IDENTIFICATION OF BUILDING DENSITY USING UAV MAPPING METHOD IN CENTRAL KALIMANTAN REGIONAL SETTLEMENT INFRASTRUCTURE

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ABSTRACT

The increased population density in urban areas has caused buildings density that need to be identified to find out the development and growth of an area that requires clear planning. This research is using aerial mapping method to produce orthophoto area of Garuda - Tingang street. The on-screen digitation was carried out based on the aerial photo data result to determine the number of buildings and the total area of the building. Then, the classification of land cover vegetation and built up land were carried out. From the data processing, 1641 buildings were found on Garuda – Tingang street. The total area of the building is 35,478 hectares. Based on the Decree of the Minister of Public Works No.378/KPTS/1987, Appendix No.22 has a low building density level. The results of the classification state that the vegetation class has a total percentage of 42,969% and the built-up land class has the percentage of 57.031%.

Keyword: Building density, classification, building, aerial photography, aerial mapping

Introduction

Palangkaraya is one of the cities that continues to undergo urban physical development. These developments are meant to overcome various development problems that should be responded quickly and accurately, such as the provision of regional infrastructure, penetrate isolated areas, basic services in the fields of education and health, management of the mining sector, improving the quality of poverty alleviation programs, providing employment opportunities, utilization of idle land/peat, increased sense of security and other development problems due increasing population. The population of Palangkaraya in 2016 was 267,757 people which consist of 137,057 male and 130,700 female residents. This number has increased from 2015 with a population growth rate of 3.04%. This increased population has affected the increased population density in Palangkaraya, which is 94 people/km2.

The increase in population density have caused increased buildings density that need to be identified. Identification of building density is carried out to see the development and growth of an area that requires good and thorough planning that is based on the existence of clear, complete, and actual land information. The great land use management in a certain area ranked first in the problem of regional development planning. Therefore, the existence of a map about the level of building density which able to provide information on the division of territory in a certain area is necessary.

In this research, the author uses aerial photography technology to map detailed scales and also to identify using supervised classification in the area of Garuda – Tingang street, Palangka Village, Jekan Raya District, Palangka Raya City. The ground control point uses sample points on google earth pro due to unavailability of coordinate acquisition tool using GPS Geodetic. Aerial photography is one of the quickest and easiest mapping methods. The results of the mapping using aerial photography provide a real picture in the field with easily-obtained aerial photo data and the validity that can be trusted. Thus, mapping using aerial photos can be used to find out how the existing buildings in Palangka Raya have been developed, especially to determine the density level of existing buildings around the area of Garuda – Tingang street, Palangka Village, Jekan Raya District, Palangka Raya City.

Methodology

Survey Mapping

Survey mapping is a science, art and technology to determine the relative position of a point above or below the earth's surface. In more general sense, survey (geomatic) can be defined as; a scientific discipline that includes all methods for measuring and gathering information about the physical earth and the environment, processing information, and disseminating various products which made for various needs (Syarifudin, 2019).

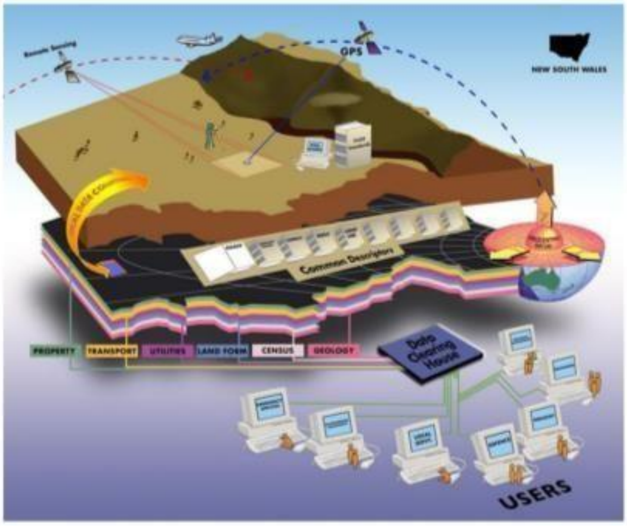

Figure 1. Scope of Survey Measurement

Currently, the role of measuring and monitoring our environment is becoming important due to increasing human population, higher price of a plot of land, diminishing natural resources, and human activities that cause the declined quality of land, water and air. In such modern times nowadays, the surveyors are able to measure, monitor the earth and its natural resources globally with the help of computers and satellite technology. Plenty information are available for various problem, such as planning decisions and policy formulation in various land uses, resource development, and environmental conservation applications (Syarifudin, 2019).

With the increasing need for survey and mapping services, the International Association of Surveyors (IFS) has adopted the following definition, "Surveyor is a professional person with educational qualifications and technical expertise to carry out one or more activities as follows (Syarifudin 2019):

- To determine, measure and identify the land-ground level, three-dimensional objects, the point on the field, and the trajectory.
- To collect and interpret surface conditions, geographic information and economic information.
- To plan the efficient administration and management of land, sea and entire structures based on the obtained information.
- To carry out urban and rural development and land management.
- To conduct research and development.

