Commercial Multirotor UAV Campaign on Data Acquisition for Disaster Management

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Abstract. UAV usage and interest have shown great popularity recently, especially for commercial multirotor. It is cheap, easy to use, flexible, and has many capabilities. That is why multirotor is widely chosen in disaster management. As a technology, it possesses certain aspects. Review of how the implementation of multirotor UAV in disaster management is important to gain improvement in the technology and evaluate at how we use it. This paper provides insight into commercial multirotor UAV campaign in disaster management through literature study and personal experience in a related theme. Similar ideas on the development of UAV and its application in disaster management then combine with personal experience was used to identify the advantage, disadvantages, challenges, and opportunities of multirotor drone applications. The result suggested that multirotor UAV has limited capability in conducting disaster management campaigns. The weakness in deploying multirotor is related to the lack of technology which may be overcome in the future as the development in hardware and software technology.

Keywords: Quadcopter, disaster management, data acquisition

1. Introduction
Rapid data assessment in every fieldwork related to any field is preferable. Since a long time ago, methods on data collection has developed to have adequate data with less time, effort, and capital. In the earlier times, data assessment for post-disaster relief was done manually by laboring surveyor to collect a large amount of data. This traditional method is time consuming, painstaking, and expensive. Another method comprising satellite imagery and aerial photograph has long been used for disaster management comprising pre- and post-disastrous campaign [1], [2].

Earth’s surface data acquisition or earth observation by satellite image for disaster management rapidly increases because of its rapidness and detail [3]. Technological advance in sensors and satellite is the factor of the increasing demand for satellite imagery. Satellite as part of aerospace technology, plays an important role in disaster risk reduction, thus rapid data acquisition, high temporal resolution, and all-weather capability is a must [4]. Satellite imagery and its wide options of sensors have the requirement mentioned by Verstappen. The satellite also has its advantages by its wide-area coverage, and the selection of sensors which some area weatherproof. Despite the advantages, satellite imagery is lacking on temporal resolution (only some have high temporal resolution) For non-radar sensors, most of the sensors are depended on the weather, which means that the cloud will be a big interference for
them. The high-quality satellite imagery is costly, and it becomes one of its drawbacks, especially for NGOs or private sectors with limited resources.

Other than satellite imagery, surface imagery can be obtained through aerial surveys utilize planes or high-altitude aircraft. This method was popular before the advancement of satellite imagery and advanced Unmanned Aerial Vehicle (UAV). An aerial photograph provides a detail image but has several limitations. Weather conditions could be the biggest hindrance to the data acquisition. The complicated Resource management for flight surveys also must be taken into consideration. Compared to any other system, aerial photography (manned system) has many constraints and requirements which is difficult to obtain, handle, store, calibrate and interpret [5].

UAV along with UAS (Unmanned Aerial System) was originated for military and intelligence concerns with their specific technologies [6], [7]. Not only UAV technology, many technologies we use daily were derived from the military, for example is internet [8]. The application of UAV has reached many aspects of life both civil and military. Various classification and types of drones utilized for different missions [9]. Drones also catch the curiosity of the enthusiast. They try to make their drones for many purposes. Aside from custom drones made by an enthusiast, commercial drones made by industries come in many type and application. Even, some are customizable following the mission.

Multirotor is the type of several commercial drones available. Several types in multirotor has 3, 4, 6, and 8 rotors called tricopter, quadcopter, hexacopter, and octacopter respectively. The main attraction of these types of drones is on its practicality, price, and data accuracy [9]. As for its benefit, many parties tend to have this type of drone. Mostly this type of drone especially used for videography or documentation. For the scientific purposes, this type is largely used for mapping and area identification. The same idea is used for disaster management as a drone is mainly used for data acquisition [10], [11], [12], [13].

As for scientific purpose, some type of drones provides customizable function to match its mission. The ability to change the sensor/camera is beneficial. The changing of sensor demonstrated in thermal imaging for eruption monitoring in Stromboli Volcano, Italy [14]. Wakeford and his team change the camera installed in their DJI Inspire using a thermal camera designed for DJI Inspire. Another use for multirotor drones aside from image capturing is for water sampling as demonstrated by several works [15], [16], [17], [18].

