Applications of Drones in Emerging Economies: A case study of Malaysia

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Abstract— **Drones or unmanned aerial vehicles (UAVs) are becoming increasingly popular for commercial and non-commercial uses – especially in fields of environment, surveillance, aerial photography, digital communications, search and rescue operations and military. Drones are in fact low cost aerial robots, that require little preparation and infrastructure and can be equipped with any number of sensors or cameras making them ideal for monitoring the environment. Environmental monitoring plays a major role in analyzing climate and management impacts on natural, agricultural systems, assessing, forecasting and even preventing natural disasters and enhancing hydrological cycle. Monitoring and data collection systems are based upon a combination of ground-based measurements and remote sensing sensors observations. These data however have spatiotemporal constraints. Drones offer an opportunity to bridge the existing gap between field observations and remote sensing by providing high spatial detail over relatively large areas in a cost-effective way. Drones have become popular in several developed countries in recent years. However, the use of drones is still in the infancy stage of development at developing countries such as Malaysia. This paper attempts to review the development of drone applications in Malaysia in order to identify future directions, applications, developments and challenges. We summarize that, to leverage the full potential of drones approaches in Malaysia, measurement protocols, retrieval algorithms, and processing and evaluation techniques need to be harmonized to ensure the sustainability and resiliency of the implementation.**

Keywords-component; Drone; Sector; Malaysia

I. INTRODUCTION (HEADING 1)

In the past years, population in rapidly developing economies such as Malaysia, Indonesia and Thailand have skyrocketed and the migration of more than half of the countries' population to live in urban environment settlement resulted in rapid urban growth, urbanization, and associated challenges; urbanization here denotes a changing balance between rural and urban populations, and should not be confused with urban growth, which is only a measure of change in urban areas. This can be seen more evidently in the big cities of Kuala Lumpur, Jakarta, and Bangkok - which are centers of economy, policy, society, and culture.

These crises further precipitate an urgent need to promote sustainable urban planning practices that preserves heritage places, increases green spaces, minimizes disproportionate wealth distributions, controls hike in pollution and carbon emission levels, and fulfill citizen needs through active public participation; along with abiding and adhering to the set of development control procedures, protocols and policies put forward by their respective legislative and administrative systems. In this context, we cannot identify, address and/or solve the rising demands by solely relying on traditional data collection methods – such as information collected by means of statistics and field surveys – as these approaches are often

limited by constraints on time, capital, and labor availability [10].

Drone has been widely applied for surveying and mapping purposes. Previously, surveying works involves a team, which usually consists of the surveyor, assistances and draft man for making plan and process the data and it is requires huge cost and laborious and also lot of time consuming. Thus, expected by using UAV, the surveying works process can be solved with less time, cost and manpower [1]. [23] built 3D Malay city model using point clouds extracted from a multi-rotor drone and assessed the land use patterns – based on three components: buildings, land use and street conditions – for evaluating if the urban development in traditional Malay cities have exceeded the demarcation underlaid by ancient architecture and heritage values. Subsequently, [2] took this study one step further and used drone's 3D mapping features for detecting historical buildings and for assessing urban form and height of multi-story buildings in the city areas of Kota Bharu, Malaysia.

However, all these studies were primarily pilot projects, done for research purposes, and to signify the impact drone based survey and analysis can have on a country's future concerns; large scale applications of drones, which exploits the benefits of latest technologies, automated workflows, cloud sharing facilities and classification algorithms, for real time support of urban planning operations are still at a latent stage in Malaysia. The aim of this study is to provide a general review on the advancement of drone technology, its ongoing usages, implications and recommendations for effective implementation of prospective applications for development and planning in Malaysia.

