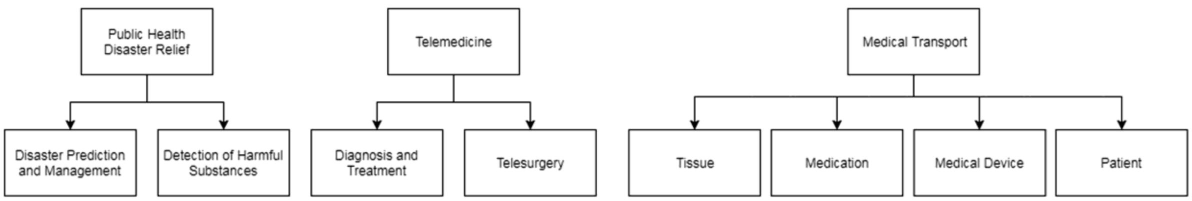

Figure 3. Subcategories of medical applications.

IV. PUBLIC HEALTH AND MEDICAL SURVEILLANCE

Drones are used for surveillance of disaster sites, areas with biological and chemical hazards, and tracking disease spread. It has been shown that drones can gather information about the number of patients in need of care and triage in high-risk environments.[16] In 2013, drones were used after Typhoon Haiyon in the Philippines to provide aerial surveillance to assess initial damage of the storm and prioritize relief efforts.[17] In an effort to improve the efficiency of response teams, the National Health Ser- vice in England has investigated the use of drones to assess injuries related to chemical, biological, and nuclear materials.[18]

Drone technology has been used to detect health hazards, such as heavy metals, aerosols, and radiation. In a study from southern Italy, drones equipped with high-resolution photo grammetry software were used to accurately access and predict cancer risk from high level copper concentrations in agricultural areas.[19] Brady et al[20] demonstrated the ability of a quadrotor drone with a built-in sampling plat- form to accurately measure aerosol and trace gas levels within complex terrain. Through early detection, this sys- tem can prevent the spread of health hazards from pathogens. Along those lines, drone technology has also been used to detect

IJRAME

INTERNATIONAL JOURNAL OF RESEARCH IN AERONAUTICAL AND MECHANICAL ENGINEERING

WWW.IJRAME.COM

ISSN (ONLINE): 2321-3051

Vol.10 Issue 2,

FEBRUARY 2022

Pg:- 34-45

radionuclides that are typical in nuclear accidents and map out radiation from uranium mines.[21,22]

Furthermore, the ability of drones to acquire real-time, high-resolution temporal and spatial information at low cost makes them viable for epidemiology research. Such a use involves monitoring deforestation, agricultural expansion, and other activities that alter natural habitats and ecological communities. Fornace et al[23] demonstrated the use of drones to characterize changing land and deforestation patterns in Malaysia that influence the zoonotic

V. TELEMEDICINE

One of the most promising uses of drones is in the emerging field of telemedicine the remote diagnosis and treatment of patients by means of telecommunications technology.26 The key word in the definition of telemedicine is telecommunications. Unfortunately, communications necessary for telemedicine missions to remote, disaster-relief, or combat environments cannot depend on commercial networks. The idea of the establishment of Instant Tele- communication Infrastructure (ITI) using drones was discussed by the senior author (JCR) in Athens, Greece, in 1998 at the Yale /NASA Commercial Space Center Tele- medicine Program Figure 4. The presentation showcased a drone platform that concentrated on providing communications for performing pre- and postoperative evaluations of patients and telementoring of certain surgical procedures in remote areas. Telementoring is the provision of remote guidance by an experienced surgeon or proceduralist to a less experienced colleague, with emerging procedures using computers and telecommunications.27 Using this ITI concept, Harnett et al28 demonstrated how drones can be used to establish a wireless communication network between the surgeon and a robot to perform tele surgery the performance of surgical procedures using a robot, with the operator being located remotely from the site of the patient. In the study, the surgeon and robot were placed in tents ~100 meters apart. The surgeon was able to successfully operate the robotic arms to perform exercises simulating surgical maneuvers. More recently,

IJRAME

INTERNATIONAL JOURNAL OF RESEARCH IN AERONAUTICAL AND MECHANICAL ENGINEERING

WWW.IJRAME.COM

ISSN (ONLINE): 2321-3051

Vol.10 Issue 2,

FEBRUARY 2022

Pg:- 34-45

researchers have expanded inves- tigation to less extreme care scenarios. William Carey University College of Osteopathic Medicine tested a telemedical drone to deliver medical supplies and communication packages for emergency clinical scenarios to assist in providing care.29

VI. DRONES AS MEDICAL TRANSPORT SYSTEMS

Fast response times and the ability to navigate otherwise impassable terrain makes drones an attractive medical delivery platform. In 2007, researchers from the National Health Laboratory Service (NHLS) and Denel Dynamics (UAV division) tested a proof-of-concept unmanned sys- tem to transport microbiological samples more efficiently from rural clinics to NHLS centers for rapid Human Immunodeficiency Virus (HIV) testing. The results demonstrated the ability of drones to facilitate medical decision- making with prompt diagnosis.[30] In 2014, the Médecins Sans Frontières (MSF) evaluated a drone-based system for delivering laboratory samples to hospitals for tuberculosis testing. This trial demonstrated that drones could deliver viable laboratory samples in ~25% of the time it took to deliver the samples by land.[31] Other research has shown that sample integrity from stationary blood samples com- pared to drone-transported blood samples is similar.[32,33]

The first government-approved drone medical delivery within the United States involved a clinic in rural Virginia. The drones served to expedite the drug delivery process, thus improving patient care.[34] Similarly, the United Na- tions Population Fund and the Dutch government addressed access to women's health clinics in Ghana with drones. They effectively delivered contraceptives and other gynecological supplies to Ghanaian women in need.35 The United States Postal Service recently partnered with Zipline to evaluate the delivery of medications, blood, and vaccines in Rwanda.36 Similar projects have been initiated in other developing countries.37,38

