The Advantage by Using Low-Altitude UAV for Sustainable Urban Development Control

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Abstract. The city will always grow and develop along with the increasing number of population which affect more demands of building space in the city. Those requirements of development can be done by the government, the private sector or by the individual sectors, but it needs to follow the ordinance which is set in the city plan to avoid the adverse negative impact in the future. The problems are if the monitored development in the city is like Jakarta - Indonesia, which have an area of 661 square kilometres compared with the limitation of government employee source. Therefore, it is important to advancing the new tools to monitor the development of the city, due to the large development area and the limitation of source. This research explores the using of Low-altitude UAV (Unmanned Aerial Vehicle) combined with photogrammetry techniques – a new rapidly developing technology – to collect as-built building development information in real time, cost-effective and efficient manner. The result of this research explores the possibility of using the UAV in sustainable urban development control and it can detect the anomalies of the development.

Keywords: UAV, photogrammetry, sustainable urban development control.

1. Introduction
The city will always grow and develop along with the increasing number of population which affect the demands of building space in the city. Those requirements of development can be done by the government, the private sector or by the individual sectors, according to the city plan in the future to avoid the negative impact of development. The city planning guidelines are arranged not just for today condition but for the future, so it must think about the sustainability of the city in the future condition. This future condition is stated in Detail Spatial Planning Ordinance. In Spatial Planning Ordinance, there is regulation in the whole part in the city that should fulfill by the development actors: maximum density, maximum ground area, green area, the height of the building, and so on.

But sometimes, if the city is like Jakarta - Indonesia, which has an area of 661 square kilometers, the monitoring of the development is a big issue, especially when the development occurring very fast and limited manpower to monitor the development. Sometimes, the development is different with the original plans. The models of this development will cause the negative impact on the area, and the city will not sustain for the future. For the examples, the development of the high-density residential area which needs to balance with the transportation facilities development in surrounding area [1]. In other hands, the high-density residential area should balance with the provision of social and cultural facilities, the educational facilities, the health facilities and the commercial facilities and so on [2,3].
Without of these balance development, it will generate the negative impact of the city: slum area, low quality of environmental health, impact on occupant psychological factor, etc. Therefore, it needs the new approach to monitor the rapid development of the city with limited manpower source.

In the other hand, the use of Low-altitude UAV (Unmanned Aerial Vehicle) combined with photogrammetry techniques, is a new rapidly developing technology for decades. This technology can collect the as-built information in a cost-effective and efficient manner [4]. According to the UVS (Unmanned Vehicle System) international definition, an Unmanned Aerial Vehicle (UAV) is a generic aircraft design to operate with no human pilot onboard. This UAV used for collecting the base image of the urban condition (buildings, Site, Landscape, etc.) and put it into the photogrammetry program to build the mesh of the object. The image from the UAV should have specific information to build the object in the computational model, which is latitude, longitude, and altitude where the image was taken. Photogrammetry techniques allow generating the model of the object rapidly [5;6].

![Figure 1](image.png)

**Figure 1.** UAV position in order to build 3D model in scene dimension and complexity [7]

Therefore, this research conducts to exploring the use of UAV to monitor the development of the city to reduce the negative impact and make urban development more sustainable.

2. Low-Altitude Unmanned Aerial Vehicles and Photogrammetry

To conduct low-altitude UAV oblique photogrammetry, flight preparation, route planning and camera calibration should be carried out in advance. A multi-rotor UAV is employed to capture the ortho and oblique images during the flight. When images are acquired, rectification is conducted using optimized internal camera parameters. An image matching procedure is carried out to provide adequate 2D key points for aerial triangulation photogrammetry processing. Then, point cloud densification is conducted for mesh generation, and texture rendering is employed to finally achieve the comprehensive 3D model [8].
2.1. **Image Data Retrieval.**
Capturing image data with UAV tools requires some initial preparation, calibration of the tool and also ensures the Global Positioning System works perfectly, because all the photos to be used in the next process must have the Latitude, Longitude and Altitude attributes. After that, use the help of Point of Interest application where the UAV will rotate with a point that has been determined as its center, which will assist in collecting the image of the object. Shooting is required to be solid enough so that it can be detected in common in the photogrammetry process.

![Figure 2. Image Data Retrieval by Using UAV](image)

2.2. **Photogrammetry**
The mission (flight and data acquisition) is normally planned in the lab with dedicated software, starting from the knowledge of the area of interest (AOI), the required Ground Sample Distance (GSD) or footprint and the intrinsic parameters of the onboard digital camera. UAV collection photo will determine the computational 3D models, therefore it required closed interval photo with 70% - 80% overlapping images and the quality of the image will affect the model as well.