Air Mapping Survey

Various types of surveys are so specialized that a person skilled in a particular discipline may have little connection with others. Someone with a career in surveying and mapping, however, must be knowledgeable at every stage, as all are closely related in modern practice. Some important classifications are briefly described here (Syarifudin, 2019).

Aerial Photography

Technological developments, especially in remote sensing are growing rapidly. Thus, learning media should be adapted toward increasingly rapid technological developments and can be used as an effective learning media (Anreza, 2016). Unmanned Aerial Vehicle technology (UAV) is the rapidly-developed technology in the field of remote sensing by obtaining data in the form of photos (photogrammetry) for mapping purposes (Haala, Cramer, Weimer, & Trittler, 2011).

Photogrammetry technology continues to undergo developments from time to time, including the usage of drones (Dynamic Remotely Operated Navigation Equipment). Drones are one of the UAV (Unmanned Aerial Vehicle) vehicles which currently used oftenly as an alternative for spatial data acquisition to replace the relatively expensive manned aircraft.

However, for "near real time" information required in the decision-making process, the data should be obtained closely toward the current conditions so that the result could be in accordance with the facts on the ground. The competencies to be achieved in remote sensing are analyzing and interpreting images from aerial photography, maps-making, identify the accuracy of the image, and for other various studies.

Based on the competencies that needs to be achieved, verbally process is not enough, but it requires near-time aerial photography media that able to visualize the process of designing, capturing and processing aerial photo images in accordance with remote sensing material so that students can easily understand them and can be applied in the learning process. (Wolf, P.R. et al, 2014)

Aerial photography is produced by shooting an area based on a certain height using metric and non-metric cameras. Aerial photos are generally acquired using a UAV vehicle. Aerial photos classified by camera orientation includes:

1. **Vertical Aerial Photograph**
   Vertical aerial photographs are created using a special photogrammetric camera mounted on the aircraft with a straight-down view. When taking a photo, the airplane would flies over a certain area in a tortuous manner so that the entire area is covered by overlapping photo. Vertical photography is the most common type of aerial photography for remote sensing and aerial survey purposes because it is scalable and able to measure objects and distances. Vertical photos can provide information about the height of an object on the earth's surface (Wolf, P.R. et al, 2014).
2. **Oblique Aerial Photograph**
   Oblique Aerial Photograph is taken at an angle between ± 20º degrees to ± 60º from the nadir point. Oblique aerial photographs are generally not used for mapping activities because the scale is inconsistent in the image result. However, oblique photos provide an easier picture of a location to be interpreted. Oblique aerial photography is divided into 2, including High Oblique (Surface and Horizon visible) and Low Oblique (shows only the surface, but the horizon is not visible) (Septiani, Subiyanto dan Ammarohman 2020).

Camera calibration

Camera calibration is required to determine precise and accurate values for a number of constants. This constant, which is commonly referred as interior orientation element, is needed to obtain an accurate spatial information from the photograph. In general, camera calibration methods can be classified into one of three basic categories: laboratory methods, field methods, and stellar methods. In one particular laboratory calibration method, the general approach consists of photographing a series of targets whose relative positions are known accurately. Then, the interior orientation elements are determined by conducting precise measurements of the target image and comparing the actual image location with the position where it should be, if the camera produced a perfect perspective view (Wolf, P.R. et al, 2014).

The elements of interior orientation that can be defined through camera calibration are as follows (Wolf, P.R. et al, 2014):

1. **Calibrated focal length (CFL),** is the focal length that produces the average distribution of lens distortion as a whole.
2. **Symmetric radial lens distortion, Symmetric radial lens distortion,** is a component of symmetrical distortion that occurs along the radial line from the principal point. Although they are negligible in number, theoretically this type of distortion is always present even if the lens system is perfectly engineered based on its design specifications.
3. **Decentering lens distortion,** is the remaining lens distortion after the compensation of radially symmetrical lens distortion. There are 2 components of this distortion, namely the radial and tangential asymmetric lens distortion components. This distortion is caused by imperfections in the fabrication and alignment of the lens system.
4. **Principal point location,** is the principal point coordinates which given with respect to the x and y coordinates of the fiduciary sign.
5. **Fiducial mark coordinates,** are the x and y coordinates of the fiduciary sign that provide a two-dimensional position reference for the main point as well as the image on the photo. Digital cameras do not have a fiduciary mark, so this value is not determined from their calibration.

