A DEVELOPMENT IN SEMI AUTOMATISATION OF UAV TERRESTRIAL DIRECT GEOREFERENCE

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Abstract. Unmanned Aerial Vehicle (UAV) can be used together with a Robotic Total Station in Terrestrial Direct Georeference system. More sophisticate terrestrial survey equipment can identify UAV postion automatically, this ability eliminate the problem of moving target focusing and be able to acquire target coordinate continously and make UAV system become reliable as an alternative solution to map some cluster of parcels in rural or village area which has less and difficult transportation facility and as the solution to provide spatial data for land administration purpose too. Inspite of UAV technology characterize with low altitude flight, adaptive with the environment, climate condition problem overcoming like cloud cover, there is some question in geometric accuracy of aerial photo map produced from UAV system. UAV geometric accuracy problem caused by several factor likes; platform flight instability, flying height variation as wind influences causing various photo scale. To solve the problem, modification of existing method carried out by introducing accurate control points into aerial photo image. The modification offered in this research is the combination between UAV and Robotic Total Station. Robotic total sation follows every UAV movement and acquired its position in the same time, these coordinte information applying as the coordinate of photo central. Aerial photo will have an accurate central photo both horizontal (x,y) and vertical (z). The error effect reduced significantly using these measured coordinate photo from a robotic total station on the ground and yield accurate map.

Keywords: UAV, Robotic, Terrestrial

1. Research Background

Mapping engineering developments, particularly cadastral mapping, has provided some options to satisfy the need ofhigh resolution land parcel datawithvarious acquisition cost. Interpreters tends to obtain as maximal information as possible from the image they have; however,it is limited by resolutions and costs should be spent to acquire the image.

Cunningham, K. (2011) found that the quality of the cadastral survey aredirectly related to population density and variety for each village, so oftenly found in some ofthe villages with no cadastral maps that meet the standards of cadastral maps. The existence accurate map for cadastral purposes for each village with diverse characteristics of population and topographyis a challenge to seek a appropriate method.

Current technology developments tendto overcomeaccuracy, precision, and cost issues, for example,how to acquirehighresolution images at low costsand may be used to extract desirable information withinmap accuracy standard for certain scale. It is seen in evolution ofremote sensing methodsparticularly in photogrammetry using*Unmanned Aerial Vehicle*(UAV) to observe and control land ownnershipstatusaccurately and complete.

Many studies weredesigned to provide high resolutions and accuracy imagemap, among of it throughintegrating cameras with GPS navigation for geometric correction.However, the resulted map is not yet meets accuracystandardof 1: 1.000 mapscale.To improve the methods,an unmanned aerial vehicle tracking system using a Robotic Total Station was developed to produce maps for cadastre purposeat better gometrik accuracy as firstly we introduce as Terrestrial Drirect Georeferencing System in ealier published paper (Hendriatiningsih, 2014).

2. Methodology

Generally, large format, medium and small format photogrammetry methods are constrainedbyproblems of aircraft availability, security officer permits to take pictures, cloud coveringthat require planes to fly at low altitude, high costin aerial photo capturing lead to photogrametery are not effective sollution forsmall area. UAV mapping methodtry toovercome problems that arise in fashion photogrammetry methodsusing manned aerial vehicle and allow to fly below 150 meters.

A robotic ETS Topcon type PS 105, a measuring device, can perform prism tracking mounted on the bottom of UAV.This deviceis able to make continuously measuring of horizontal and vertical angles, and slant distance of UAV as long in the range of ETS. This eliminates the handicap in focusing at targets of UAV using ETS reflectorless as in previous research. Inthe range of longlink about 600 meter, it is allowingto perform continuouslyobservation of a position at radius of ± 500 meter.

Architecturally, land parcel aerial photo using UAV is a photogrammetric method in which photography use a digital camera carried by aerial vehicle, in spite of the vehicle used is a small unmanned aerial vehicle under remote control.

Method used in this research is throughmeasuring many targets either in the field or laboratory in which their positionswere determined by GPS or ETS. Those targetsare used as either control points or check points in the photogrammetric process. In general, the research methodology is depicted in flow chartof figure 1.

