# APPLICATIONS OF UNMANNED AERIAL VEHICLES: A REVIEW

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## ABSTRACT

In recent development period of modern technology, the flying automatons UAVs (unmanned aerial vehicles) need are increasing day by day for different applications. However, this is an important area to explore and review the vicinity where UAVs can be deployed for a specific application. In this study, researchers have explored the usage of UAVs according to the areas of application in this domain. These vehicles can fly in various circumstances and zones and are capable to perform various missions. The paper presents the numerous applications of UAVs according to the current need of the autonomous technology in various areas of agriculture, military and civilian usage of the modern age. In this article, the applications of UAVs are studied and summarized in tabular form.



## KEYWORDS

UAV, Unmanned aerial vehicles, Applications areas of UAVs, Agriculture, Military, Civilian applications.

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# 1. INTRODUCTION

The UAVs are known as the flying robots, airborne devices that do not convey signals to human administrator but they fly remotely, self-sufficiently to convey lethal or non-lethal shipments. A disaster is a characteristic of hazards bringing about the occasion of large degree causing critical physical harm or damage including loss of life or intense nature (Militaru, Popescu, & Ichim, 2018). The characterization as any shocking occasion originating from natural incidents. For example, earthquakes, accidents, floods, fire or blast. It can make harm to lives, property and destroy the financial, social or cultural life of individuals. There are numerous approaches to scale typical disasters. Misadventures can be mounted for limited influenced region or population from the expulsion to steadily spreading when it occurs or in numerous different routes depending upon the condition. This paper makes use of specifically a few calamities, for example, earthquakes, floods, atomic mishaps, and jungle fires, anyway conclusively communicate that point is so gigantic, all displayed work is simply touching the surface.

# 2. LITERATURE REVIEW

Before going through the detail first we should see how UAVs takeoff and function. We have to know the fundamentals of development and structure of a typical UAVs. Different UAVs are made of numerous kind of light fused materials in order to lighter the weight and expand the rate of mobility while flying, can be additionally installed with other needful equipment's, including camera, GPS (global positioning system), GPS guided rockets, navigation, sensors (Chen & Gao, 2019). The UAVs The different type of UAVs are available in the market, it depends upon cost, an expansive assortment of shapes, sizes, capacities, and functions. The present models can be launched manually and can be controlled by remotes or from special ground cockpits. The simplified UAVs are developed for commercial applications. The vehicle is reasonable and suitable for kids since they are easy to move but difficult to control and are found in multiple varieties. The waterproof engine frame is one of the fundamental parts of each UAV other than this flight engine controllers, motors,

transmitter and collector, propellers, and batteries are some other energy cradle (Sładkowski & Kamiński, 2019).

In addition, escape UAVs is very effective or it is the sole tool for supporting disaster management. Just in case of the nuclear accidents a number of the foremost information square measures are there to sturdy the emission. What's the affected location currently is and the way quick spreading the emission. In most cases, we know that emission is limitedly allowed for human. Therefore, for any man-on-board operation, it's simply dangerous, however even useless for human, if there are many and similar effective resolutions. Observant and observance the emission sometimes created by aerials that mean these days, not simply man-on-board resolution however conjointly for UAVs application (Sugisaka, 2011).

It may be a speedy escalating disaster. Where no alternative method for speedy injury assessment is available then an aerial reconnaissance is the solution. For special rescue groups, the UAVs application will facilitate a very speedy location choice in abundance. The earthquake may be a disaster that is broke with none pre-sign and inflicting not simply seriously building damages however conjointly several deaths. The possibility for surviving of individuals at bay in folded buildings depends in the main on the injury forms of the affected buildings. A speedy mapping of affected space is incredibly necessary not only assessing damages however additional to optimize sources. The restricted resource, the tiny UAVs is often the best solution for speedy mapping (Yamazaki, Matsuda, Denda, & Liu, 2015).