Easiness, reliability, and flexibility made commercial multirotor is the logical choice for most people. With its properties, the performance of a multirotor drone for fieldwork, mapping, and its application on disaster management needs to be explicitly described. Therefore, review on the application of multirotor UAV, especially for disaster management is important, so, many users and people who interested in using drones in the future can evaluate their experience and use of drones. For enthusiasts and industry, the result of this paper can be used to improve and develop drone technology.

2. Methods
Commercial drone experience and its related data on disaster management were obtained not only from authors experience and previous research but also depends on the literature studies. Previous research selected in this study were disaster management covering multi-type of hazard which utilize drone/UAV/UAS for their data acquisition.

As literature study in this study is part of a narrative study which represent a generalization of ideas or cumulative knowledge [19], [20], [21] on the topic of disaster management with the utilization of multirotor drone for data acquisition. Cumulative ideas presented in a table to be easily recognized. Conclusion on the application of multirotor UAV synthesized from the shared ideas among the previous studies to find the benefit, disadvantages, challenges, and opportunities in the future.

This method was chosen as much data are available outside of the author’s possession. They came in books and journals. The only way to reach and collect the information was through the literature study as presented by several works in the various theme of drone [22], [23], [24]. There are several steps to obtaining the information and drawing conclusions. The first step was literature retrieval in the form of
journals and books. The second step was information extraction. The information that was gathered including the development of drones and the application of multirotor on the field of disaster management.

3. Result and Discussion

3.1. Result

3.1.1. UAV development. The earliest application on the unmanned aerial vehicles was in 1849 during the military campaign of the Austrian Empire by using unmanned blimp to air raided Venice. The next unmanned aerial vehicle application was used in the American Civil War in 1861-1865. It presents the same system as used by the Austrian Empire in 1849. Non-military application of aerial photographs was demonstrated by British meteorologists by attaching a camera to a kite in 1887. In 1916, the first real unmanned vehicle was flown by Royal Flying Corps (recently called Royal Air Force), British. The rising application and development of UAS were conducted during World War 1 and 2, for combat and aerial survey. Modern use and technology on UAS were developed in the post-war era, but mostly still serving a military campaign. Since the 2000s, a vast application of commercial drones for recreational use emerged, a sign of the booming of drone usage for civilians [6].

The expansion of UAV application from military operation in the beginning, into much more vast utilization, makes human-drone interaction is more complex [25]. From the study conducted by Tezza and Andujar in 2019 [25], the profile of the most used commercial drone and their application, their growth, and favourable model information were obtained. Figure 1 shows the highest estimation of drones registered to the FAA in the US. That number can demonstrate that the growth of interest and application in drones is high. Unfortunately, Indonesia has no published data on the registered drone yet as the regulation on the UAS deployment in Indonesia has not evenly known to the public yet. But, from many sources, the prospect of the commercial drone in Indonesia is high, manifested from the drone sales figure (Hussein, 2019) and the increasing number of drone hobbyist communities, which is now globally increasing rapidly in number [26].

![Figure 1. High estimation of drone growth by FFA [25], [27]](image-url)

