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DESIGN AND DEVELOPMENT OF TARGET DESIGN WITH BASIC IMAGE PROCESSING ON OTHTT SYSTEM PROTOTYPE (*OVER THE HORIZON TARGET TRACKING*)

Sigit Purwanto, I Made Jiwa Astika, Erpan Sahiri, Ekaris K. Novarendra

Indonesian Naval Technology College, STTAL Surabaya Indonesia
Pdtapmako2@gmail.com

ABSTRACT

Based on Law No. 34 of 2004, the Indonesian Navy has the main task of maintaining state sovereignty in territorial waters. Various attempts have been made to strengthen the Navy so that it can carry out these basic tasks, one of which is to add defense equipment, namely ships that have the ability to shoot missiles. This missile possession is important because in addition to being a deterence effect, modern naval battles are dominated by long-distance warfare or Over The Horizon. In missile fire, accurate intelligence is needed to determine the position of the target. So far what has been done is sending submarines or reconnaissance aircraft. This is very inefficient because in addition to requiring large resources, the risk of losing personnel and material is also very large. Based on this, the researcher makes a prototype of a vehicle that can identify and determine the position of a target. The vehicle in the form of a UAV is equipped with GPS, altimeter, compass and camera. This equipment will provide data in the form of UAV latitude and longitude position, UAV height, UAV heading and UAV camera angle. From the four data above, the ground station on the missile carrier gets the target's latitude and longitude data based on image processing. While the method used is color thresholding which can distinguish a target based on its color. After several trials, the UAV has been able to carry out the target positioning up to a height of 15.4 meters. At these heights the target latitude can be determined with a system accuracy of 3.3 meters. To be used as a reference for missile firing, it is necessary to increase the capability of the equipment specifications to reach the desired distance.

Keywords: Target, Latitude, Longitude, Image Processing.

1. INTRODUCTION

In terms of its range, the missile owned by the Navy can be said to be a very reliable missile. For example, the ownership of Yakhont missiles with a range of up to 350 km, the Navy can provide deterence effect to any group or country that wants to disrupt the sovereignty of the Republic of Indonesia. But until now, the ability of such a capable missile has not been matched by detection sensor equipment, in this case radar, which can provide target data that is at a considerable distance. This results in the ability of the missile that can reach targets up to a distance of 350 km is not optimal. Therefore we need an equipment or vehicle as an "extension of the eye" of the KRI to detect targets so that later can be used as a reference in carrying out missile shooting. During this time before carrying out missile fire, submarines were sent as an element of reconnaissance of the target. This submarine will later provide target data to KRI as a shooting reference. Submarine delivery certainly requires significant resources coupled with great risk. From the above problems, researchers have an idea to create a vehicle that can replace the submarine's role in providing target data to KRI as a missile shooting reference.

The vehicle that will be created is a UAV that uses the OTHTT (Over The Horizon Target Tracking) system. This UAV will provide data in the form of the latitude longitude of the target processed from the latitude and longitude data of the UAV itself. In addition, the UAV will also provide a visualization of the target so that it can convince KRI that the intended target is really the target to be paralyzed. This UAV will communicate continuously (real time) with the KRI in order to provide accurate data so as to provide high accuracy at the time of the shooting. All of this is an effort to minimize the risk of submarine resource use in a military operation carried out by the task force by applying the Design of the Target Tracker to the Image Processing Base of the OTHTT (Over The Horizon Target Tracking) Prototype System.

2. LITERATUR REVIEW

2.1 *Color Thresholding.*

Thresholding is a process that is used to produce binary images or images that have only two colors namely black and white (Zhou, Wu, &

Zhang, 2014). Thresholding can be done if the brightness level or grayscale level of the image is known. Thresholding can have pixel values that have a certain value or certain scope. In general the thresholding technique is divided into 3, namely:

a. Dynamic Thresholding
Dynamic Thresholding is done by dividing the image using several sub images. Then in each sub-image, segmentation is done by using a different threshold value in each sub-image. Threshold can also be done based on the color format used in image processing. Threshold RGB, HSV threshold and YCrCb threshold.

b. Static Thresholding
Static thresholding is a thresholding method by determining the threshold values of an image. So to get a thresholding must know the colors contained in the image. If thresholding using the RGB color format, then the value of each pixel of the image component must be known in advance of the RGB value of the pixel. Likewise with the HSV and YCrCb color formats.

c. Distance Thresholding
Distance thresholding is a thresholding method using the value of the distance limit of a color with a reference color. If the thresholding uses the 24-bit RGB color format, then the values of R, G and B are respectively in the range 0 - 255. With 0 being black and 255 white. For the reference value obtained by knowing the value of the sample image that will be done thresholding.