Flood is a type of disaster. The authority or disaster management head office has a large amount of data for the prediction of size and intensity of heaviness of disaster. The slow flood development in repeatedly giant affecting the space, voters, and trees. Though UAVs it is easy to facilitate the situation, around a restricted space and it helps the management. As a pre-disaster activity, UAVs follow the stream of rivers and collect the dam's status. In the case of un-usual recognition, the authority will react in time to look after the situation. This activity is incredibly elastic while the flight patrol will be optimized counting on time or alternative work load. While exaggerated areas are usually outsized. However, supervising floods by aerial is normally suffered from

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controlled sources. Hence, UAVs will support disaster management at a native level. The task needs military science or operational UAVs (Liu *et al.*, 2014).

Flood is normally for a slow inception disaster. In the peculiarity, managing flood may be an extremely complicated and troublesome task and it needs continuous observation of the flood and threatened areas. The UAVs will facilitate to authorities mostly keep a neighborhood underneath observation.

The UAVs can be used for fireplace recognition, observation and conjointly for the post-fire execution. The UAVs applications of fire management are definitely the foremost incontestable activity among all disasters. The police investigation is hot spots aerial prior to reportage by civilians those clearly helps hearth authorities limiting the cause of the fire damages. It has studied that, the reason why this methodology is not perpetually used for its vast price through aerial devices. If this procedure fashioned by UAV is an inexpensive resolution than the standard one that possibility of UAV use that higher resolution (United States Patent Nº US20130134254A1, 2013).

At huge fires, exploitation manned craft for bombing water or simply for supporting data the reconnaissance mission could be a traditional procedure. On the other hand, the little fires don't need aerial support, these area units managed by ancient instrumentality. The hearth size is larger than management might be suppressing it with success simply with ancient instrumentality. However not enough giant asking manned craft for facilitating. During this manned craft is economically clearly not effective. However, the answer is similar to the UAVs which is cheaper than the utilization of manned aircraft.

In this century in the field of medical sciences, the UAVs will provide first aid to the team need medical services like dispensing to faraway and arduous locations. These help in identifying the injured in critical areas and distribute necessary supply until the medical squad team arrives. These types of UAVs are being placed in the market. It can be helpful and have an important impact on the drugs field because it will provide its helpful amenities that as a result augment the remedial services (Bitar, Jamal, Sultan, Alkandari, & El-Abd, 2017).

Unfavorable climate means low visibility of weather condition that causes a severe impact on the safety and operations of drivers on an interstate highway. It disturbs the driver and vehicle performance. In this situation, no one can rescue through conventional vehicles. The observing of climate sometimes causes similar issues of visibility impairments, precipitation, high winds, and temperature. This extreme issue has an effect on the competences of the driver and the performance of the vehicle. However, the UAVs plays an important role in monitoring the weather condition through the highway. Same as of fog issue the visibility distance is reduced which ends up and multiplied speed. That increment will enhance the risks of a crash (Dandois, Olano, & Ellis, 2015).

The Improving farmer's yields in the conventional system are very difficult nowadays. However, in the current era, digital and technological advancement modify the farmer's yields and performance increased through the use of technology. The matter of feeding an international population this can be more sophisticated with the problems of environmental impact, the necessity to scale back water waste, eliminate chemical break out, and greenhouse gas emissions. The current technology will pay to these issues and establish farming processes. Maximum members should be part of this enhancement. The giant farms will take pleasure in a variety of applicable knowledge to extend the amount of yields the source of food from an equivalent space. The latest technology involvement can improve the finance, agriculture and improve the performance of farmers and increase the yield that leads towards better profits. The small farm may become smart due to technology usage and it will boost the crops. However, the UAVs are the smart vehicle which can be deployed for smart farming. In these days the UAVs are mostly used in the developed countries for smart farming, these devices play an important role in exactitude farming, crop health analysis, observance stock, and different agricultural uses has been deemed a game changer by one exactitude agriculture professional mechanism (Burwood-Taylor, 2017; Garcia-Ruiz *et al.*, 2013; Gonzalez-Dugo *et al.*, 2013; Lu, Nagata, & Watanabe, 2017; Zhang & Kovacs, 2012).