IJRAME

INTERNATIONAL JOURNAL OF RESEARCH IN AERONAUTICAL AND MECHANICAL ENGINEERING

WWW.IJRAME.COM

ISSN (ONLINE): 2321-3051

Vol.10 Issue 2,

FEBRUARY 2022

Pg:- 34-45

VII. CONCLUSION

Drones are used for surveillance of disaster sites and areas with biological hazards, as well as in epidemiology for research and tracking disease spread. Telecommunication drones are being used for diagnosis and treatment, perioperative evaluation, and telementoring in remote areas. Drones have the potential to be reliable medical delivery platforms for microbiological and laboratory samples, pharmaceuticals, vaccines, emergency medical equipment, and patient transport. Government agencies have placed drone use on the national agenda. The next steps include aggressive research initiatives in the areas of safety, industry expansion, increased public awareness, and participation.

REFERENCES

1.Newcome LR. Unmanned Aviation: A Brief History of Un- manned Aerial Vehicles. Reston, VA: American Institute of Aero-nautics and Astronautics, Inc, 2004.

2.Gupta SG, Ghonge MM, Jawandhiya PM. Review of Un- manned Aerial System (UAS). *Int J Adv Res Comp Eng Technol.* 2013;2:1646 –1658.

3.What do we call them: UAV, UAS or RPAS? Australian Cer- tified UAV Operators Inc. (ACUO), 2014. Available at: http:// www.acuo.org.au/industry-information/terminology/what-do-we-call-them/. Accessed November 12, 2017.

4.Unmanned Aircraft System (UAS) Service Demand 2015– 2035 Literature Review and Projections of Future Usage. Wash- ington DC: Federation of American Scientists, 2017. Available at:https://fas.org/irp/program/collect/service.pdf. Accessed on November 12, 2017.

5.Watts A, Ambrosia V, Hinkley E. Unmanned aircraft systems in remote sensing and scientific research: classification and con- siderations of use. *Remote Sensing*. 2012;4:1671–1692.

6.Beyond the Basics. Washington, DC: Federal Aviation Administration, 2017. Available at:

https://www.faa.gov/uas/ beyond_the_basics/. Accessed November 12, 2017.

7.Unmanned Aircraft Systems (UAS): Frequently Asked Ques- tions. Washington. DC: Federal Aviation Administration. 2017. Available at: https://www.faa.gov/uas/faqs/. Accessed Novem- ber 12, 2017.

8.Gupta S, Ghonge M, Jawandhiya P. Review of Unmanned Aircraft System (UAS). *Int J Adv Res Comp Eng Technol*. 2013;2: 1646–1658.

9.Rife J, Carlisle R. The sound of freedom. Dahlgren, VA: Naval Surface Warfare Center, Dahlgren Division; 2006.

10Keane JF, Carr SS. A Brief History of Unmanned Aircraft.*Johns Hopkins APL Tech Dig.* 2013;32:558–571.

11.Goebel G. The Lightning Bug Reconnaissance Drones, 2001. Available at: http://craymond.no-ip.info/awk/twuav3.html/. Ac- cessed November 12, 2017.

12.1970s & 1980s—UAV Universe Sites. Available at: https:// sites.google.com/site/uavuni/1960s–1970s/. Accessed Novem- ber 12, 2017.

13.Chen S. The Predator RQ-1/MQ-1/MQ-9 Reaper UAV. Air Force Technology. Available at: https://www.airforce-technology.com/projects/predator-uav/. Accessed November 12, 2017.

14.Hlad J. Drones: A Force for Good When Flying in the Face of Disaster. The Guardian. July 08, 2015. Available at: https:// www.theguardian.com/global-development/2015/jul/28/ drones-flying-in-the-face-of-disaster-humanitarian-response/. Assessed November 12, 2017.

15.Aron J. NHS to use drones to help chemical, bio and nuke response teams. New Scientist, January 29, 2016, Available at: https://www.newscientist.com/article/2075625-nhs-to-use-drones-to-help-chemical-bio-and-nuke-response-teams/. As- sessed November 12, 2017.

INTERNATIONAL JOURNAL OF RESEARCH IN AERONAUTICAL AND MECHANICAL ENGINEERING

WWW.IJRAME.COM

ISSN (ONLINE): 2321-3051

Vol.10 Issue 2,

FEBRUARY 2022

Pg:- 34-45

16.Capolupo A, Pindozzi S, Okello C, Fiorentino N, Boccia L. Photogrammetry for environmental monitoring: the use of drones and hydrological models for detection of soil contami- nated by copper. *Sci Total Environ.* 2015;514:298 –306.

17.Brady JM, Stokes MD, Bonnardel J, Bertram TH. Character- ization of a quadrotor unmanned aircraft system for aerosol– particle-concentration measurements. *Environ Sci Technol.* 2016;50:1376 –1383.

18.Tang X-B, Meng J, Wang P, et al. Efficiency calibration and minimum detectable activity concentration of a real-time UAV airborne sensor system with two gamma spectrometers. *Appl Radiat Isot.* 2016;110:100 –108.

19.Martin PG, Payton OD, Fardoulis JS, Richards DA, Scott TB. The use of unmanned aerial systems for the mapping of legacy uranium mines. *J Environ Radioact.* 2015;143:135–140.

20.Fornace KM, Drakeley CJ, William T, Espino F, Cox J. Map- ping infectious disease landscapes: unmanned aerial vehicles and epidemiology. *Trends Parasitol.* 2014;30:514 –519.