International Journal of
INTELLIGENT SYSTEMS AND APPLICATIONS IN ENGINEERING

ISSN:2147-6799 www.ijisae.org Original Research Paper

IoT Drone Design for 3Dimensional Mapping of the Republic of Indonesia Defense University (RIDU) Campus in the Sentul, IPSC Area (The Center Of Indonesia Peace and Security Area)

Rudy Agus Gemilang Gultom[1], Nadiza Lediwara[2], Kristijarso[3], Suhartotok[4], Muhammad Hanifuddin[5], and Hilman Putra Sandrika[6]

Submitted: 27/10/2022 **Revised:** 30/11/2022 **Accepted:** 28/12/2022

Abstract: The development of technology in the 21st century is unstoppable. Indonesia must be able to gradually become independent in the field of defense technology. Presidential Decree No. 8 of 2021, one of the priority defense systems development programs is the development of Unmanned Combat Aircraft in which one of the types is drones. The purpose of this study is to design an IOT Drone for mapping the IPSC Sentul area as the center of peace and security in Indonesia. The results of the study in the form of a three-dimensional model of The Republic of Indonesia Defense University area that were further compiled could be used for several national interests as well as conducting visual analysis in the area. The development of this research has several updates, namely the object of mapping research in the IPSC Sentul Area, Bogor. The results of the research are that commercial drones are designed and added with an Internet of Things (IoT) system so that they can do 2-dimensional and 3-dimensional mapping. Mapping requires internet which can connect the drone with at least 3 GPS satellites. Once connected successfully, it is possible to create waypoints or mapping paths. The next result is a two-dimensional and three-dimensional mapping. The results of the two-dimensional mapping can be seen in Figure 5. The results are processed using agisoft metashape to produce a three-dimensional map. The three-dimensional map can be seen in Figure 6.

Keywords: *IOT Drone, IPSC Area, 2-dimensional and 3-dimensional Mapping*

1. Introduction

Threats that come from both within and outside the country require a strong defense force, especially the Indonesian National Armed Force as the spearhead of the Indonesian defense force, which requires the quality and quantity of personnel as well as the main tools of a reliable defense system (alutsista). The Indonesian National Armed Force as the main guard for the defense and security of the Indonesian territory requires a defense system that is able to overcome any threats that come from land, sea and air. In addition, it is necessary to master the defense equipment technology so that Indonesia can manufacture defense equipment independently so as to avoid the defense equipment embargo from other countries.

The Indonesian government through the Defense Industry Policy Committee is based on Law no. 16 of 2012 and Presidential Decree No. 8 of 2021 concerning the General Policy of State Defense 2020-2024 have diversified 7 priority defense systems development programs into 11 defense systems development priority programs, namely:

1. Submarine
2. Fighter Aircraft
3. Medium Tank
4. Rocket R-Han 122
5. Unmanned Aircraft
6. Cyber
7. Missile
8. CGI Radar
9. Propellant
10. Military Satellite
11. Sensing (Sensor)

One of the defense systems development programs that are of concern is the Unmanned Combat Aircraft / Drone. Unmanned Aircraft can generally be defined as a "device used for flight in the air without having an on-board pilot, programmed with an automatic pilot system and guided by a remote operator (Utama, 2021). PTTA/Drone. not only used as a deadly combat fleet, but can also be used for monitoring and mapping.In this research, drones will be designed for the benefit of 3-dimensional mapping located in the Sentul IPSC area.

[1,2,3,4,5,6] The Republic of Indonesia Defense University, West Java, Indonesia
** Corresponding Author Email: rudygultom67@gmail.com*

The Indonesia Peace and Security Center (IPSC) area is a government agency located in Bogor Regency. IPSC is a strategic area under the auspices of the Ministry of Defense, inaugurated on Monday, April 7, 2004 by the 6th President of the Republic of Indonesia Susilo Bambang Yudhoyono. IPSC is located in Tangkil Village, Citereup District, Bogor Regency. This area is a tangible manifestation of Indonesia's commitment to participate in realizing world peace.