For the RGB threshold, the threshold is based on the degree of brightness or gray degree of the three color components (Red, Green, Blue) that make up an object. The RGB format that is often used is the RGB format with a length of 24 bits. For thresholding with HSV color format, it is more often used to detect fruit, flowers, skin and objects that are not man-made. The advantage of thresholding with HSV color format is more stable to the effect of light when compared to RGB thresholding. Even though all the color components are greatly affected by light, the degree of influence varies for each color format used. Thresholding YCrCb, using the colors yellow, Crominan Red and Crominan Blue. The range of values for each YCrCb color component varies. Of the various types of thresholding, in essence it is used to get the range of a certain value of a color that composes on an object. The results of this thresholding will be done for image processing get other information or change the original image to binary image.

2.2 Binary Images

Binary images are images that only have two gray degree values, namely black and white. The purpose of changing the gray degree of an image, to simplify the image processing so that information is obtained about the image. Converting an RGB image into a binary image through the process of separating pixels based on the degree of gray they have. This change is done by the thresholding method by providing a specific value as a reference to convert pixel images in the RGB format to binary format which only has a value of '0' for pixel values less than the reference and a value of '1' for pixels that have more values than the reference.

Binary images are obtained by grouping the gray degree values of each pixel into two classes, namely black and white. In black and white images there are 256 levels, meaning they have a scale from 0 to 255. In this case black has a value of 0 and white has a value of 255. To achieve images with binary images is usually done by thresholding or limiting values according to the range that has been predetermined. So that way it's easy to get the desired color. Colors that are in the range are represented in the value 1 or white, while black is a color outside the expected range or a value of 0.

2.3 Determination of Target Position.

In determining the target position, four pieces of data are needed, namely UAV position data, UAV height data, UAV heading data and UAV camera angles. The steps to determine the target position are as follows:

a. The first step is to look for a horizontal distance between the UAV and the target. How to determine this distance is to utilize the height of the UAV with the UAV camera angle. Calculation of horizontal distances can be described as follows:

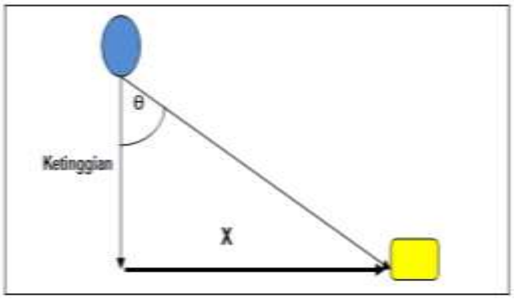


Figure 2.1 Calculation of Horizontal Distance

With the trigonometric formula we get:

$$\tan \theta = \frac{X}{Ketinggian}$$

$X = \tan\theta \,.\, Ketinggian$ ... (rumus **Error! No text of specified style in document.**.1)

b. Then next is to project the distance between the UAV and the target to the latitude and longitude. Projection to latitude and longitude can be seen as the image below:

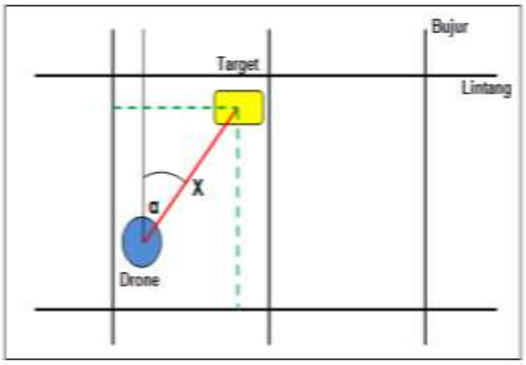


Figure 2.2 Projection of latitude and longitude

Projections to latitude can be obtained using the trigonometric formula:

$$\cos \alpha = \frac{\Delta\, lintang}{X}$$

$\Delta\, lintang = X \,.\cos\alpha$ ... (rumus **Error! No text of specified style in document.**.2)

Whereas for projections to the longitude it can be obtained using the trigonometric formula:

$$\sin \alpha = \frac{\Delta\, bujur}{X}$$

$\Delta\, bujur = X \,.\sin\alpha$ ... (rumus **Error! No text of specified style in document.**.3)

Because Δ latitude and Δ longitude are still in units of distance (meters), we must first convert them to units of latitude and longitude. Given 1 degree = 111,320 meters, then Δ latitude and Δ longitude can be converted to degrees using the formula:

Δ bujur (derajat) = Δ bujur (meter) / 111.320

Δ lintang (derajat) = Δ lintang (meter) / 111.320

a. The final step is to add the change in latitude and longitude with real GPS data received to find out the position of the target's latitude and longitude.