In the US, multirotor, especially quadcopter is the most favourable among the hobbyist. DJI, one of many drone corporations still becomes the ruler of drone market share globally (Mordor Intelegence, 2020) with multirotor as the biggest type of drones in the market. Multirotor drone tends to have a more stable image capturing which increase the accuracy and number of the image due to the low-speed flight coupled with the ease of vertical take-off and landing [28]. A comparison of the basics of technical properties of multirotor drones that commonly used for survey and mapping is sown in Table 1. The table show variety of multirotor drone, from the small recreational drone, up to the big-heavy-duty-industrial purposed drone. The price also varies between hundreds to thousands of dollars. Some are originated for recreation purposes but can be enhanced into survey and mapping with the addition of mapping and surveying software.
The recreational purpose for several drones is mainly for image capturing and video recording with the enhance of the capability of the drone such as following objects, following points or tracks, fly in circles, or following several rules. Enhanced software for mapping is introduced by several developers. The software has two main functions, first is to plan the flight track and properties such as speed, altitude, overlapped size, type of orthophoto, and camera angle. Second, the software is used to aid the image processing process and analysis, for example, to produce the mosaic, DEM, or analysis on the vegetation. Some software has multi-platform use, desktop (pc-based), and mobile (installed the mobile device). To have better assistance from the software developer, the user must make a payment subscription, unless only basic or time-limited service can be provided by the developer. Several software developers provide free service for flight planner in a mobile platform, and it can be used only for several drone manufacturers. Some software for flight planning and analysis are available such as Pix4D, dronedeploy, DJI ground station pro, Map pilot, etc. That software can enable the autonomous and semi-autonomous flight over planned track/points with the ability to override the control during the flight. In mobile platforms, some software can be run under android or iOS which is come handy for most users.

3.1.2. UAV Operation on disaster management. Data demand right after the occurrence of a disaster covering the abrupt changes of the affected area is one of the top priorities in disaster management, so rapid data assessment is crucial [29] to provide data to improve the response and mitigation of the disaster [30]. Rapid data assessment after the onset of disaster can be covering a large sector including access and security, demographics, community resources, health, water, sanitation, food and non-food items, and shelters [31], and most of the data can be obtained from remote sensing survey [29], including the deployment of UAV. Aside from rapid data assessment, a UAV survey in a disaster can be applied to mitigation as a pre-disaster event. This application is widely used and reported by many researchers (see Table 2).

Table 1. Comparison of several Multirotor UAV commonly used in mapping

| Brand | Model       | Flight time (min) | Speed (Km/h) | Weight (gr) | Range (Km) | Picture resolution | Control Interface |
|-------|-------------|-------------------|--------------|-------------|------------|--------------------|-------------------|
| DJI   | Mavic Pro  | 27                | 64           | 734         | 7          | 12 MP              | RC, phone         |
| DJI   | Mavic 2 Pro| 31                | 70           | 907         | 8          | 20 MP              | RC, phone         |
| DJI   | Phantom 3 Pro| 23               | 57           | 1,280       | 5          | 12 MP              | RC, phone         |
| DJI   | Phantom 4 Pro V.2.0 | 30               | 72           | 1,375       | 9          | 20 MP              | RC, phone         |
| DJI   | Phantom 4 RTK | 30               | 58           | 1,391       | 5          | 20 MP              | RC, phone         |
| DJI   | Inspire 2  | 27                | 93           | 3,440       | 7          | Varies by camera   | RC, phone         |
| DJI   | Matrice 300 RTK | 55             | 82           | 6,400       | 15         | Varies by camera   | RC                |
| Dji   | Matrice 200 series | 38             | 80           | 4,672       | 8          | Varies by camera   | RC, phone         |
| Parrot | Anafi   | 25                | 53           | 320         | 4          | 21 MP              | RC, phone         |
| Parrot | Bebop2  | 25                | 59           | 500         | 3          | 14 MP              | RC, phone         |
| Yuneec | H520   | 28                | 61           | 1,995       | 1.6        | Varies by camera   | RC                |
| Yuneec | Tornado H920 Plus | 24             | 50           | 4,990       | 1.6        | 16 MP              | RC                |
| Vulcan | Raven  | 12                | 28           | 7,250       | 8          | Varies by camera   | RC                |

The data demand right after the occurrence of a disaster covering the abrupt changes of the affected area is one of the top priorities in disaster management, so rapid data assessment is crucial [29] to provide data to improve the response and mitigation of the disaster [30]. Rapid data assessment after the onset of disaster can be covering a large sector including access and security, demographics, community resources, health, water, sanitation, food and non-food items, and shelters [31], and most of the data can be obtained from remote sensing survey [29], including the deployment of UAV. Aside from rapid data assessment, a UAV survey in a disaster can be applied to mitigation as a pre-disaster event. This application is widely used and reported by many researchers (see Table 2).