Based on the background that has been explained, the purpose of this research is divided into two, namely designing IoT-based drones to be used in 3D mapping of the RIDU Campus in the RIDU Campus Area at IPSC Sentul and conducting two- and three-dimensional mapping of the Sentul IPSC area.

2. Literature Review

2.1 Types of Drones

Drone is a type of unmanned aircraft in the form of a quadrotor. The term drone itself was first mentioned by the United States Army in 1935 (Respati, 2020, p.3). This aircraft is controlled automatically through a computer program designed, or through remote control from the pilot (Hidayat, 2019, p.2). Initially, UAVs were remote-controlled aircraft, but now automated systems are being widely applied. This automated system includes an auto-take off and landing system, a waypoint system using GPS and various other autopilot features.

Drone systems have various kinds and types. The type of drone can be classified based on the type of wing, propulsion, and weight of the drone (Saputra, 2013). Judging from the type of wing, drones can be divided into 2, namely:

a. *Fixed Wing*

This type of drone is an unmanned aircraft that has a fixed wing shape or does not move. The drone gets thrust from a motor that rotates the propeller so that the drone moves forward. Because the wind that moves from front to back passes through the wings that have a streamlined airfoil shape, the drone can get a lift so that it can fly.

b. *Rotary Wing*

This drone has wings that move or rotate so that the rotation of the wings or commonly called propellers produces lift. This type of drone can have one or more propellers. If it has one propeller then it can be called a monocopter/helicopter, if it has four propellers it is called a quadcopter, if it has 6 propellers it is called a hexacopter and so on.

2.2 DJI Matrice 600 for Mapping

Basically, the DJI Matrice 600 has a lot of benefits. One of the benefits of the drone is automatic area mapping, either in 2 Dimensions or 3 Dimensions. Drones used in mapping must have special specifications. In 2-dimensional mapping, drones must have a minimum specification of the waypoint feature to set the path of the image capture process. The waypoint feature is obtained if the drone has GNSS. In 3D mapping, mapping can be carried out more easily if the drone has LIDAR.

Light Detection And Ranging (LIDAR) is a laser-based remote sensing technology. The idea behind LiDAR is quite simple, aim a small laser at a surface and measure the time it takes the laser to return to its source. This technology is used in Geographic Information Systems (GIS) to generate digital elevation models (DEM) or digital terrain models (DTM) for 3D mapping.

The principle of LIDAR technology is similar to the principle of radar technology, namely active remote sensing techniques using lasers instead of radio waves. The principle of LIDAR is to emit a laser pulse on the surface, capture the laser that is reflected back to the source of the LIDAR pulse with a sensor, measure the time traveled by the laser, and calculate the distance from the source. Broadly speaking, the LIDAR system integrates three components, namely a laser scanner, a Navigation and Positioning System, and a Computing Technology.

3. Methodology

The method used in this research is associative quantitative method and remote sensing research method, where the research survey refers to the principles of remote sensing survey. The remote sensing method has two techniques for interpreting the object under study, namely visual and digital interpretation. Visual interpretation is done by looking at existing features to identify objects based on interpretation criteria, while digital interpretation is done through quantitative calculations (Sutanto, 1999).

This research is included in the type of associative research, where research variables are measured directly in the field and then look for the relationship between variables that affect research results (Creswell, 2009). This study also uses a sequential mixed method, carried out by implying the collection and analysis of first quantitative and then qualitative data in two successive phases in one study (Creswell, 2006). A descriptive quantitative approach is used to assist in weighting and scoring the quantitative data obtained (Inaqqa, 2017). Another approach used is descriptive qualitative, where data is obtained directly from the source and data in the form of words in sentences or pictures that have their own definitions (Sutopo, 2006).