Aerial Photo Interpretation

Photo interpretation can be formulated as "the act of examining photographic images for the purpose of identifying objects and assessing their significance" (Colwell, 1997). The principles of image interpretation have been developed empirically over 150 years. The basic of these principles are elements of image interpretation including location, size, shape, reflection, tone/color, texture, pattern, height/depth and site/situation/association. These elements are routinely used when interpreting an aerial photograph or analyzing photographic images. A trained draftsman uses many elements during his analysis without thinking about them. However, perhaps beginner draftsman does not need to force themselves to consciously evaluate an unknown object with respect to its elements, but also needs to analyze its main features in relation to other objects or phenomena in a photograph or drawing. The following are the elements of interpretation of aerial photo images (Colwell, 1997):

- **Hue and color**

  Hues (tone/color tone/grey tone) is the level of darkness or brightness level of objects in the image. The hue in a panchromatic photo is an attribute for objects that interact with all of the visible spectrum that often referred as white light, which is a spectrum within a wavelength of (0.4 – 0.7) µm. In terms of remote sensing, such spectrum is called a broad spectrum, therefore the hue is a shift from black to white or vice versa. Meanwhile, color is an object that is visible to the eye using a narrow spectrum, which is narrower than the visible spectrum. For example, an object will appear as blue, green, or red if it reflects the spectrum within the wavelengths of (0.4 – 0.5) µm, (0.5 – 0.6) µm, or (0.6 – 0.7) µm. On the contrary, an object absorbs blue light because it will reflect as green and red. As a result, the object will appear in yellow color (Jensen, 2000).

  In contrast to hues which only present the level of darkness, color shows a more diverse level of darkness. Has a level of darkness in blue, green, red, yellow, orange, and other colors. Although it does not indicate the matter of measurement, it does state that the human eye can distinguish 200 hues and 20,000 colors (Jensen, 2000).

  Hue and color are called basic elements. This shows how important hue and color are in object recognition. Each object appears first in the image based on its hue or color. After the same hue or color is grouped and given a border to separate it from different hues or colors, then the shape, texture, pattern, size and shadow can be seen. That's why hue and color are called basic elements (Jensen, 2000).

- **Shape**

  Shape is a qualitative variable that describes the configuration or framework of an object. Shape is a clear attribute so that many objects can be recognized based on their appearance alone. Shapes, sizes, and textures in Figures are grouped as secondary hue spatial arrangements in terms of complexity. It derived from hue which is the basic element and includes primary in terms of complexity. The hue can be observed very easily. Therefore, shapes, sizes, and textures that can be directly recognized based on color and secondary classified based on its complexity (Jensen, 2000).

- **Size**

  Size is an object attribute in the form of distance, area, height, slope, and volume. Since the size of the object in the image is a function of scale, thus the image interpretation which using size as an element should always based on its scale (Jensen, 2000).

- **Texture**

  Texture is the frequency of changed hue in an image or the repetition of the hue of a collection of objects that are too small to be distinguished individually. Texture is often expressed as rough, smooth, and mottled (Jensen, 2000).

- **Pattern**

  Patterns, heights, and shadows on the map are grouped into tertiary levels of complexity. The level of complexity is one level higher than the level of complexity of shape, size, and texture as an element of image interpretation. The spatial pattern or arrangement is a defining feature for many human-made objects and for some natural objects (Jensen, 2000).

- **Shadow**

  Shadows are hiding details or objects that are in dark areas. Objects or symptoms located in the shadow area are usually not visible at all or sometimes appear vaguely. However, shadows are often considered as an important recognition key for some objects that are more visible than their shadows (Jensen, 2000).

- **Site**

  The location of an object toward another objects surrounding it (Estes and Simonett, 1975). In this sense, Monkhouse (1974) calls it as a situation, such as the location of the city (physical) to the city area (administrative), or the location of a building relative to the land area. The situation is also called a geographic site, which is defined as the position or location of an area or region relative to its surroundings. For example, the location of the climate has a lot of influence on image interpretation as geomorphology (Zuidan, 1979).

  The location of the object against the landscape, such as the site of an object in a swamp, on a dry hilltop, along a river bank, and so on. This kind of site by van Zuidam (1979) is described as a topographical site, namely the location of an object or place in relation to the surrounding area (Jensen, 2000).

- **Association**
  Association can be interpreted as a relationship between one object with another object. Therefore, the appearance of an object in the image is often a clue to the presence of another object (Jensen, 2000).

Classification of satellite image

Classification is a process of identifying the whole pixels of an image with the same spectral recognition. The main function of classification is to perform the separation of a complex population into groups called classes, which considered as homogeneous units for a particular purpose (Malingreau and Cristiani, 1982). Wiradisastra (1982) also explains that land cover classification is the division of an area into smaller and homogeneous units so that the description is simpler.

In general, there are two classification methods, which are supervised classification and unsupervised classification. Supervised classification is a classification in which the analyst has a number of pixels that represent each of the desired classes or categories. These identifying pixels are often referred as training data, while the activities to identify them in the image and then used to create class signatures are called training areas. The class signature will vary depending on the method used. For the parallelepiped method, the class signature is the upper and lower threshold of the DN, while the minimum distance method is the mean vector of the training area for each class. In the maximum likelihood method, the class signature is the average vector and the variance-covariance matrix of each class (Jaya, 2002).