Table 2. Publication on disaster management with the implementation of multirotor UAV

| Author               | Year | Predisaster | Disaster assessment | Post-disaster | Monitoring, planning | Damage assessment | Cargo, SAR | Type of Disaster |
|----------------------|------|-------------|---------------------|---------------|----------------------|-------------------|------------|------------------|
| Wulan et al.         | 2017 | √           | -                   | -             | -                    | √                 | -          | Landslide, Flood |
| Baker, Rapp, Elwakil, & Zhang | 2020 | -           | -                   | √             | -                    | -                 | -          | Hurricane        |
A previous study inferred that UAV campaign for disaster management is a sophisticated method that enables users to achieve data easily and rapidly with less effort and resources. Its ability to take off and land in limited space is also a key factor for the vast campaign of multirotor in disaster management. Various methods of hazard management application, algorithm, and modelling have been developed to enhance the success of disaster management. Modelling and monitoring regarding mass movement have been conducted, so any changes in the environment that can trigger the landslide could be detected early to minimize the damage and loss [12]. The same concept also applied in mitigation of volcanic eruption of Stromboli Volcano by utilizing thermal images to produce 3 dimensional model of the volcano [14].

Frequently, UAV is mobilized due to assessing the surface conditions in the post-disaster event. Multirotor can also be deploy in this kind of event due to its flexibility. A study on the utilization of commercial quadcopter for mapping in the impact of landslide onset was carried in Banyumanik [42] and in Bangli, Bali as the result of flood and landslide a day before [32]. Based on the study carried by Azeriansyah, Prasetyo, & Yuwono, they can identify the affected area with good accuracy compared to the standard issued by Geospatial Information Agency (BIG/Badan Informasi Geospasial) under the regulation of the head of Geospatial Information Agency Number 15/2014. While based on the study by Wulan et al., they did not specify the technical result related to the data accuracy as they did not focus on that issue. Their study mainly focused on the mapping of the area affected by the flood and landslide. Another utilization of UAV and on landslide data measurement in India resulted in 5% difference between measurement using data assessed form UAV and data obtained from field measurement using a total station [13].

Disaster comes in many forms and triggering factor. Man-made structure and technology also exposed to a certain possibility of failure due to natural and artificial events. UAV mission for monitoring and assessing data on technology/engineering failure is common nowadays. Certain UAV deployment on an artificial structure is regularly made to investigate damage and verdict future possibilities and steps in disaster management. The sample of this work presented by Leizer & Tokody...
in 2017, when the utilize drone in the railway accident and disaster. Their work was motivated by the large amount of hazardous substances being transported using trains, and often accidents occur in the process of transporting the substance. They develop a method to monitor and assess the data utilizing RFID (Radio Frequency Identification) to identify the transported goods, their company, and any other data. They also revealed that deployment of drones, especially multirotor gave a huge benefit as their sensors are interchangeable and cheap. Identification of hazardous radioactive waste or substance also can be monitored using a thermal sensor-equipped drone. Assessment on a structure which has high potential of danger requires the assistance of drone. If the result of drone assessment suggested detailed manual observation, then human intervention is needed. The example of this work was done by Aiello et al. in 2020, they promote the use of mini-UAV in an inspection as to its participation in mitigation. Based on their study, mini-UAV with MTOW (Maximum Taking off Wight) is less than 300 grams, has a high potential in the monitoring stage of mitigating disaster risk in an industrial complex.

Even after several weeks of disaster occurrence, UAV participation is still possible. Works on tsunami impact and its inundation distribution and run-up heights did 1 month after the onset was conducted in Sulawesi as the response of landslide-generated tsunami triggered by an earthquake [38]. Based on the study, Mikami and his team able to identified the run-up height, inundation distribution, damage pattern. They conclude that the topographical factor plays an important role in the distribution of inundation. Another example of UAV deployment after the earthquake presented by Qi et al in 2015 after the Lushan earthquake in china. He deployed rotary-wing UAV to assist in SAR (search and rescue) process by capturing and processing data through low altitude flying. The mission proves its applicability and saves time by utilizing the rotary-wing UAV.