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# 3. APPLICATION AREAS OF UAVS

The following are the areas of UAVs applications which have been explored in this research study, are agriculture, military, and civilian usage. Each has been discussed as:

# 4. AGRICULTURE USAGE

Agriculture is an important area of research which can be improved by modern technology. The feeding of human beings is totally depending upon agricultural crops. The traditional method is not fulfilling the demands of the market. And, the population is increasing with linearity with respect to time. However, the matter of feeding of the massive population at international level is going to raise the problem due to low cultivation and production of agricultural goods. This can be more sophisticated with the problems of environmental impact, the necessity to scale back water waste, eliminate chemical break out, and greenhouse gas emissions. The new digital technology will contribute to solve these issues and establish proper farming processes by introducing smart farming (Garcia-Ruiz *et al.*, 2013).

Agricultural farming can be improved by using UAVs technology. By introducing a new methodology of cultivation. For example, the soil analysis mechanism, crop spray technique, monitoring of crops, irrigation system reconnaissance should be carried out by these UAVs and timely prevent the crops and can improve the yields production (Zhang & Kovacs, 2012). Different purposes of using UAVs are discussed below:

## 4.1. UAV IN ANALYSIS OF FIELD SOIL

The UAVs can be the initial stage of the cycle applies for the crop to create 3-D mappings for early soil analysis that is useful. Installing the UAVs-driven soil analysis it provides data that can be used for irrigation and nitrogen level management, and the steps can be taken for proper fertilizer dosages that can be given to crops to protect the soil fertilization. Through this mechanism, the soil will get the proper nutrients and increase with healthy growth (Lu *et al.*, 2017).

## 4.2. UAV IN HEALTH ASSESSMENT OF CROPS

The different health issues in crops take place, however, it is necessary here to discuss the plant's, crops health. It spots bacterial or fungal infections. The crop scanning, assessment is essential for providing an immediate remedy as cultivation of field is not affected. Hence the conventional method of assessment is not more useful in the future by using visible and near-infrared light individually. The UAVs are the best assessment approaches through which the scanning of crops are very easy to identify the diseases and agronomy measures can be taken for proper production (Wu *et al.*, 2018).

## 4.3. UAV IN PLANT PREVENTION SPRAY

The equipment which can measure from far a distance with the help of ultrasonic or echoing and lasers technology used for detection of light, and set the range of LiDR that enables the UAVs to set altitude with respect to topography and landscape. However, this type of mechanism available in UAVs, that why it is possible for UAVs to do the scanning of land to perform spray activities using the exact quantity of liquid and to modulate the actual distance from the ground. In the result with a reduction of penetrated chemicals amount into groundwater will increase the efficiency. According to the expert's estimation, the spray which can be completed with the help of UAVs is five times faster as compared to manual or traditional machinery (Garcia-Ruiz *et al.*, 2013).

## 4.4. UAV IN MONITORING CROP

With the passage of time, different areas are being monitored in a different way such that crops are not left behind. However, the monitoring system of crops is not appropriate usually, so the unpredictable weather conditions also affect this process. However, satellite photography is the major and superior form of observation with some disadvantages due to the low quality of images the decision could not be taken properly sometimes (Lu *et al.*, 2017). Hence UAVs are very important for monitoring the crops and for collecting correct high-quality images for taking the right decision through this monitoring approach.

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### 4.5. UAV IN IRRIGATION SYSTEMS

UAVs multi spectral, hyper spectral or thermal sensors can discover the needs of the field that which part of the field is dry and have need of improvements. In addition, as the crop is growing once, the UAVs can start the computation of the foliage index. This index elaborate the practical concentration and physical condition of the field crops and exhibit the total of energy and the temperature emitted from the crops (Jiménez-Bello, Royuela, Manzano, Zarco-Tejada, & Intrigliolo, 2013)

## 5. MILITARY USAGE

The UAVs have a variety of applications within the military and defense area (Bucaille *et al.*, 2013; Tesfa-Alem Tekle, 2013). UAVs can be used in military operations that develop interest nowadays. Actually, the technology started within the military that may blow your mind away. UAVs are used for varied military operations because of high convenience to reduce the losses and facilitate the execution of the status of the mission. It has been studied that France had the thought of developing a craft that had no human pilot on board to be utilized in warfare. Initially, these crafts were used throughout Vietnam. Military UAVs square measure a part of an outsized system that is associated with remote-controlled craft System, a term that encompasses the entire system with the bottom management and sensors being factored. The square measures have many categories and therefore the difference relies on weights. Military UAVs can be classified according to their operations, these UAVs performs the operation for specific targets and decoy to provide intelligence, which can be used in combat. However, in this modern era, the traditional craft is not appropriate for these missions. In the recent, period the UAVs are used which can trigger the information remotely and play an important role within the resolution of future military usage. The swarm of UAVs concept is used to collect the information and for taking some square measures. The variety of applications and usage of UAVs for military operations are discussed as follows.