In contrast to the guided classification, the unsupervised classification is automatically carried out with the computer by searching for groups based on the spectral group of the pixels concerned (clusters). Then the grouping of spectral that has been formed are marked as a certain object by the analyst (Danoedoro, 1996).

- Maximum Likelihood Clasification (MLC)
  This method is the most widely used guided classification method for Remote Sensing data. Before doing the classification, the user determines the training area that is used to see the statistical characteristics of each class candidate. The MLC classification is based on the probability density estimation for each land cover/use. The probability calculation here makes it possible to find a pixel of class i in the vector X defined by the equation as follows (Danoedoro, 1996):

  $$P\ (Ci|x) = P\ (x|Ci) * P\ (Ci)/P(x)$$

  Where:

  P(i|X) = The conditional probability of class i, which calculated based on the that vector X which was assigned a priori/unconditionally. This probability is also called likelihood.

  P(X|i) = The conditional probability of the vector X, which calculated based on the class that has been assigned a priori.

  P(i) = The probability of class i appeared in an image

  P(X) = Probability of vector X

  Lillesand and Kiefer (1994) stated that MLC classification evaluates the variance and co-variance of category spectral response patterns quantitatively upon classifying unknown pixels. Thus, to conduct this, an assumption that the distribution is normal was used.

Classification accuracy test

Analysis using remote sensing methods provides many advantages, including being able to reach mapping locations that are difficult to access, but on the other hand it is also necessary to check directly in the field to prove the results of the interpretation that has been carried out. UAV vehicle, for example, provides many advantages, but the results of aerial photo data that have been obtained from shooting also need to be tested whether the conditions recorded in aerial photographs are real conditions in the field. One of the tests that can be conducted is the classification accuracy test (Ibrahim,2014).

The classification accuracy test uses the confusion matrix analysis method. Confusion matrix is a technique to summarize the performance of classification algorithms. Classification accuracy alone can be misleading if the classification object has an unequal number of observations in each class or if it has more than two classes in its data set. Calculating the confusion matrix is able to give a better idea of the correct classification model and what types of errors it makes. The confusion matrix is suitable for traditional classification methods where it is assumed that the pixels at the reference location can be assigned to a single class, and an accuracy measure based on the proportion of the correctly classified area is then calculated from the number of correctly classified pixels. However, it has been suggested that this assumption is not suitable to represent the real situation as several classes may occur in the instantaneous field of view of the satellite sensor represented by a single pixel (Ibrahim, 2014).

Building density

Building density can be seen from the comparison of the number of objects with the existing area. The density of buildings occurs due to intensive development of buildings yet with limited land availability. The process of developing building density horizontally has two types, namely centrifugal and centripetal development. The first type is centrifugal, which is the development of the density of buildings that lead out of the city center to the suburbs. The second type is centipetal development where urban buildings develop within the city by using the existing vacant land (Puspitasari, 2016).

a. Building Block Mapping Unit

The building block mapping unit is a land cover in the form of building blocks. However, they are limited by differences in spectral characteristics in an image, and/or limited by existing natural features such as rivers, roads, and ditches (Suharyadi, 2011). Determining the unit of mapping of building blocks is quite difficult due to different spectral characteristics between objects (built-up land and vacant land). There is a need for special transformation assistance to classify land use. There are two (2) types of land use classification, namely building land use and non-building land use. The use of building land consists of settlements, service areas, sports buildings, industry, offices, education, health and others. Non-building land uses consist of sports fields, rice fields, dry fields, city parks, gardens, roads and vacant land (Suharyadi,2011).

b. Building Coverage Ratio (BCR)

One of the methods in determining the built and unbuilt areas is using Building Coverage Ratio (BCR) to find out the building densification value. The BCR calculation process can be done using equation 1.

$$BCR = (n / x) * 100\% \quad (1)$$

Explanation:

BCR = Building coverage ratio (density)

x = the total area of the roof cover of the mapping unit

n = mapping unit area (building block)

The building density obtained with BCR method is classified to make it easier to analyze (Melati 2020). Some of the density class is presented at the following table

Table 1. Building Coverage Ratio (Nugraha,2014)

No	Density Class	Density Value	Explanation
1	I	>70%	Solid
2	II	50-70%	Medium
3	III	10-50%	Sparse
4	IV	<10%	Not a Building

Broadly speaking, the methodology of implementing the Practical Work is described as follows:

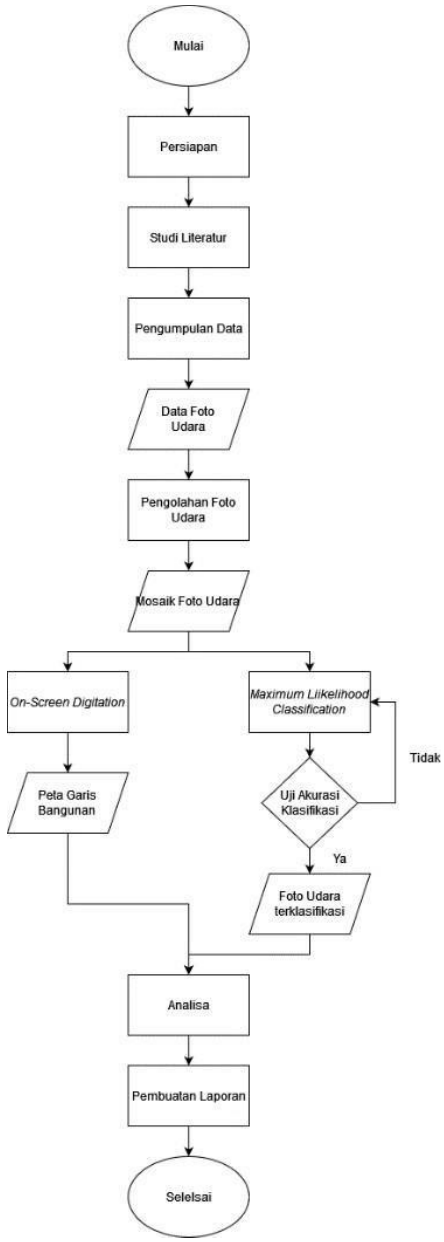

Figure 2. Flow Diagram of Work Method

Explanation of the work methodology flow chart:

a. Preparation
Preparing to make bathymetric maps such as determining the frame of mind, planning the data needed, the methods used and the objectives to be achieved.

b. Literary Studies
Conducting research for the required theories that to complete and achieve the goals that have been determined.

c. Data collection
The required data collection is aerial photo data of Garuda street and area boundaries that have been determined in the shapefile form.

d. Aerial Photo Data Processing
Aerial photo data processing is as follows:

- Align photo process, which is aligning aerial photos. At this stage, the camera position and orientation will be found for each angle and build a point cloud models.
- Building dense cloud process, which is the process of calculating depth information for each camera that produces single dense point cloud. This dense cloud can be used as the basis for advanced processing.
- Build mesh process. After reconstructing the dense point cloud model, a polygonal mesh model can be generated based on the dense cloud data that has been conducted.

e. Aerial photo mosaic
Aerial photo mosaic is the process of combining various aerial photos in such a way that the details between one aerial photo and another are matched. The result of the aerial photo mosaic is an orthophoto of the entire aerial photo.

f. On-Screen Digitation
On-Screen Digitation is the process of converting geospatial data or information from hardcopy maps or scanned images. Digitation process was done by capturing coordinates in point, line or polygon format.

g. The Line Map of the Building
Line Map is vector data that shows the appearance of the earth's surface which is manifested in the form of points, lines and polygons. The Building Line Map is generated through the on-screen digitation process. In the line map there are several elements of the earth's appearance which are stated in the legend. On the line map There is information on the line map about map title, directions, legend, scale, symbol, inset and outline.

h. Maximum likelihood classification
Maximum likelihood classification is a guided classification which assumes that the statistics for each class in each band are normally distributed and calculates the probability that a particular pixel belongs to a particular class. All pixels are classified unless the user select a probability threshold. Each pixel is assigned to the class that has the highest probability (that is, the maximum likelihood). If the highest probability is less than the threshold the user specified, the pixel remains unclassified.

i. Classification Accuracy Test
This classification uses the confusion matrix method. The confusion matrix is used as a quantitative method to identify the accuracy of image classification. The calculation of a confusion matrix was done by omission and commission errors and derives the kappa index of agreement and overall accuracy between the classified map and the reference data.
The confusion matrix is able to show where the classification is really wrong and where the classification is right. There is a combination of the actual value with the predicted value in the confusion matrix. The accuracy test in this research was carried out to compare the ground truth of the polygon sample between the vegetation class and the built-up land class.
Then, the overall accuracy of the classification can be seen which states the accuracy of the classification that has been conducted.

j. Classified aerial photos
The classified aerial photos will show the two desired classes, namely the vegetation class and the built up land class. This classified aerial photograph will be considered correct if it has passed the classification accuracy test and is declared overall accuracy to have a good percentage value. The classification information generated able to assist in decisions making and regional planning development in the future.

k. Analysis
After the classification, accuracy test classification and on-screen digitation have been carried out, the next step is to conduct an analysis related to the density of buildings and the availability of built up land and vegetation in the area of Garuda – Tingang street. The density of the building will be seen based on the comparison of the total area of the building to the total of the built area. Analysis of the availability of vegetation and built up land

can be identified through the results of the classification. If the accuracy test states the classification is good, it can be assumed that the value of the stated land area is a value that is close to the truth in the field.