![Figure 3. The Photogrammetry Model Processing](image)

3. **Method and Experimental Design**
Methods in this research by using Unmanned Aerial Vehicle issued by the company DJI called Dji Mavic Pro™ for Image Collecting and Autodesk Recap™ and Drone Deploy™ as a tool for image processing into a computational mesh. From the Computational mesh, it can be determined the
dimensions of the object of the building which compared to the spatial plan of local government, to
determine whether the development accordance with the spatial plan or not.

4. Experiment Results and Discussion
The Selection of UAV method is due to the existence of some differences resulting from Satellite
Imagery that cannot be used for photogrammetry process and determine the dimension of the object.
The difference is that, in terms of image sharpness, the image produced with the latest technology can
produce a sharper image, which in the next process will make object modeling more accurate. Another
difference is because the satellite position is far enough, so the resulting image is not perpendicular to
the work field that complicates the process of photogrammetry.

![Comparison between the High Satellite Image (left) and the Low-Altitude UAV (Right)](image)

4.1. Image Data Collection
Image collection data by using UAV Point of Interest. In this mode, the UAV is set to one point of
interest and rotating it in some of the radius. In this research, the altitude of UAV is set 100 meters and
radius of 100 meters. The image that collects in this research is 27 images.

![Image Data Collections from UAV](image)
4.2. Photogrammetry Process
In the photogrammetry process, the photo was uploaded to the cloud program and rendered. There is some difference between the Autodesk Recap application with the Drone Deploy. The 3-dimensional model produced from Autodesk Recap looks more refined in terms of rendering the building, while the models from the drone deploy only form the outline building mass.

![Computational 3 Dimension models from Autodesk Recap (left) and Drone Deploy (Right)](image)

**Figure 6.** Computational 3 Dimension models from Autodesk Recap (left) and Drone Deploy (Right)

4.3. Dimensioning and Calculating
From the 3dimension modelling, we can measure the dimension of the building and calculate the overall area of development. The overall development area can be compared to the City Spatial Ordinance to decide whether the development align with city plan or doesn’t.

![Measuring and Calculating the Building Development Area](image)

**Figure 7.** Measuring and Calculating the Building Development Area

In result of this research, the area of the development is about 2800 square meters and the building area is about 1000 square meters. The building has eight storey heights, so the total of development
area is 8000 square meters. This development data compared with the city ordinance in the area which set in Spatial Planning Ordinance Jakarta 2030, in Kembangan Region, West Jakarta.

Figure 8. The City Ordinance: Zoning Regulation (Above) and Development Regulation (Below)

The city ordinance regulates the development of the ground area is 50% of the site area – around 1400 square meters. The maximum development is maximum 16 storey heights. The maximum density is 3.5 times from the site area – around 9800 square meters for the total development area. The green area is set 25% of total the site – around 700 square meters minimums. The basement area is maximum 60% of the site area – around 1680 square meters. By comparing the calculation between the regulation and the real condition, it can be defined whether the development follows the city ordinance or not.

Table 1. Comparison between On-Site Measurement and City Ordinance

| Aspect       | On-Site Measurement | City Ordinance                  | Mark    |
|--------------|---------------------|---------------------------------|---------|
| Ground Area  | 1000 square meters  | Maximum of 1400 square meters   | Suitable|
| Maximum Heights | 8 Storeys        | Maximum of 16 Storeys           | Suitable|
| Floor Area   | 8000 square meters  | Maximum of 9800 square meters   | Suitable|
| Green Area   | Cannot be defined  | Minimum of 700 square meters    | -       |
| Basement Area| Cannot be defined  | Maximum of 1680 square meters   | -       |
5. Conclusion
The main advantage of using this UAV is that the accuracy is quite high along with the development of technology. In addition, this study also re-proved the Use of Low-altitude UAVs (Unmanned Aerial Vehicle) combined with photogrammetry techniques, as well as the collected information in a cost-effective and efficient manner [4]. Photogrammetry usage also depends on the photo density taken and the sharpness of the photo which will support the accuracy of computational models.

From the computational models built, we can determine the dimensions of both the length, width, and height (forecast of the number of floors) of a building so that it can be determined the total area of the buildings. By obtaining the total area of land and the total area constructed it can be estimated whether the building accordance the city zoning regulations or not. The usage of UAV can be the solution for control and monitor the rapid development in the city with limited resources.

Even though the usage of UAV can be very helpful but not every building can be calculated precisely. Some of the cases, the calculation does not reflect the real condition. In this research, the UAV cannot predict the area in the basement, even though in some condition the basement area is calculated in overall building area. The UAV is also cannot calculate the green area, which usually develops in the last stage of the development phase. The other condition, if the building that has void inside is cannot be predicted precisely because the UAV only calculate the outline mesh of the building, which does not predict the interior of the building.

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