3.1.1 Primary Data Collection

There are two primary data collected in this study, which are as follows:

a. Image of Mapping Using Drones

Primary data in the form of images from mapping using drones was collected by conducting a field survey conducted in June 2022. The data acquisition used remote sensing techniques, using digital optical sensors found in drone camera images. The following is a mapping area using drones.

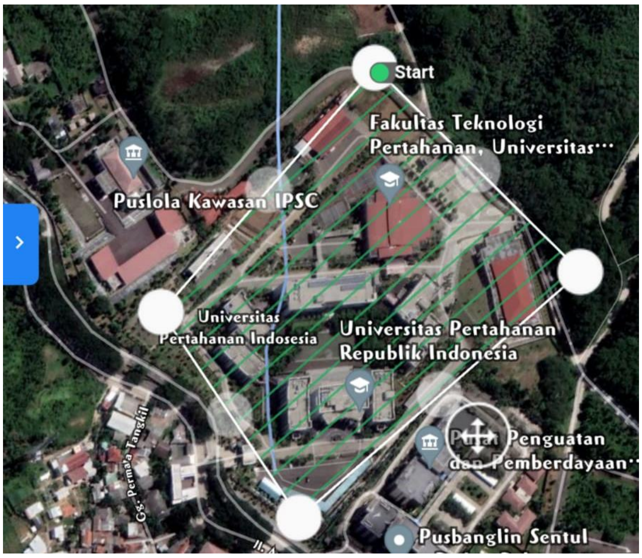

Fig. 1. Drone Mapping and Shooting Path

b. Textual Information

Primary data in the form of textual information is collected by conducting expert interviews with an open nature, where interviews are conducted freely so that researchers do not use interview guidelines that are systematically arranged, but only with a few outlines of the problems that require information (Sugiyono, 2017). The results of the interview are in the form of textual information that functions as complementary data or attribute data on geospatial data/information that will be generated at the end of the study..

3.1.2 Secondary Data Collection

Terdapat dua data sekunder yang dikumpulkan dalam penelitian ini, yakni sebagai berikut:

a. Avalanche Parameter Map

Secondary data in the form of maps of slope, geology and rainfall. The data is collected by submitting a request for data to the relevant agency. The slope, geology, and rainfall maps were obtained from Bappedalitbang, Bogor Regency.

b. Satellite Image

Secondary data in the form of Landsat satellite images in 2006, 2009, 2012, and 2015, obtained by downloading using the help of software. This satellite data serves to identify land use changes that occur in the research area, in this case the Sentul IPSC Complex.

3.1.3 Data Analysis Techniques

There is data analysis in this study, namely the analysis of land use changes. The initial stage of the analysis of changes in use is classification. This stage uses satellite imagery in 2006, 2009, 2012 and 2015, then interpreted and classified. Interpretation of satellite images pays attention to elements such as hue, shape, pattern, texture. size, shadow and association. In this process, land use classification is carried out as seen in satellite imagery. The appearance of homogeneous land characteristics will be classified by digitizing so that it will produce vector data in the form of polygons (Wijaya, 2017). From the vector data set in the form of polygons, it can produce land use maps for 2006, 2009, 2012, and 2015 in the research area.

Analysis of land use change is carried out by overlaying maps for 2006, 2009, 2012, 2015, and 2019. The size of the area undergoing land change is calculated using the following equation:

$$A = A2 - A1 \quad (1)$$

With:

A= Land Use Area

A2= Land Use Area of Latest Year

A1= Land Use Area Last Year

The overlaid maps depict land use changes by showing the spatial distribution of changed and unchanged land. Changes in land use are displayed in four time periods, namely the period 2006-2009, 2009-2012, 2012-2015, and 2015-2019.

4. Result and Discussion

4.1 Aerial Photography Stage Using Drone

4.1.1 Drone Calibration

Drones in mapping are designed to be Internet of Things (IoT) based so that drones will be connected to GPS satellites using the internet. In mapping, it takes at least three satellites that are connected to the drone so that the drone can place shots precisely according to the desired coordinates. Therefore, in calibration, it must be ensured that the drone can fly according to the coordinates, is strong in resisting interference, takes pictures normally, and anticipates any errors that could potentially occur.