## 5.1. UAV IN BOMB RECOGNITION

The slight size of the UAVs sometimes penetrates constricted areas. The elevation of effective cameras that makes capable of UAVs for performing an appropriate functionality of bomb recognition. These UAVs are created by the United States for triggering the alerts about the undercharged bombs and save the human lives (Sathyamoorthy, 2015).

## 5.2 UAV IN SURVEILLANCE

To substantiate security in the region, mostly the surveys take place in the selected locations. The conventional mechanism is not appropriate which ensure the security in the period of digital technology. However, UAVs are very important to perform the surveillance that is might noteworthy solution, it will not only reduce strive and you get a wider field of the geographical area but also get more information with limitation of smaller time. This conjointly doesn't hamper the lives of the individuals but an easy and economical solution (Yang *et al.*, 2019).

## 5.3. UAV IN AIR STRIKE

The UAVs are used to intending of Air strikes. It was declared by a political entity that they used these UAVs for often to attack militants of the Asian countries. It hovers around the highlighted suspected areas and controlled by defense authorities. It can be deployed for a particular area to satisfy the military operations or to get information about subject data. However, the authors recommending the findings of the article concerning the enforcement of UAVs (Clary & Narang, 2019).

## 5.4. UAV IN SECURITY

The prompt implementation of UAVs is necessary for the purpose of security. In addition, the confidentiality point of view, UAVs engaged by voyeurs and paparazzi to get images of inhabitant groups in their residences or dissimilar places formerly implicit to be individual. The UAVs swarm can be installed in deemed areas which are almost certainly unsafe, like metropolitan areas and near to the landing field

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means airports. However, UAVs plays a vital role in the provisioning of security. It is an important area, the researcher can further explore in depth (Hein, Kraft, Brauchle, & Berger, 2019).

# 6. UAV IN CIVILIAN USAGE

The civilian applications of UAVs are photography, shipping and delivery, rescue in disaster management, rescue operations, archaeological survey, safety inspection, life observance, weather forecasting and livestock surveillance which is discussed below.

## 6.1. UAV IN PHOTOGRAPHY

The aerial photography is one of the glorious applications of UAVs. This technology equipped and holds significant camera gear that would extremely facilitate enthusiasts in delivering the aerial views of the precise regions. UAVs aerial photography may provide you with crisp and clear pictures. And have the options of live Wi-Fi streaming, you're conjointly entitled to urge person views of the UAVs movements. Live broadcasting of aerial footage is changing the most effective UAVs for motion-picture photography (Bravo, Leiras, & Oliveira, 2019). The UAVs perform a significant role which would extremely facilitate the regions (Li & Yang, 2012).

## 6.2. UAV IN SHIPPING AND DELIVERY

The shipping and delivery application of UAVs is also an important area; this concept is a revolutionary idea of modern times. It reduces the delivery times and improves the performance of the system and decrease the individual manual labor, such as, distribute the pizzas, correspondence, small parcel packages, the automatic UAVs provide services to society but still limitedly. DHL has dispatched parcel and deliver with a UAV. As a matter of reality, Amazon is functioning on its resources to facilitate the services by using UAVs in 30 minutes delivery. If this is often delivered at execution, over 1/2 you are looking for food orders may be placed inside a span of a number of minutes, UAVs delivering your packages at your doorstep in minutes.

These types of civil services carried out by UAVs in the future (Perna & Rodrigues, 2018).

## 6.3. UAV IN DISASTER MANAGEMENT

The foremost necessary application of pilotless UAVs can be used for disaster management. It is usually observed that the complete anarchy takes place in the direction of resources in a moment once a disaster occurs. In this situation, the UAVs plays an important responsibility to rescue the operation team in the affected area. These UAVs have powerful and special cameras through which the affected peoples, properties highlighted through footages and then save the human beings (Erdelj, Natalizio, Chowdhury, & Akyildiz, 2017).