Posisi lintang target = Posisi lintang $UAV + \Delta$ lintang (derajat)

Posisi bujur target = Posisi bujur $UAV + \Delta$ bujur (derajat)

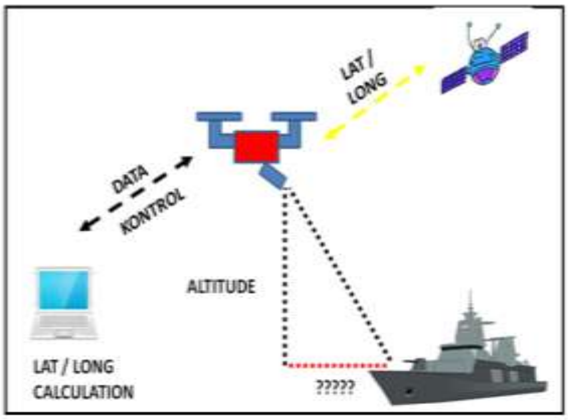
3. SYSTEM DESIGN

3.1 System Design

In general, the target tracker system consists of two main parts, namely the ground station and UAV section. Each - each part is then divided again into several sub-sections. These parts will form a system that can determine the position of targets in the format of latitude and longitude.

At the ground station used a laptop computer with core i5 specifications and has 4 GB of RAM. In this laptop computer contains two main software namely Qt Creator and Arduino IDE. Qt creator software is used for coding in image processing. Coding carried out includes determining the target position using the color filtering method, calculating the UAV horizontal distance and target, calculating the latitude and longitude position of the target obtained from the conversion of the UAV distance to the target. As for the Arduino IDE software, it is used for coding Arduino Mega. Coding is carried out including making flight controllers and transferring data from GPS sensors, altimeters and compasses to ground stations.

The UAV section uses a quadcopter or UAV type UAV using a four propeller drive. This UAV has seven major sub-parts, namely the frame, the driving motor, batteries, sensors, cameras, telecommunications systems and flight controllers. The frame on this UAV uses carbon fiber tube measuring 550 mm (motor to motor) and has the advantage of light but strong and able to lift heavy loads. The driving motor on this UAV uses four RC Timer Motors 2830-850 kv brushless motors which have 187 Watt of power per motor. Then the battery used is a 3S LiPo 5200 mAh battery. While the sensor used is the GPS type Adafruit Ultimate GPS Breakout which has a sensitivity of more than -165 dBm, data updates every 0.1 seconds and has 66 channels. Then the UAV uses a 650 TVL 3 MP CCD camera that functions as an input image to be processed at the ground station. For the telecommunications sub system in this UAV, it is divided into three. First, UAV control uses 915 MHz frequency, the second is telemetry data using 433 MHz frequency and third, real time video communication uses 5.8 GHz frequency. The last sub-system is the flight controller that uses Arduino Mega. The system design can be seen in the image below:



Gambar 3.1 Desain *UAV tracker*

As for the parts at the ground station and UAV section, it can be seen as shown below:

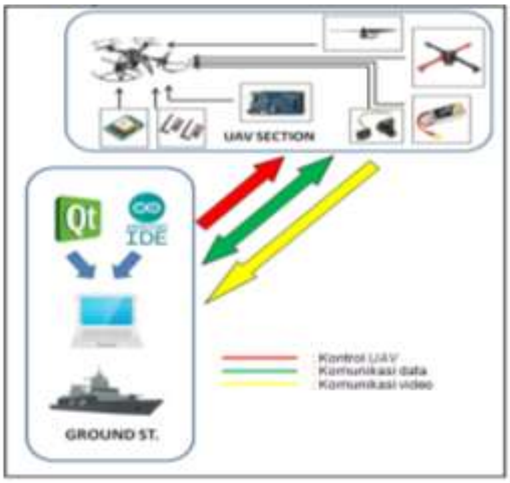


Figure 3.2 Parts of the ground station and UAV section

3.2 Blok Diagram Sistem

The working principle of the UAV Tracker can be seen in the block diagram below:

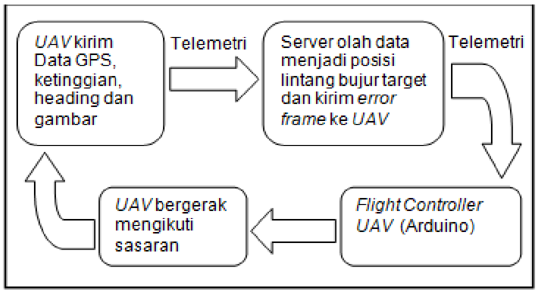


Figure 3.3 Block diagram of the UAV Tracker

4. TESTING THE SYSTEM

The main system testing is testing to determine the target position. The target positioning test was carried out at a height of 10.4 m and 15.2 meters UAV, the results of which will be compared with other position reference references (in this case GPS from a cellphone). Testing the determination of the target position 1 can be seen in Figure 4.1 as follows:

Figure 4.1 Testing the target position 1

Whereas the calculation of target positions can be elaborated as follows:

UAV longitude position: 112,716096 ° East
UAV latitude position: 7.217645 ° LS
Altitude: 10.4 meters
Heading: 20
Camera angle: 70 °

According to the formula given, then we can carry out the calculation of the target's latitude and longitude position as follows:

UAV horizontal distance to the target
= tan 70° x 10,4
= 28,6 m

Target longitude position:
Δ bujur = sin 20 x 28,6
= 9,8 m
Δ longitude in degrees = 9,8 / 111.320
= 0,000088
So the target longitude = UAV longitude + Δ longitude (°)
= 112,716096 + 0,000088
= 112, 716184° BT

Target longitude position
Δ lintang = cos 20 x 28,6
= 26,8 m
Δ longitude in degrees = 26,8 / 111.320
= 0,000241
So the target longitude = UAV longitude + Δ longitude (°)
= - 7,217645 + 0,000241
= 7,217404° LS

Then the target latitude and longitude position 1 is 7.217404 ° latitude and 112.716184

° east. Meanwhile, when compared with GPS on mobile phones are as follows:

Figure 4.2 Comparison of processed target position 1 data on the server with mobile GPS data.

By using the formula of the distance between two points, we can determine the difference from the system calculation by designating a handphone.

Difference distance = √ ((server latitude - latitude handphone) ² + (server longitude - longitude handphone) ²)

= √((7,217404 – 7,217410)² + (112,716184 – 112,716180)²)

= 0,000007°

= 0,8 meter

This 0.8 meter difference can be caused by the accuracy of GPS on mobile phones that are different from the accuracy of GPS on UAVs.

Furthermore, the determination of the target position 2 can be seen in Figure 4.3 as follows:

Figure 4.3 Testing position target 2

Whereas the calculation of target position 2 can be described as follows:

UAV longitude position: 112,715544 ° East

UAV latitude position: 7.218047 ° LS

Altitude: 15.2 meters

Heading: 149

Camera angle: 70 °

According to the formula given, then we can carry out the calculation of the target's latitude and longitude position as follows:

UAV horizontal distance to the target

= tan 70° x 15,2

= 41,76 m

Target longitude position:

Δ bujur = sin 149 x 41,76

= 21,5 m

Δ longitude in degres = 21,5 / 111.320

= 0,000193

So the target longitude = UAV longitude + Δ longitude (°)

= 112,715544 + 0,000193

= **112,715737° BT**

Target longitude position:

Δ lintang = cos 149 x 41,76

= - 35,79 m

Δ longitude in degres = - 35,79 / 111.320

= - 0,000322

So the target longitude = UAV longitude + Δ longitude (°)

= - 7,218047+ (- 0,000322)

= **- 7,218369° LS**

Then the target's latitude and longitude are 7.218369 ° latitude and 112.715737 ° east. Meanwhile, when compared with GPS on mobile phones are as follows:

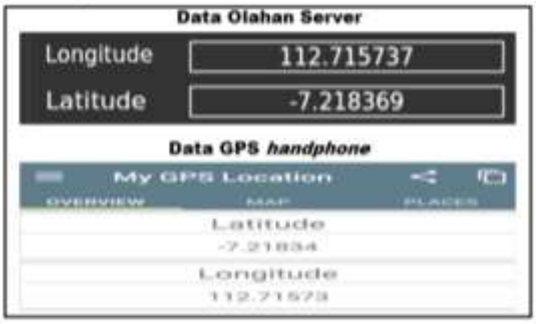


Figure 4.4 Comparison of processed target position 1 data on the server with mobile GPS data.