In the calibration stage, it is also ensured that external factors such as weather do not interfere with operating the drone. Researchers must pay attention to the level of potential rain, brightness, temperature, air pressure, wind speed to ensure that the drone can operate normally. Therefore, the drone needs to be flown vertically first to ensure that the weather is favorable. After confirming that the weather supports the mapping, the mapping stage can be carried out.

Fig. 2. Drone Ability Test During Flight

4.1.2 Setting the Drone Waypoint

Waypoints are points where the drone will take aerial photos and the path the drone will choose in mapping. Aerial photo points and operating paths need to be selected and set before the drone is run, so that the drone will take aerial photos and pass through the path automatically without needing to be controlled during flight. However, researchers also need to monitor through a smartphone screen that is connected to a mapping camera in the drone. This needs to be done to ensure that the drone operates in a safe and normal condition. If suddenly the drone experiences an error, very large interference, deviates from the set path, or weather factors such as rain, the drone operator must immediately cancel the operation and manually control the drone to a safe place. The waypoints in this mapping can be seen in **Figure 3**.

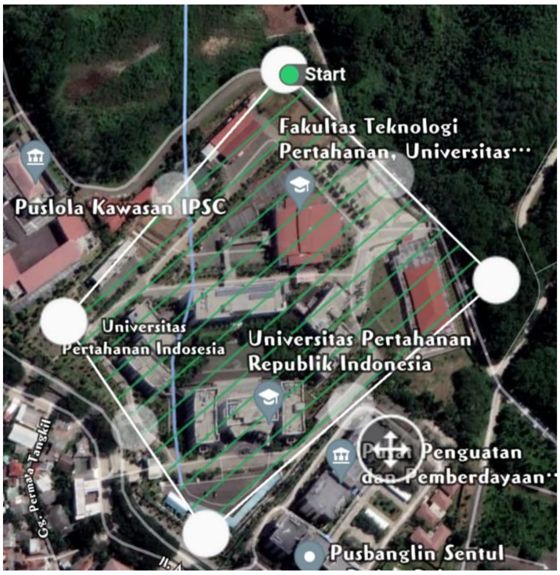

Fig. 3. Waypoints Selected in Mapping

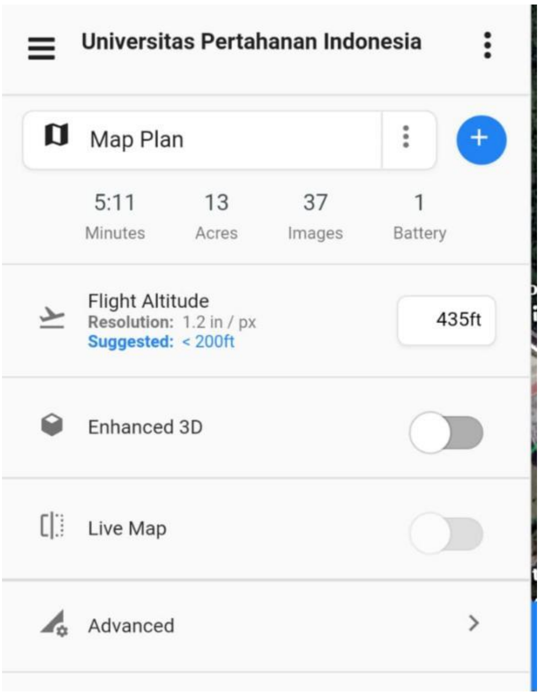

Fig. 4. Altitude Setting in Mapping Operation

In this mapping, researchers took a sample of The Republic of Indonesian Defense University and not the entire IPSC area. This is because it is constrained by permission from the relevant leadership. However, researchers can confirm if the IoT Drone design for mapping is successful. However, it would be better if the mapping was carried out throughout the IPSC area. For coordinate data, the height of the research sample, and the boundaries in the mapping can be seen in **table 1.**