## 6.4. UAV IN RESCUE OPERATIONS

In the rescue operations and care, UAVs can be launched through the flood areas. These are more helpful for provisioning of food and medicines to those human resources which are out of reach of these facilities before the reaching of rescue team assistance. The UAVs are the primary solution to be used to provide necessary products which can save human lives during this difficult time. The flood affected region data can be easily collected through aerial view during the rescue operations (Scherer *et al.*, 2015).

## 6.5. UAV IN ARCHAEOLOGICAL SURVEY

Many individuals have spent lots of time and energy over archaeological surveys. Nowadays, UAVs are used for this work. It is easier, as they will bring necessary information concerning archaeological sites through the aerial view. UAVs archaeological surveys will consider the mission of discovery as well (Saleri *et al.*, 2013).

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## 6.6. UAV IN GEOGRAPHIC MAPPING

The UAVs have a massive impact in the field of 3-D geographic mapping. In the globe, there are numerous areas, regions which could not accessible to humans. This may embody hazardous coastline, unrealizable peaks of mountains. Except for the aim of learning about a parcel in addition to making ready 3-D maps UAVs place to use. Geographic mapping through UAVs is very significant to make ensure capturing the required locations, sites for mapping processes. It is easier for a geologist to gather essential information nowadays all the way through UAVs (Sun, Wang, & Zhong, 2018).

## 6.7. UAV IN HUMAN HEALTH

The UAVs are advanced technology devices which can be used in many risk-based human health remedies. The risk means such as, plethora disease that is caused due to stagnant contaminated water having mosquitoes and houseflies. Hence due to these tiny mosquitoes, the diseases spread in Pakistan, India, Thailand, Cambodia, Srilanka, and Brazil. The dengue is a famous disease which affects these countries population and spreads very fast and very critical to handle. However, the UAVs can be used to locate the dengue spots or the ponds of dirty water in the environment and the rapid measures can be taken for remedies which cause the health problems (Sreeram & Shanmugam, 2018).

## 6.8. UAV IN LIVESTOCK SURVEILLANCE

The livestock surveillance is a more reliable solution through UAVs to scan the large area very easily for counting the animals throughout making the videos. The animal can be tracked or analyzed through the recorded video or images (Chamoso, Raveane, Parra, & González, 2014). The UAVs have been considered for livestock monitoring, several peoples do not know that UAVs are used for monitoring the cattle in real, they know that this is science fiction. Tracking the livestock in huge farms is very difficult, however, the UAVs is a novel solution for surveillance of dairy cattle's (Barbedo & Koenigkan, 2018). These UAVs are important for inspecting of availability of water and food for the livestock. Hence, by using these tiny devices that

can save the time of farmers from tedious work. To keep the cattle's out of the reach of thieves within the ranch can be possible through UAVs tracking and remain up-to-date about the animal counts. The UAVs are equipped with thermal sensors through these the animal health can be monitored (AG. TECH., 2016).

## 6.9. UAV IN SAFETY INSPECTION

The safety is an important factor for individual, society, organization, and nation. Hence, safety measures, inspections are essential in this modern age. However, to perform regular inspections to make sure about safety and security is considered on high priority. So at the national level, the aerial inspection is mandatory for safety. Therefore the UAVs can be used for safety by the brink of capturing the representational process which will provide an additional careful plan for safety and development (Choi & Kim, 2015).

## 6.10. UAV IN LIFE OBSERVANCE

The life observance of the lakes and rivers. For example, why millions of useful birds are vulnerable due to lack of feed and diseases. Hence aerial observations and footages facilitate to know the behavior of birds and analyze the data and collect the required statistics. However, UAVs perform this operation without disturbing the bird's life. Besides this, UAVs can be used in the dark with thermal cameras, sensors to observe these birds at any times. Millions of life sanctuaries and conservation parks area can be observed (Ward, Hensler, Alsalam, & Gonzalez, 2016).