I. Generating Report

After the entire process of data acquisition, data processing and data analysis is complete, a report on Job Training activities is carried out at the Central Kalimantan Regional Settlement Infrastructure Center.

Result and Discussion

Result

The orthophoto results from the garuda street was obtained from data processing. Through this orthophoto, building digitization and a classification is carried out between vegetation and built-up land based on aerial photos that have been taken.

Table 2. Georeferencing Accuracy Report with 5 GCP

Label	X error (cm)	Y error (cm)	Z error (cm)	Total (cm)	Image (pix)
GCP 1	15.4283	-6.07032	-2.27884	16.7354	13.370 (3)
GCP 2	11.1813	17.087	-2.11016	20.529	34.177 (2)
GCP 3	-14.097	-24.9113	-0.742883	28.6331	33.523 (2)
GCP 4	15.8663	1.71189	1.35351	16.0157	19.915 (2)
GCP 5	-28.2134	12.1071	5.63336	31.214	21.917 (3)
Total	**17.9417**	**14.825**	**2.95853**	**23.4614**	**24.756**

Table 3. Georeferencing Accuracy Report with 10 GCP

Label	X error (cm)	Y error (cm)	Z error (cm)	Total (cm)	Image (pix)
GCP 1	2.62385	-16.4139	-1.03566	16.6545	23.550 (2)
GCP 2	6.28017	-6.37092	0.592518	8.9655	6.823 (3)
GCP 3	-26.8551	-54.5632	2.27355	60.8565	65.154 (2)
GCP 4	17.937	-38.2281	-3.17832	42.3465	30.915 (3)
GCP 5	-41.9573	-21.7153	4.0363	47.4158	36.432 (3)
GCP 6	8.38896	9.70183	3.16295	13.21	22.640 (2)
GCP 7	31.9187	10.588	0.0810583	33.6291	32.760 (2)
GCP 8	11.6779	14.8171	-4.05962	19.2977	28.740 (2)
GCP 9	-33.0114	60.3721	-3.75725	68.9105	61.807 (3)
GCP 10	23.1423	41.7618	3.99224	47.912	53.513 (2)
Total	**23.8758**	**33.2185**	**2.9922**	**41.018**	**40.104**

Table 4. Georeferencing Accuracy Report with 15 GCP

Label	X error (cm)	Y error (cm)	Z error (cm)	Total (cm)	Image (pix)
GCP 1	5.02435	-4.37367	-1.41872	6.81071	16.936 (2)
GCP 2	11.7778	-5.2907	-1.7431	13.0287	11.533 (3)
GCP 3	-27.4081	-50.1459	1.72388	57.1733	61.149 (2)
GCP 4	26.5202	-28.9714	-5.24897	39.626	28.183 (3)
GCP 5	-39.4676	-14.8492	3.07869	42.2808	31.932 (3)
GCP 6	14.7667	27.005	3.93978	31.0298	37.280 (2)
GCP 7	28.1399	12.2755	-1.05606	30.719	29.988 (2)
GCP 8	19.3149	26.3654	-4.49946	32.9916	41.851 (2)
GCP 9	-14.1414	76.9303	1.87395	78.2417	83.468 (2)
GCP 10	26.6341	48.0859	3.82149	55.102	59.875 (2)
GCP 11	6.95116	-4.02045	2.03292	8.28344	8.709 (3)
GCP 12	-9.61018	31.168	-1.73322	32.662	17.574 (4)
GCP 13	-4.53914	-21.1118	0.0408917	21.5943	28.582 (2)
GCP 14	-8.54512	-32.7362	1.52018	33.8672	17.516 (4)
GCP 15	-35.2845	-60.3934	-0.204161	69.9457	73.999 (2)
Total	**21.5218**	**36.129**	**2.70237**	**42.1401**	**39.187**