Table 1. Attribute Data from Research Sample (RIDU)

Source: Google Earth (Processed by Researchers, 2022)

No	Attribute	Ket
1	**2**	**3**
1	Coordinate	6.524° South Latitude- 6.526° South Latitude and 106.878° East Longitude - 106.881° East Longitude
2	Altitude	240-270 Masl
3	Northern Boundary	Forest
4	West Boundary	Puslola
5	East Boundary	Center for Language Strengthening and Empowerment

No	Attribute	Ket
1	**2**	**3**
6	South Boundary	Tangkil Village Office

4.1.3 Mapping Results Using Drones

Mapping using a drone of 428 feet or about 130 meters from the ground or the RIDU building. If the height of the RIDU is 240 meters above sea level, the drone will fly at an altitude of 370 meters above sea level. The total time required for mapping is 5 minutes. This is quite safe because the drone used is capable of flying for 30 to 35 minutes. The mapping process with drones can run without running out of battery. A total of 37 photos were taken, and you can see the aerial photo samples in **Figure 5.**

Fig. 5. Mapping Results Using Drones

4.2 Stages of 3D Map Processing of RIDU

After the aerial photography stage is completed, the next step is to process the 2d map of RIDU Campus into a 3D map using the software that has been prepared. The processing can be divided into several stages, namely Align photos, Dense Cloud, Mesh, Texture, DEM, and Orthomosaic.

4.2.1 Align Photos

Align photos are carried out to identify the points in each photo and perform the process of matching the same points in two or more photos. The align photos process will generate the initial 3D model, the camera position and photos in-each recording, and sparse point clouds that will be used in the next stage. The processing time depends on the choice of accuracy and the hardware capabilities of the computer used. The higher the accuracy the longer the processing time..

4.2.2 Creating Dense Point Clouds

Dense Point Clouds are collections of high points in the thousands to millions of points generated by aerial photogrammetric processing or LIDAR. Dense point clouds will then be further processed to produce a Digital Surface Model (DSM), Digital Terrain Model (DTM), which is the main thing in the orthophoto generation process and related mapping results.

4.2.3 Development of 3D Models (Mesh)

Mesh models are one of the main outputs of aerial photo processing at Agisoft. The 3D model will later be used as the basis for earning DEM or DSM, DTM and also orthophoto. The resulting mesh can also be exported to other formats for further processing in other software such as Google Sketchup, AutoCAD or ArcGIS. For best results, use Dense Point Clouds. For the Face Count parameter, there are options from low, medium to high. This Face Count determines the number of polygon meshes to be generated. Face count High can produce a mesh with millions of polygons which may later cause visualization problems. In addition to the three options above, there are also two additional options, namely interpolation and point classes. There are two options for interpolation, namely interpolated and extrapolated. Interpolated mode will allow some gaps between unprocessed photos to be interpolated automatically. Extrapolated options do not need to be used in orthophoto processing.

4.2.4 Development of Texture Model

A texture model is a 3D physical model that appears to be in the photo coverage area. Texture models can be exported into various 3D model formats which can then be used to create 3D models via other desktop software or via websites.

4.2.5 Development of DEM

DEM or Digital Elevation Model is a digital terrain model in raster/grid format which is usually used in raster-based spatial analysis/GIS. From DEM data, information on elevation, slope, aspect, direction of illumination can usually be derived, to further modeling such as cut and fill, visibility, watershed creation and others. There are two terminology related to DEM, namely DSM (Digital Surface Model/height calculated from the land cover surface, such as building roofs, tree roofs, bridges, etc.) and DTM (Digital Terrain Model/height calculated from ground level).