## 6.11. UAV IN WEATHER FORECASTING

The application of UAVs is weather forecasting that means the prediction of climate conditions. Hence, these UAVs can be used in hurricanes, tornado, and provides the essential footages, in addition, test the patterns and occurrence. However, UAVs are an economical solution to perform the operation of weather prediction (Cecil, 2018). While the UAVs sniff out an impending storm or on another hand, some threatening interruption, the additional UAVs can be launched. For this, the swarm of UAVs that can communicate with each other on how finest to cross-examine that

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area of the environment, by collecting more data, by using different mobility models as per need. Slighter, dispensable winged UAVs are dropped into the storm, which can gather more samples.

Table 1 shows a summary of unmanned aerial vehicles applications.

**Table 1.** Summary of UAVs Applications.

| Summary of UAVs Applications | | |
|---|---|---|
| **S. N.º** | **Category of Application** | **UAVs Applications** |
| **1** | Agriculture Usage | Analysis of field soil |
| | | Health assessment of crops |
| | | Plant prevention spray |
| | | Monitoring crop |
| | | Irrigation system |
| **2** | Military Usage | Bomb recognition |
| | | Military surveillance |
| | | Air strikes |
| | | Military security |
| **3** | Civilian Usage | Photography |
| | | Shipping and delivery |
| | | Disaster management |
| | | Rescue operation |
| | | Archeological survey |
| | | Geographic mapping |
| | | Human Health |
| | | Livestock surveillance |
| | | safety Inspection |
| | | Life observance |
| | | Weather forecasting |

# 7. CONCLUSION

In this study, the applications of UAVs explored with respect to the modern needs of society. The variety of applications meets the current demand. Three categories

of UAVs applications are focused which are agricultural usage, military usage, and civilian usage. Each category has a variety of applications. Furthermore, it is a significant area for the advancement of technology usage. However, researchers can explore this domain of technology according to society needs and can develop testbed scenarios for different purposes and evaluate each application domain. These vehicles can fly in various circumstances and zones and can perform various missions.

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## REFERENCES

**AG. TECH**. (2016, August 8). *Farmers are Using Cattle Surveillance Drones to Keep an Eye on their Livestock.* Retrieved from: https://dairynow.ca/using-drones-for-monitoring-dairy-cattle/

**Barbedo, J., & Koenigkan, L**. (2018). Perspectives on the use of unmanned aerial systems to monitor cattle. *Outlook on Agriculture*, *47*, 214-222. doi: https://doi.org/10.1177/0030727018781876

**Bitar, A., Jamal, A., Sultan, H., Alkandari, N., & El-Abd, M**. (2017). Medical Drones System for Amusement Parks. *2017 IEEE/ACS 14th International Conference on Computer Systems and Applications (AICCSA)*, 19-20. doi: https://doi.org/10.1109/AICCSA.2017.62

**Bravo, R. Z. B., Leiras, A., & Oliveira, F. L. C.** (2019). The Use of UAVs in Humanitarian Relief: An Application of POMDP-Based Methodology for Finding Victims. *Production and Operations Management*, *28*(2), 421-440. doi: https://doi.org/10.1111/poms.12930

**Bucaille, I., Héthuin, S., Munari, A., Hermenier, R., Rasheed, T., & Allsopp, S**. (2013). Rapidly Deployable Network for Tactical Applications: Aerial Base Station with Opportunistic Links for Unattended and Temporary Events ABSOLUTE Example. *MILCOM 2013-2013 IEEE Military Communications Conference*, 1116-1120. doi: https://doi.org/10.1109/MILCOM.2013.192

**Burwood-Taylor, L.** (2017, March 16). The Next Generation of Drone Technologies For Agriculture. Retrieved June 27, 2019, from https://agfundernews.com/the-next-generation-of-drone-technologies-for-agriculture.html

**Cecil, J.** (2018). A conceptual framework for supporting UAV based cyber-physical weather monitoring activities. *2018 Annual IEEE International Systems Conference (SysCon)*, 1-8. doi: https://doi.org/10.1109/SYSCON.2018.8369588

**Chamoso, P., Raveane, W., Parra, V., & González, A**. (2014, June 20). *UAVs Applied to the Counting and Monitoring of Animals*. *291*. doi: https://doi.org/10.1007/978-3-319-07596-9_8

**Chen, D., & Gao, G. X.** (2019). Probabilistic graphical fusion of LiDAR, GPS, and 3D building maps for urban UAV navigation. *Navigation*, *66*(1), 151-168. doi: https://doi.org/10.1002/navi.298