II. EVOUTION OF DRONES

A drone can be perceived as a flying robot, or a powered aerial vehicle, that can be remotely controlled, without having a human onboard, or flown autonomously, through software-controlled flight plans [5]; [8]; [11]. The emergence of drones can be attributed to the World War I. The Dayton-Wright Airplane Company is considered to be the first to bring the concept of unmanned aerial aircraft into fruition; they built a torpedo whose mission was to explode at a preset time. This was later followed by the development of another aerial torpedo, which was a part of the Hewitt-Sperry Automatic Airplane project, and here, the drone's purpose was to carry explosives to enemy's territories [5]; [16].

Consequently, World War II witnessed the first large-scale production of drones, and their numbers kept proliferating with the advent of the cold war. Even though the initial decades of drone evolution were confined to the boundaries of the military sector, recent advancements in technology – in areas of Global Navigation Satellite System (GNSS), Inertial Measurement Unit (IMU), robotics, image processing, machine learning algorithms and artificial intelligence - and an upsurge in accessibility – because of a cut-back in prices and increased production rates – have extended the applications of drones to civilian (non-military) fields, especially in the realm of agriculture, forestry and construction, at an astounding rate.

III. TYPES OF DRONES

Drones can be classified into multiple categories depending on their functions, size, weight, number of propellers, aerodynamic flight principles, range, equipment, cameras used and so on. Considering the operations accompanied to the urban planning sector, the prominent types of drones are rotary-wing and fixed-wing drones, where the classification is based on the differences in their aerodynamic flight principles [17]. The rotary-wing motors are more common, as they offer high accessibility, ease of use, good camera control, ability to function in confined spaces and supports hover and vertical take-off and landing (VTOL); cost-wise also these are very affordable options. Depending on the rotor configurations, the rotary-wing drones can be further classified into tricopters, quadcopters (Figure 1), hexacopters (Figure 2), etc. However, all these drones have limited flight time (of not more than 30 minutes; [4] and small payload capacity (mostly below 8 kg; [19]. Below show a few examples of drones.

Figure 1. Quadcopter Drone

Figure 2. Hexcopter Drone [4]

On the other hand, fixed-wing drones (Figure 3) exhibit long endurance and can cover a large area with fast flight speed. In the case, the constraints fall on the expenses regarding equipment, ample amount of space required for take-off and landing, and the difficulty in flying – which requires proper training. This results in their applications to sway more to the commercial sides, and hence, rotary-drones show a higher presence in the non-commercial sectors. More recently, hybrid drones, which merges the benefits of fixed-wing UAVs with the ability to hover, have also started entering the drone markets; these drones can take off and land vertically [5]. Irrespective of

the types of drones, the subsystems and components of a drone primarily comprises of frame, propeller, brushless motors, motor mount, landing gear, flight controller, batteries, payload (such as remote sensing camera, agricultural spraying systems or logistics related applications), and sensors.

Figure 3. Fixed-wing Drone [26]

IV. Drone Data

In the context of remote sensing and analysis applications, drone collected data can be classified into two main categories: aerial imagery and 3D point clouds; the 3D point clouds are in fact derived from a collection of images using various software and structure-from-motion (SfM) algorithmic techniques. Detailed walk-through on the process of building 3D point clouds (Figure 4) from aerial imagery, can be found in [12]; [25].

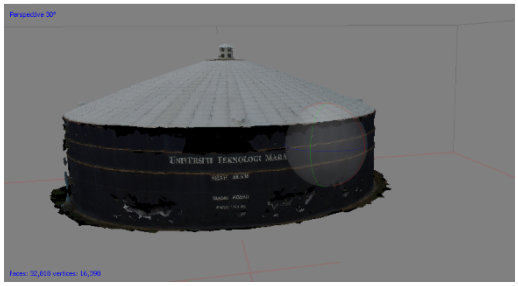

Figure 4. Processing of building 3D point clouds

Here, the aerial imageries can be seen as 2D images having high spatial resolution obtained using a camera(s) attached to the drones (gimbal). Depending on the sensors and cameras used, the number of bands in the images can also vary and this determines the specific applications of the data acquired. For instance, cameras used for adventure photography purposes might only have bands of red, green, and blue, whereas, cameras for precision agricultural (Figure 5) and site inspection (Figure 6) purposes, might include additional near-infrared and thermal bands respectively.