UAV comes in many sizes, capability, and prices. Each drone is unique due to its characteristics. Large size UAV with high capability and endurance may be used as a logistic carrier during the post-disaster campaign. This idea is brought by Estrada & Ndoma in 2019 in their study. They emphasize that the success of UAV campaign depends on the development of technology and training for pilots to have efficient and effective missions in different stages. Technological development and balance mentioned by Estrada & Ndoma comprise of hardware and software. This development of technology demonstrated by Zenkin et al in 2020 by promoting the UAV software and hardware for s forest fire.

Some disaster requires height data, such as for tsunami, mass movement, flood/inundation, liquefaction, etc. Height data is obtained by photogrammetry of the overlapping photograph from an aerial acquisition. Aerial image captured by UAV can be processed using various software developed by various developers such as global mapper, esri, Agisoft, dronedeploy, pix4d, etc. Many analyses and properties regarding the process can be adjusted. More accuracy in georeferencing can be enhanced
using GCP (Ground control point) obtained by applying geodetic GPS during the survey. The example of the result is shown in Figure 2.

Height data extracted from the photogrammetric analysis will be in a DSM (digital surface model). DSM still including the height of land cover such as trees and buildings, while DTM only represents the bare earth [43]. Based on DSM dan DTM, some analysis and modelling can be conducted for mitigation and damage assessment. Meanwhile, an aerial photograph is used to interpret the surface properties such as land use and land cover, structural damage, affected area, and resources identification.

3.2. Discussion

Based on the result derived from the literature study and personal experience in utilizing commercial multirotor UAV in disaster management, several aspects can be identified respectively as seen in Table 3 with the following discussion.

| Benefit | Disadvantage |
|---------|--------------|
| VTOL (Vertical Takeoff and Landing) | Limited flight range |
| Low-cost | Short flight time |
| Easy to control | Small coverage area |
| Hovering maneuver | Some small multirotor have problems in their camera |
| Play autonomous or semi-autonomous | Wind-resistant |
| Interchangeable parts | Small device means the small payload |
| Some are small enough, flexible and easy to carry | |
| Stable | |
| Better accuracy | |

| Challenge | Opportunity |
|-----------|-------------|
| Flight safety | A vast field of application |
| Flight regulation | Favoured by market |
| Pilot qualification, certification, and skills | Development of technology to meet the needs |
| Issue of invasion to a privacy | |

3.2.1. Benefit.

The good thing coming from multirotor UAV is its many benefits. Many commercial multirotor available in the market are small, even foldable, and some can fit in a pocket. Its practicality will come handy during fieldwork where we have to carry so many additional equipments. We often use small size foldable UAVs such as DJI Mavic Pro. Its often used during our research and fieldwork to assess the environmental condition or reach inaccessible points from a safe place [44] and conduct aerial mapping to obtain a surface elevation model. Commercial multirotor can be controlled easily using a remote control or remote control with a mobile device connected to the controller. Some models provide double remote control as pilot control the movements and cameraman control the camera/sensor. To have consistent speed and direction, a flight plan for fly autonomously/semi is made. From the software flight pattern and properties can be adjusted to ensure the best overlap and result of the aerial photograph [45].

The many reasons why multirotor is chosen is for its price, easy to control, and maneuverability. Its VTOL (Vertical take-off-and-landing) capability assures the flexibility in any field and terrain of operation. Some small multirotor UAV can take and land in the face of a palm. Movement of the UAV during flight contributes to the accuracy of the data it obtained. One movement that can only be done by multirotor than fix wing is hover maneuver. It is a still flight condition mid-air. This maneuver is beneficial as we can concentrate and examine objects without moving. The movement of multirotor UAV ensures the stability of data capturing [28], [46] which resulted in a better aerial image and accuracy [28]. Several missions require a custom-made apparatus to be mounted on a drone. Such as
thermal, visible light sensor, lidar, radiation detector, sampler, etc. Multirotor is can provide stability to
grab the sample, such as water sample [15], [16], [17], [18] and radiation monitoring [47], [48], [49].