**Choi, S., & Kim, E.** (2015). Design and implementation of vision-based structural safety inspection system using small unmanned aircraft. *2015 17th International Conference on Advanced Communication Technology (ICACT)*, 562-567. doi: https://doi.org/10.1109/ICACT.2015.7224924

**Clary, C., & Narang, V.** (2019). India's Counterforce Temptations: Strategic Dilemmas, Doctrine, and Capabilities. *International Security*, *43*(3), 7-52. doi: https://doi.org/10.1162/isec_a_00340

**Dandois, J. P., Olano, M., & Ellis, E. C.** (2015). Optimal Altitude, Overlap, and Weather Conditions for Computer Vision UAV Estimates of Forest Structure. *Remote Sensing*, *7*(10), 13895-13920. doi: https://doi.org/10.3390/rs71013895

**Erdelj, M., Natalizio, E., Chowdhury, K. R., & Akyildiz, I. F.** (2017). Help from the Sky: Leveraging UAVs for Disaster Management. *IEEE Pervasive Computing*, *16*(1), 24-32. doi: https://doi.org/10.1109/MPRV.2017.11

**Garcia-Ruiz, F., Sankaran, S., Maja, J. M., Lee, W. S., Rasmussen, J., & Ehsani, R.** (2013). Comparison of two aerial imaging platforms for identification of Huanglongbing-infected citrus trees. *Computers and Electronics in Agriculture*, *91*, 106-115. doi: https://doi.org/10.1016/j.compag.2012.12.002

**Gonzalez-Dugo, V., Zarco-Tejada, P., Nicolás, E., Nortes, P. A., Alarcón, J. J., Intrigliolo, D. S., & Fereres, E.** (2013). Using high resolution UAV thermal imagery to assess the variability in the water status of five fruit tree species within a commercial orchard. *Precision Agriculture*, *14*(6), 660-678. doi: https://doi.org/10.1007/s11119-013-9322-9

**Hein, D., Kraft, T., Brauchle, J., & Berger, R.** (2019). Integrated UAV-Based Real-Time Mapping for Security Applications. *ISPRS International Journal of Geo-Information*, *8*(5), 1-16. doi: https://doi.org/10.3390/ijgi8050219

**Jiménez-Bello, M. A., Royuela, A., Manzano, J., Zarco-Tejada, P. J., & Intrigliolo, D.** (2013). Assessment of drip irrigation sub-units using airborne thermal imagery acquired with an Unmanned Aerial Vehicle (UAV). In J. V. Stafford (Ed.), *Precision agriculture '13*, 705-711. Wageningen Academic Publishers.

Li, **X., & Yang, L.** (2012). Design and Implementation of UAV Intelligent Aerial Photography System. *2012 4th International Conference on Intelligent Human-Machine Systems and Cybernetics*, *2*, 200-203. doi: https://doi.org/10.1109/IHMSC.2012.144

**Liu, P., Chen, A. Y., Huang, Y.-N., Han, J.-Y., Lai, J.-S., Kang, S.-C., … Tsai, M.-H.** (2014). A review of rotorcraft Unmanned Aerial Vehicle (UAV) developments and applications in civil engineering. *Smart Structures and Systems*, *13*(6), 1065-1094. doi: https://doi.org/10.12989/SSS.2014.13.6.1065

**Lu, Z., Nagata, F., & Watanabe, K.** (2017). Development of iOS application handlers for quadrotor UAV remote control and monitoring. *2017 IEEE International Conference on Mechatronics and Automation (ICMA)*, 513-518. doi: https://doi.org/10.1109/ICMA.2017.8015870

**Militaru, G., Popescu, D., & Ichim, L.** (2018). UAV-to-UAV Communication Options for Civilian Applications. *26th Telecommunications Forum (TELFOR)*, 1-4. doi: https://doi.org/10.1109/TELFOR.2018.8612108

**Moore, J.** (2013). *United States Patent No. US20130134254A1*. Retrieved from: https://patents.google.com/patent/US20130134254A1/en