Figure 2. Orthophoto of Garuda – Tingang Street

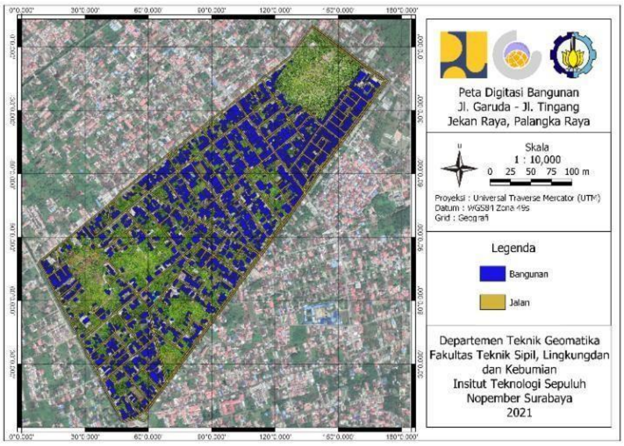

Figure 4. Digitation map of Garuda – Tingang street

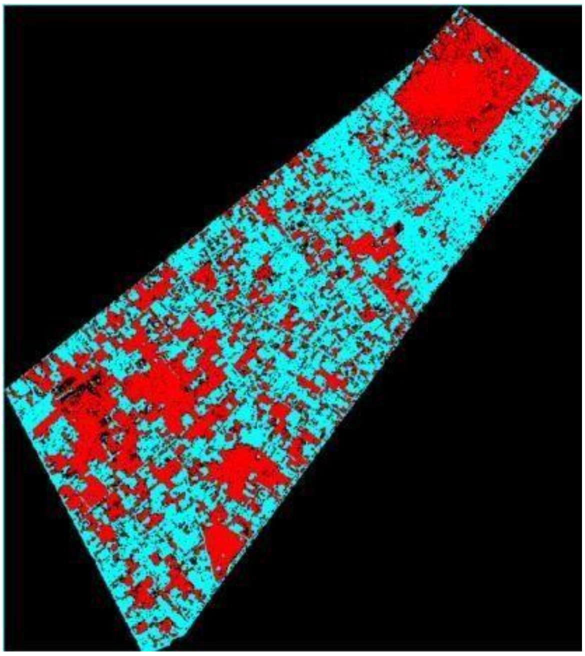

Figure 4. Land cover classification of Garuda – Tingang street

Table 5. Table Area of the Building

Building	Building Appearance	Area on Google Earth (m)	Area for GCP 5 (5)	Area for GCP 10 (m)	Area for GCP 15 (m)
1		225.181652	219.440962	220.274949	220.885774
2		371.594412	435.652721	432.701691	432.700833
3		207.683343	224.802539	223.040385	223.748848
4		256.299482	298.463335	297.344681	297.72545

Analysis

Georeferencing Accuracy Analysis

Georeferencing was conducted using 5 GCP, 10 GCP and 15 GCP. Based on the obtained accuracy value, it was found that more GCP does not always in accordance with the result of accuracy level. Based on the comparison conducted by the author, the accuracy result of 5 GCP points showed the best accuracy with 23,6314cm total error. Then, the accuracy result with 15 GCP points showed the worst result with 42,1401cm total error. The large error value happened due to the georeferencing process that used building points on Google Earth as GCP points. The google earth imagery used satellite imagery from various remote sensing satellites, which caused different image resolutions as well. Generally, The satellite imagery used has a spatial resolution of 15 meters in most countries in the world. However, there are satellite images that have better spatial resolution for some areas. Meanwhile, the drone's spatial resolution is at the level of 2.13026cm. Therefore, there must be quite a big difference in terms of taking GCP points due to big difference in resolution.

Area Comparative Analysis

Area comparative analysis is needed in order to see the impact of orthophoto resulting from the georeferencing process with various amounts of GCP. In this analysis, the author takes four examples of buildings which will be compared with the area and the difference obtained.

Based on the previous comparison, the comparison of the building area was carried out between orthophoto rectified aerial photographs with google earth images. The difference in building area on the 5 GCP rectified aerial photo orthophoto with google earth images resulting in a total difference of 117,600668 meters. This result is the largest difference between the comparison of building areas produced by orthophoto aerial photos with google earth images.

Table 6. Comparison of Building Area

Building	Building Appearance	GCP 5 Area Difference with Google Earth (m)	GCP 10 Area Difference with Google Earth (m)	GCP 15 Area Difference with Google Earth (m)	GCP 5 Area Difference with GCP 10 (m)	GCP 5 Area Difference with GCP 15 (m)	GCP 10 Area Difference with GCP 15 (m)
1		-5.74069	-4.906703	-4.295878	-0.833987	-1.444812	-0.610825
2		64.058309	61.107279	61.106421	2.95103	2.951888	0.000858
3		17.119196	15.357042	16.065505	1.762154	1.053691	-0.708463
4		42.163853	41.045199	41.425968	1.118654	0.737885	-0.380769

Then, the difference in the building area of ortophoto aerial photo rectified 10 GCP google earth image by producing a total difference of 112.602817 meters. This is the smallest difference result between the comparison of building area produced by orthophoto aerial photography and google earth imagery.

Then, the comparison of building area on the aerial photo from 5 GCP, 10 GCP and 15 GCP rectification results was conducted. Differences of building area on the ortophoto aerial photo.

The difference in building area between 10 GCP rectified orthophoto aerial photo and 15 GCP rectified aerial photo orthophoto is 1.699199 meters. This is the smallest difference between the comparison of building area as a result of aerial photography orthophoto. The difference in building area on the 5 GCP rectified orthophoto aerial photo and 10 GCP rectified aerial photo orthophoto is 4.997851 meters. This is the largest difference between the comparison of building area as a result of aerial photography orthophoto. This is caused by the digitization process of buildings that are not identical in point, so that there are some differences based on calculations using ArcGIS software.