Figure 5. Precision Agriculture [13]

Figure 6. Site Inspection

V. Drone-as-a-Service Sector

Research on benefits of drones over other modes of remote sensing techniques have been studied from early 2000s and the conclusion on its superior nature was supported primarily by the high resolution imagery offered, affordability, ease of use, applicability in confined spaces and frequency at which operations can be done; moreover, all the pertinent tasks could be done without compromising anyone's safety as well. Additionally, advancements in robotics, artificial intelligence, data science and software engineering made automation of flights and workflows - related to data analysis, which includes applications of various machine learning algorithm and classification techniques – and faster processing of software possible, which worked in favor of the drone industry. Advancement of emerging technologies such as 4G/5G networks can boost the drone's potential in delivering Internet of Things (IoT). As a consequence, when the drones entered the global markets, companies were very eager to exploit its advantages and often times chose to replace low resolution satellite imagery and/or high-cost lidar data with the "newly found panacea". Among the reasons for the proliferation of commercial drones, plummeting of machine cost due to fierce competition in consumer markets, increased leniency of Federal Aviation Administration (FAA) on drone regulations in the U.S. and swaying of a myriad of jockeying startups by the Da-Jiang Innovations (DJI), the Chinese firm that dominates the consumer-drone industry [18], can be intuited as the root causes.

However, the commercial drone market has changed a lot in the past few years and we have witnessed a shift in the core focus – which was once on the hardware components and robotics research – to drone services and software solutions [9]. This speaks volumes about the applicability of drone collected data and marks the dawn of a drone-as-a-service sector era. This sector aims at providing services that transforms how decision makers manage their time, energy, efficiency, and safety demands of their respective organization; Measure, Cyberhawk, Hemav and Aerodyne are few of the top drone operating companies focused on the inspection, mapping, and survey domains, which are an indispensable component of urban planning [9]. Also, this sector has been successful in providing employment opportunities to tens of thousands of individuals so far, within a short amount of time, and is expected to continue its reign in coming years; for example, a recent study conducted by the Association for Unmanned Vehicles Systems International showed that drone industry is expected to create more than 100,000 jobs in 10 years, just in the U.S., thereby adding $13.7 billion to the American economy.

Besides, drone already widely used in world of industries and many sectors such as oil and gas sector. As in website [27] stated Lloyd's enrollment has issued another guide that bolsters the business in the use of age flying machine innovation and a sheltered and viable non-pilot flying machine framework that can altogether expand efficiency increases through decreasing danger exposures, overview time and investigation costs in seaward administrations, foundation marine and land.

VI. Applications of Drones

Applications of drones have been on a boom in the last couple of years – finding new strongholds from place to place and time to time. They are increasingly playing a salient role in our day-to-day life by creating new possibilities in all sorts of area. Among these, major areas include precision agriculture, forestry [28] (Figure 7), construction and survey, disaster (Figure 8) and humanitarian relief, anti-poaching, security and surveillance and education. By using drones having multi-spectral cameras, plant growers are able to derive environmental indicators such as Normalized difference vegetation index (NDVI) for assessing plant health [20]. Recently drones have been used for planting trees as well, where the tree planting pace was found to be 10 times faster than that of human labor; this in a way allows us to save time along with offer us an alternative to fight deforestation briskly [29].