**Perna, M. D., & Rodrigues, L.** (2018). A UAV software flight management system using arinc communication protocols. *IEEE Aerospace and Electronic Systems Magazine*, *33*(9), 18-28. doi: https://doi.org/10.1109/MAES.2018.170085

**Saleri, R., Cappellini, V., Nony, N., Luca, L. D., Pierrot-Deseilligny, M., Bardiere, E., & Campi, M.** (2013). UAV photogrammetry for archaeological survey: The Theaters area of Pompeii. *2013 Digital Heritage International Congress (DigitalHeritage)*, *2*, 497-502. doi: https://doi.org/10.1109/DigitalHeritage.2013.6744818

**Sathyamoorthy, D.** (2015). A review of security threats of Unmanned Aerial Vehicles and mitigation steps. *The Journal of Defence and Security*, *6*(2), 1-14.

**Scherer, J., Yahyanejad, S., Hayat, S., Yanmaz, E., Andre, T., Khan, A., … Rinner, B.** (2015). An Autonomous Multi-UAV System for Search and Rescue. *Proceedings of the First Workshop on Micro Aerial Vehicle Networks, Systems, and Applications for Civilian Use*, 33-38. doi: https://doi.org/10.1145/2750675.2750683

**Sładkowski, A., & Kamiński, W.** (2019). Using Unmanned Aerial Vehicles to Solve Some Civil Problems. *Cases on Modern Computer Systems in Aviation*, 52-127. doi: https://doi.org/10.4018/978-1-5225-7588-7.ch003

**Sreeram, S., & Shanmugam, L.** (2018). Autonomous Robotic System Based Environmental Assessment and Dengue Hot-Spot Identification. *2018 IEEE International Conference on Environment and Electrical Engineering and 2018 IEEE Industrial and Commercial Power Systems Europe (EEEIC / I CPS Europe)*, 1-6. doi: https://doi.org/10.1109/EEEIC.2018.8493849

**Sugisaka, M.** (2011). Working robots for nuclear power plant desasters. *5th IEEE International Conference on Digital Ecosystems and Technologies (IEEE DEST 2011)*, 358-361. doi: https://doi.org/10.1109/DEST.2011.5936593

**Sun, Z., Wang, D., & Zhong, G**. (2018). Extraction of Farmland Geographic Information Using OpenStreetMap Data. *2018 7th International Conference on Agro-Geoinformatics (Agro-Geoinformatics)*, 1-4. doi: https://doi.org/10.1109/Agro-Geoinformatics.2018.8476088

**Tesfa-Alem Tekle.** (2013, February 14). Ethiopia produces first military drone aircraft-Sudan Tribune: Plural news and views on Sudan.

**Ward, S., Hensler, J., Alsalam, B., & Gonzalez, L. F.** (2016). Autonomous UAVs wildlife detection using thermal imaging, predictive navigation and computer vision. *2016 IEEE Aerospace Conference*, 1-8. doi: https://doi.org/10.1109/AERO.2016.7500671

**Wu, W., Qurishee, M. A., Owino, J., Fomunung, I., Onyango, M., & Atolagbe, B**. (2018). Coupling Deep Learning and UAV for Infrastructure Condition Assessment Automation. *2018 IEEE International Smart Cities Conference (ISC2)*, 1-7. doi: https://doi.org/10.1109/ISC2.2018.8656971

**Yamazaki, F., Matsuda, T., Denda, S., & Liu, W.** (2015). Construction of 3D models of buildings damaged by earthquakes using UAV aerial images. *Proceedings of the Tenth Pacific Conference on Earthquake Engineering Building an Earthquake-Resilient Pacific*, 1-8.

**Yang, T., Li, Z., Zhang, F., Xie, B., Li, J., & Liu, L.** (2019). Panoramic UAV Surveillance and Recycling System Based on Structure-Free Camera Array. *IEEE Access*, *7*, 25763-25778. doi: https://doi.org/10.1109/ACCESS.2019.2900167

DOI: http://dx.doi.org/10.17993/3ctecno.2019.specialissue3.85-105

**Zhang, C., & Kovacs, J. M.** (2012). The application of small unmanned aerial systems for precision agriculture: A review. *Precision Agriculture*, *13*(6), 693-712. doi: https://doi.org/10.1007/s11119-012-9274-5