4.2.6 Development of Orthophoto

Orthophoto is an aerial photo that has corrected its geometric errors using DEM data and GCP data so that it can be used for mapping purposes without any scale inconsistencies throughout the photo coverage. Orthofoto can be created after the creation of Dense Point Clouds, Mesh and DEM has been completed. Orthophoto is the last stage of processing a 3-dimensional map. Furthermore, the results can be exported data in png/jpg format. **Figure 6** is the final result of the 3d mapping of the RIDU Campus.

Fig. 6. 3D Mapping Results of the RIDU Sentul Campus Side View

4.3 Discussion

4.3.1 Discussion of 2D and 3D Map Results of The RIDU Campus

Some sample results from aerial photo mapping can be seen in Figure 5. While the results of the 3-dimensional map process can be seen in Figure 6. For aerial photography, the resolution is very high and sharp. Image results using drones are much higher than using satellites. This will affect the results of the process and analysis that is much more accurate. However, mapping using drones has limitations from range to flight time. These limitations mean that mapping can only be done in a limited area. Therefore, to choose tools in mapping between satellite imagery and drones, if the object of research is limited, such as villages, campuses, buildings, lakes and others, you can use drones, while if the object of research is broad, such as provinces, mountains, and even countries, then satellite imagery is recommended.

4.3.2 Discussion on the Utilization of 2D and 3D Maps of the RIDU Campus

Furthermore, the RIDU's 3-dimensional map can then be used for several analyzes, such as changes in land use from year to year. According to Kusrini (2011), land use change is the transition from an old location and form of land use to a new land. Land use change in the IPSC area is analyzed by comparing land use maps in 2006, 2009, 2012, 2015, and 2019. The land use change map is a map that can describe the spatial distribution of the object under study, in this case in the form of land that has changed or not. changed its use (Wijaya, 2017). Existing land use maps are used to analyze land use changes in each period.

Land use is classified by drone by digitizing it on the screen with the help of software. The image is interpreted visually by looking at existing features to identify objects. The appearance of the image seen in the image visually, grouped based on the similarity of color, size, shape, texture, shadow, and site. Grouping is done by creating vectors that produce land use classes. Each land use has certain characteristics that distinguish it from other types of land use. The digitized land use classification results in a multi-temporal land use map in the IPSC area.

The results of identification and analysis of land use changes that occur in the IPSC area are used as one of the parameters in identifying potential landslides, namely land use parameters. Changes in land use are needed to determine the trend or level of development activity that occurs in the IPSC area. The existence of development activities that cause land changes, so that these activities are feared can cause landslides or other ground movements in certain areas that have the highest landslide potential. The results of the analysis of land changes that occur due to regional development are also an early warning that a comprehensive study or special methods are needed before carrying out construction or during the development process itself, so as not to trigger an increase in the potential for landslides.

Furthermore, the results of this study can be used for future development analysis in the IPSC area. The IPSC area is categorized as a defense area because every agency in this area is under the supervision and authority of the Ministry of Defense. This area is also called the National Strategic Area , because its existence is very important and prioritized for state sovereignty, defense and security, as well as economy, social and culture. Structuring or managing areas that are included in the KSN category is very necessary, and must be done specifically because it is included in the defense area.

In response to this, the arrangement of the defense area must of course take into account many factors in developing and managing it, for example geographical conditions, climate and other parameters. Judging from its geographical condition, the IPSC area is located in a highland area, which has a fairly high intensity of rainfall as well. The topography of the hills and mountains in this area is also one of the factors that is very carefully considered and studied in the development and management of the IPSC area. The most obvious thing found in this area is the threat from the disaster sector, namely landslides or ground movement. The high level of activity and the large number of development plans that will be carried out in the future make it very important for the management or structuring of defense areas to be studied comprehensively, considering the characteristics of the IPSC area itself.