Figure 7. Forestry purpose [14][22][28]

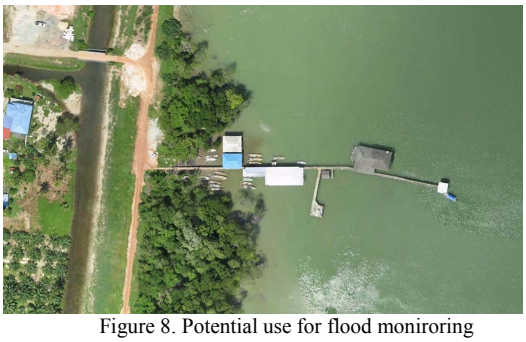

Figure 8. Potential use for flood monironing

The applicability of drones in events of natural disaster crisis has been evaluated by [3] and [15] proclaimed the potential of drones for safety and security verification tasks. Areas of mining and construction too have found applications of drones very useful, mainly as in this case the safety of their employee is not compromised [7]. Drones have been used to advance the sustainable development goals (SDG) in a variety of creative ways for example in urban planning and management where most of the operations revolves around aerial mapping, survey and modeling features made possible using drones and software technologies. Drones have been modified to acquire LiDAR and Synthetic Aperture Radar (SAR) data as well, thereby pushing boundaries of remote sensing research [25]. [30] developed a low-cost Unmanned Aerial Vehicle-Light Detecting and Ranging (UAV-LiDAR) system to produce 3D point clouds and reported elevated spatial accuracy while performing forest inventory operations.

Another study, which was led by [24] of a UAV-LiDAR system with Structure from Motion (SfM) photogrammetry and reported that UAV-LiDAR offer advantages over SfM photogrammetry in terms of surface elevation and vegetation height estimations. Drone technology is constantly evolving and undergoing groundbreaking progressive improvement and have become an indispensable component to the functioning of various businesses and governmental level organizations [21]. As they are piercing through areas where certain industries were either stagnant or lagging behind, their applications are expected to become ten-folds in the coming decades.

VII. MALAYSIA DRONES POLICIES, RULES, REGULATIONS AND LIMITATIONS

The legal exercise of drone in Malaysia in Malaysian Airspace stated that there are two categories of drones/UAV comprises of civil aircraft and state aircraft. Drones in Malaysia falls under "Malaysia Aircraft" category which means it must fulfill the operational standards as the manned aircraft – to not cause or create any harm towards persons or property in the air or on the ground [6]. Malaysia has enforced operating permit and private pilot's license is required for flying commercial drones (>20 kg). Operators must receive authorization from Department of Civil Aviation and The Department of Survey and Mapping Malaysia before flying [8]. At times, even carrying certain types of drones – for example the ones having multi-sensors – are viewed as a potential threat to nation's security, thereby limiting the applicability of aerial mapping – especially for a precision agriculture stand point of view. Interestingly, the rules designated for recreational or experimental purpose drones are mostly different from those listed for commercial purpose drones; flying drones for hobby usually entails very few regulations, and in most cases does not require you to have a pilot license. Irrespective of the intended purpose and nation under consideration, few legal conditions – such as not flying near airport or government monuments or parliament houses (zoning), always maintaining a line of sight, constraints on flying heights, and getting pilot license and certifications - are ubiquitous, as otherwise the safety, security and/or privacy factors of the people would be put at risk. There are pros and cons came along with this technology. But with the best designed protocols and zoning for its applications will give more positive impacts and open to new findings for various applications in the field.

VIII. CONCLUSION

Drones are highly adaptable technology as they are constantly changing in an innovative way to provide greater utility. The evolution of drones in various fields of study have attracted researchers, drone enthusiasts, urban planners and everyone in between to dig its potential. However, the present form of drone application in Malaysia is still not fully utilized and being explored; but it is enough to acknowledge that the roles of drones/UAVs will go beyond the airborne and satellite platform in the future. The implementation of drones and its technical aspect development will be expected to take a number of years to fully develop and expand. Future research such as on 3D modelling, buildings detection and agriculture in Malaysia, is envisioned, and should drive advancements in other ASEAN countries as well. Therefore, the development of appropriate sensors and their specifications to suit with concurrent environmental issues by adhering and adopting the protocols and policies is required and should be highlighted for future decision making purposes. The wide range of applications evidence the great potential of this tool, but at the same time, the variety of methodologies adopted testifies that there is still need for parallel efforts.

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