3.2.2. Disadvantage.
Despite multirotor advantage, as opposites, it possesses several weaknesses that in the future may be
overcome with the introduction of new technology. As for today, many commercial drones are lack of
flight time, range, covered area, wind-resistance, payloads, and sensor. In several occasion, mapping
mission using our quadcopter create a horrifying moment. As we have several mappings done in the
windy coastal area, our quadcopter cannot meet the maximum flight duration. Once, we experienced
only less than 5% battery remained with flight time less than the maximum duration. Based on our
colleague’s experience, they have lost drones due to a signal lost on the hilly and forested area. It is not
only happened in multirotor, fix wing also experienced similar events sometimes. This event
demonstrates the deployment of multirotor UAV carrying risks. Topographic barrier, high and dense
vegetation cover may disrupt the signal. The maximum range and flight time may be reached under
preferable conditions. Problems in several cameras found in several commercial multirotor. The camera
tends to condensate and produce blurry and misty images due to changes in atmospheric pressure and
temperature during flight. This mist will be gone as the UAV stay longer in the air. The example of the
blurry and misty image can be seen in Figure 3.

Figure 3. Blurry image as the result of condensation in the camera
Source: Author fieldwork in 2018

3.2.3. Challenge.
The introduction of UAV is a revolutionary thing [6]. Introduction of a drone to the rapidly changing
society carries a great challenge. Issues on terrorism, crime, and invasion of privacy emerge related to
drone deployment. To prevent misuse and protect the community, several regulations are made due to
the application of UAV and the use of air space to ensure flight safety. Pilot as the controller and
decision-maker in the drone deployment needs to be well educated on flight safety, regulation, and
understand the use of air space as well as a responsible individual. Every UAV deployment is using air
space that must be shared for some interest such as commercial, recreation, and military. Each air space
has its regulation that needs to be followed by the user and the UAV pilot. Besides that, drones
development is facing a level where a new novel drone is expected with the ability to fly autonomously
in every condition for many purposes [9]. Related to disaster, UAS need to be developed to enhance the
effectivity, flexibility, and the rate of success of UAV deployment in the field to support disaster
management campaign. Several cases mention the technical issue as a problem need to be overcome for the future supports in disaster relief programs. The issues mention here are data transfer [50] and data safety [51].

3.2.4. Opportunity.
Technological development has created a vast possibility for multirotor drone to advance. From sensors, flight systems, power sources, and capability [52] that will open new opportunities of UAV, especially multirotor new mission and field. Also transformable multirotor UAV has been developed to increase its manuverable, movement, and flexibility [53]. Based on current technology, UAV has been applied in the field of disaster management, crime prevention, law enforcement, border police, life safety and healthcare service, military service, commercial, construction, private uses, education, research, entertainment, sport, logistic, firefighter, agriculture, geology, astronomy, meteorology, and environment [34], [36]. Commercial drone, especially for multirotor, has shown a huge interest in the market and provide a huge amount of profit. Business on drone become a new prospect. The huge drone technology will be achieved for the next decade as computer technology is greatly advancing [54].

4. Conclusion
Multirotor technology provides new insight into the possibilities of UAV deployment in many fields of interest. Furthermore, the large usage of multirotor UAV has risen alarms on privacy, safety, air space usage, and regulatory system. In needs time for UAV to be fully accepted in daily life. Multirotor is widely used in daily activity because of its advantages, from price, flexibility, and capability. The weakness of multirotor for a disaster management survey is related to the technological aspect related to the software and hardware. Those weaknesses can be overcome with the future advance of technology. As the technology in multirotor UAV is advancing, market interest will grow in its resemblance. Overall, according to the literature study and personal experience, commercial multirotor UAV has a proper but limited capability in disaster management campaigns due to its weakness. The high usage of multirotor UAV for disaster management represents its benefit as a system, as it provides many benefits and promises a high possibility in future technological development.

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