In simple terms, the structuring and management of defense areas can be carried out by taking into account the level of real threats that have the potential to occur in this area, in this case the potential for landslides. Regional development should not be carried out at points that have a high enough potential for landslides. If you look at the 3-dimensional images that have been made, and also see directly in the field, the IPSC area has a land surface that is not flat, in other words the method of carrying out development will also be different from areas that have a flat land surface. It is necessary to dredge the soil to create a flat land surface, but it can potentially reduce soil resistance and soil density. Another thing that must be considered is the path of the water pipe or water channel in this area, development must avoid the existence of a water pipe underneath, because it can cause sedimentation of ground water which eventually saturates and causes soil movement.

Several agencies in the IPSC area have indicated that there is ground movement, as can be seen from the cracks in the building, the descent of the road, and the fracture of the concrete in the building. This of course should be a special concern for every agency or manager in this area. The development carried out should be based on the results of the evaluation of the development that has occurred, so as to create a conclusion or other method in responding to the potential for landslides or soil movements in this area. With the potential for landslides, there is a need for more special treatment in structuring and managing the IPSC area, so that disaster mitigation can be measured precisely and accurately.

5. Conculsion

Based on the results and discussions that have been listed, there are two conclusions in this study:

1. In the research, commercial drones were designed and added with an Internet of Things (IoT) system to be able to do 2-dimensional and 3-dimensional mapping. Mapping requires internet which can connect the drone with at least 3 GPS satellites. Once connected successfully, it is possible to create waypoints or mapping paths as in Figure 3.
2. Two-dimensional and three-dimensional mapping results have been obtained. The results of the two-dimensional mapping can be seen in Figure 5. The results are processed using software to produce a three-dimensional map. The three-dimensional map can be seen in Figure 6.

References

Hidayat, R., Muhaimin., & Aidi, F.(2019). Rancang Bangun Prototype Drone Penyemprot Pestisida Untuk Pertanian Padi Secara Otomatis. Jurnal Tektro, 3(2), 86-94.

Ilic, D., & Vladimir, T. (2021). The Impact of The Nagorno-Karabakh Conflict in 2020 on The Perception of Combat Drones. Journal of Engineering Management,6(1).

Kristian, W; Mussadun. 2013. Penentuan Tipologi KDB dan KDH pada Perumahan Dengan Topografi Perbukitan (Studi Kasus: Kelurahan Gedawang Kota Semarang). Jurnal Ruang. Vol.1 Hal.141-150

Pratama, B. M., Gunawan, D., & Gultom, R. A. G. (2020). Deep learning-based object detection and geographic coordinate estimation system for GeoTiff imagery. In Journal of Physics: Conference Series (Vol. 1577, No. 1, p. 012003). IOP Publishing.

Respati, R.E., & Irwansyah, I. (2020). "Smart Flight" sebagai Bentuk Pelatihan Pilot Drone oleh Pasukan Drone Bogor Indonesia. Jurnal Komunikasi, 14(1), 1-14.

Saputra, D.R.H., & Bambang. P. (2013). Rancang Bangun Prototype Unmanned Aerial Vehicle (UAV) dengan Tiga Rotor. Jurnal Teknik Pomits, 2(1), 47-52

Susdarwono, E.T. (2021). Artificial Intelligence (AI) Drone dalam Pertahanan: Problem dan Kemajuan. Jurnal Ilmiah Intech Information Technology Journal of UMUS, 3(1), 1-11.

Syam, T, et al. 2012. Pemanfaatan Citra Satelit dalam Mengidentifikasi Perubahan Penutupan Lahan: Studi Kasus Hutan Lindung Register 22 Way Waya Lampung Tengah. Globe Vol 14 No.2 Desember 2012: 146-156

Voskuijil, M. (2021). Performance analysis and design of loitering munitions: A comprehensive technical survey of recent developments. Jurnal Defense Technology. 1-19

Wijaya, A; Susetyo, C. 2017. Analisis Perubahan Penggunaan Lahan di Kota Pekalongan Tahun 2003, 2009, dan 2016. Jurnal Teknik ITS. Vol.6 No.2