By using the formula of the distance between two points, we can determine the difference from the system calculation by designating a handphone

= √((lintang server – lintang *handphone*)² + (bujur server – bujur *handphone*)²)

= √((7,218369 – 7,218340)² + (112,715737 – 112,715730)²)

= 0,000029°

= 3,3 meter

The difference of 3.3 meters can be caused by the accuracy of GPS on mobile phones that are different from the accuracy of GPS on UAVs.

For testing the other target position errors can be seen from table 4.1 below:

Table 4.1 Testing the error of the target position of several heights

No	Ketinggian *UAV*	Kesalahan posisi
1	10,4 m	0,8 m
2	11,3 m	1,3 m
3	12,2 m	1,5 m
4	13,1 m	1,9 m
5	14,1 m	2,7 m
6	15,2 m	3,2 m

From some of the tests above can be made a graph of the relationship between altitude and target position error as shown below:

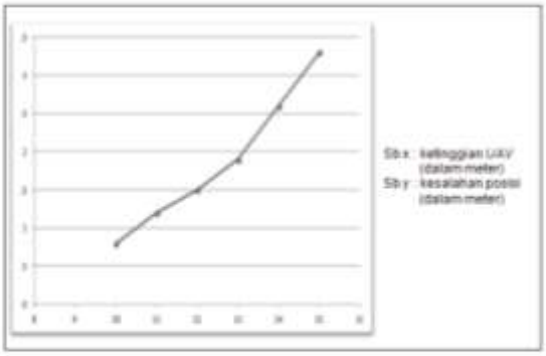


Figure 4.5 Graph of relationship between UAV height and target position error

From the graph above it can be seen that the higher the UAV flies, the greater the target position error.

5. CONCLUSIONS AND SUGGESTIONS

5.1 Conclusions

Determination of the target position can be carried out on the OTHTT (Over The Horizon Target Tracking) prototype system by utilizing data obtained from GPS, altimeter, compass and camera namely UAV longitude latitude position, altitude, UAV heading and camera angle. The first data needed is the height and angle of the camera. From these two data a horizontal distance between the UAV and the target will be obtained. After getting this distance, it will be projected to the latitude and longitude. The final step is to convert the projection distance to degrees and add it to the UAV latitude and longitude position to get the target position. Experiments to determine the target position up to a height of 15.2 meters resulted in a target position error as far as 3.3 m. The level of accuracy shown by this position error can be used as a guideline to determine the increase in equipment specifications that exist in the UAV so that when developed into a product can achieve the desired level of accuracy.

5.2 Suggestion

a. This research is still in the form of a prototype design. To be able to be used in the actual field of work, it is necessary to hold an increase in UAV capability. These capabilities include increasing flight time, increasing the accuracy of sensors such as GPS, altimeter and compass, increasing camera resolution and increasing the ability of servers on the ground station to process data.

b. Furthermore, there needs to be integration between the server and missile fire control so that the target position data obtained can be directly used as a reference in missile shooting.

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REFERENCES

Gonzales, R. C. (1992). *Digital Image Processing 2nd Edition.* New Jersey: Prentice Hall.

Hadiwijoyo, S. S. (2017). *Aspek Hukum Wilayah Negara Indonesia.* Yogyakarta: Graha Ilmu.

Mulyawan, H., Samsono, Z. H., & Setiawarhana. (2014). Identifikasi Dan Tracking Objek Berbasis Image Processing Secara Real Time. 2.

Pemerintah. (1999). Undang-Undang RI No. 36. *Telekomunikasi*. Indonesia: Sekretariat Negara.

Pemerintah. (2004). Undang-Undang RI No. 34. *Tentara Nasional Indonesia*. Indonesia: Sekretariat Negara.

Prianggodo, L. B. (2016). Perancangan Object Tracking Robot Berbasis Image Processing Menggunakan Raspberry Pi. 3.

Rovianto, M. (2014). Desain dan Realisasi Sistem Telemetri FSK. 1.

Sariningsih, N. O. (2017). Perancangan Dan Implementasi Tracking Obyek Manusia untuk Autonomous Car. 3.

Saunders, S. (2017). *Jane's Fighting Ships 2017-2018.* London, UK: IHS Markit.

Zhou, H., Wu, J., & Zhang, J. (2014). *Digital Image Processing Part II.* London, UK: Bookboon.