Job Data Processing Analysis

Based on the on-screen digitation that has been conducted, it was found that the number of buildings on Garuda street are 1641 buildings with a total building area of 35,478 hectares. The information on the area and number of buildings is presented on the following map (figure 5).

Then the building density analysis on Garuda street was conducted with orthophoto media that has gone through a series of data processing. This analysis is carried out using the following formula (Nofrizal, A.Y. dan Nizam, K., 2018) :

$$Kb = \frac{Lb}{Llt} x\ 100\% \quad (2)$$

Kb is the density of the building, Lb is the area of the entire building and Llt is the area of the built-up area.

From the results of the analysis, it was found that the building density or building coverage ratio in the area on Garuda – Tingang street reached 57.272%.

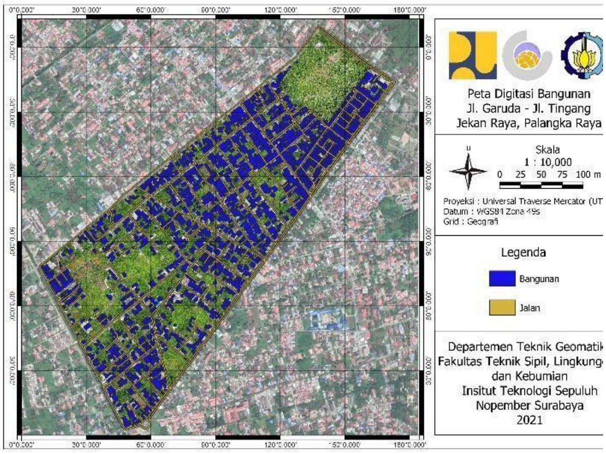

Figure 5. Result of Building Digitation

The classification that has been carried out is a guided classification with the maximum likelihood method. The maximum likelihood classification works by assuming that the statistics for each class in each band are normally distributed and calculating the probability that a certain pixel will fall into a certain class. Each pixel will be grouped based on the highest probability of similarity based on a predetermined region of interest. The results of this classification states that:

1. Vegetation class of 42.969% or widely stated as 46.672 hectares.
2. Built-up Land Class with a percentage of 57.031% or widely stated at 61,946 hectares.

The results of the classification test using the Confusion Matrix using Ground Truth ROIs tools shows that the classification results have an overall accuracy of 89.927% and a kappa coefficient of 0.7097. Based on this value, it can be stated that the classification carried out is acceptable due to the very good level of accuracy. The building density analysis is based on the Decree of the Minister of Public Works No. 378/KPTS/1987, Attachment No. 22 as follows:

Table 6. Classification of Building Density

Classification	Building Density
Very low	< 10 building/ha
Low	11 – 40 building/ha
Currently	41 – 60 building/ha
Tall	61 – 80 building/ha
Very high	> 81 building/ha

Source: The Decree of the Minister of Public Works No.378/KPTS/1987, Attachment No.22

The building density on Garuda – Tingang street is at the level of 25.5 Buildings/ha. Based on the previous classification, it can be concluded that the density of buildings on Garuda – Tingang street is at a low level. Moreover, more than 50% of the land on Garuda – Tingang street has been developed based on the classification that has been carried out. This indicates that the area of Garuda – Tingang street has been built quite well and the density level is medium or included as density class II which is 57.272%. There are 46,672 hectares of remained vegetated land which is potential for further development. The low level of building density can be maintained to avoid the Garuda - Tingang street to be a slum area due to increased density.

Conclusion

The conclusion of this research are as follows :

- A proper planning is needed to produce a good orthophoto model, according to the length of time for data acquisition and the desired accuracy. The order of processing aerial photo data are align photo, build dense cloud, build mesh and build orthomosaic.
- The greater number of Ground Control Points (GCP) does not always directly proportional toward the improved level of accuracy. Georferencing using 5 GCP points produces the best accuracy, namely at 23.6314cm total error and Georferencing using 15 GCP points produces the best accuracy, which is at 42.1401cm total error.
- The comparison of building area on google earth imagery and aerial photography orotofoto has an enough large difference due to the spatial resolution of the images that are far different.
- The difference comparison of building area between orotophoto aerial photographs that are verified with 5 GCP, 10 GCP and 15 GCP happened due to the placement of points at the time of digitizing that are less identical. Based on the on-screen digitation process, 1641 buildings were found on Garuda – Tingang street, with the total area of the building of 35,478 hectares.
- Building density on Garuda – Tingang street is at the level of 25.5 Buildings/ha, so the density of buildings on Garuda – Tingang street is at a low level based on the Decree of the Minister of Public Works No.378/KPTS/1987, Attachment No.22.

  The results of the maximum likelihood classification states that the vegetation class has a total percentage of 42,969% or is broadly stated as 46,672 hectares. The built-up Land Class has the percentage of 57.031% or widely stated as 61,946 hectares. Classification test using confusion matrix produces an overall accuracy of 89,927%. Thus, the classification results can be accepted.

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