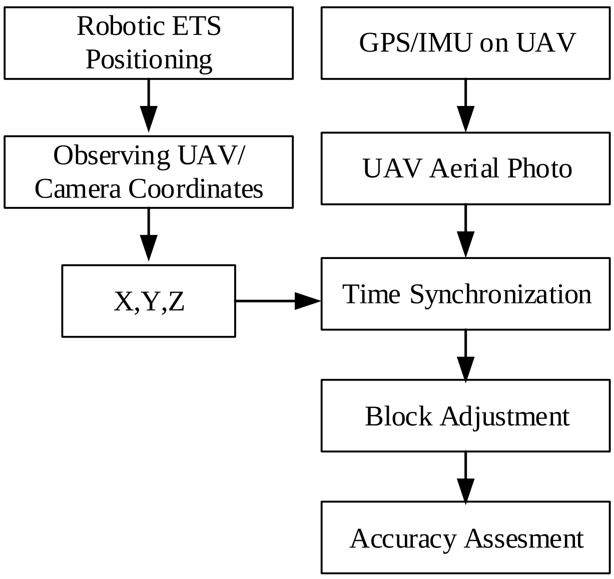

Figure1. Research method

2.1 Data Acquisition

Prior to data acquisition, robotic ETS (Electronic Total Station) calibrated from systematical error.This is done to clarify the angle data are free of collimation and index errors effect. Both vertical and horizontal angles are measured on two targets and the magnitude of errors is calculated. The results show the magnitude of collimation errors are still qualifying for the measurement.According to collimation errors, the tool canbe used for angle measurement.

The first activityis carried outinthe observatory location of football court, ITB campus, Jatinangor. The activity isstarting by installing 1 unit ofGPS Receiver as Base Station in front of the main building of ITB campus, Jatinangor.Furthermore, 36 white circle-shaped premarkswith 40 cm diameterin dark background within 6 x 6 grid formation are installed, and distance between premarks is 15 meters. Media used to install the premarksare prism and measuring tape.

Furthermore, the position (circle center) of Premark is determinedusing 1 unit GPS Receiver as Rover Station and the method used is RTK (Real Time Kinematic) Positioning. At themoment, the accuracy of position on the device is about ± 5 mm. The data collection processon the coordinates of premarks is depicted in Figure 2.

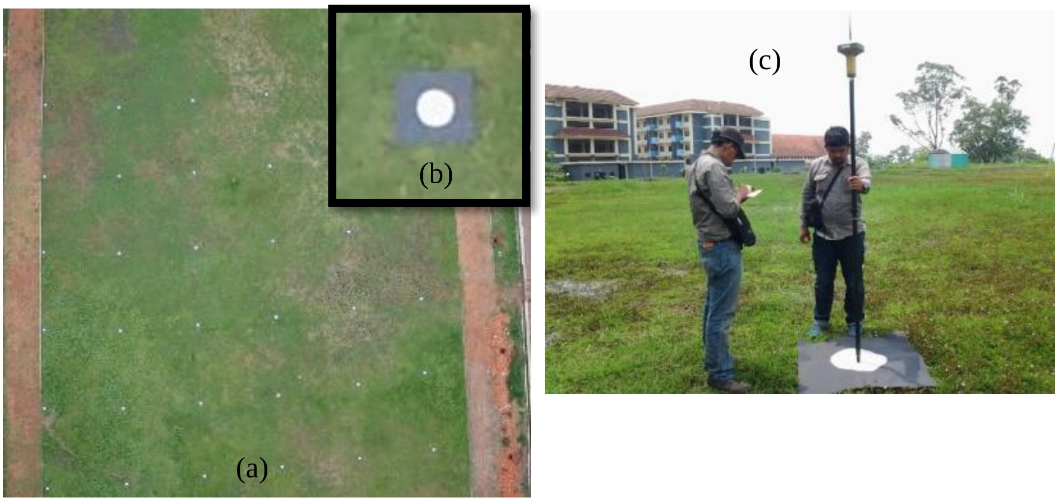

Figure 2. Formation of grid premark (a), Premark zoom (b), RTK GPS for the position of premark (c)

At the same time, the UAV team prepares Hexacopter and Robotic Topcon ETS. The preparation involve setting the focus of fixed 20 mm lens Sony Nex 5N prosumer camerato be attached onto Hexacopter. The lens focus is set for100 meters distance in order to obtain good quality photograph (sharp or not blur).

To understand the ability of Robotic ETS tracking, the instrument is put in a test for prism target tracking, prism installed/integrated with camera on hexacopter. For this test, the hexacopter is controlled manually by UAV operator. When hexacopter still on the ground, the Robotic ETS is directed to the prism target of hexacopter for recognition process and locked on the target. After ETS recognize the target, the UAV operator liftand flying up hexacopter and make various maneuvers in different directions, various heights and speeds. At this beginning step of experimentation, the UAV did not fly high, as the main goal is to observeprism object recognition movement. As a result, ETS can follow prism movement automatically and overcoming moving target focusing problem.

Figure 3. Preparation of HexaCopter (a) and Robotic ETS (b)

In the initial stage of flight, the 360º prism is placed verticallyunder the UAV in accordance with the prism design for terrestrial mapping. In the mapping, the prism is mounted on pole vertically. The problems with theinstallation of vertical prism is ETS wavepropagation to the prism hindered of by the prism retaining body made of plastic when the vehicle was flying quite high, causing ETS can not receive reflected wave. To overcome signal blocking by prism body a modification in prism orientation carried out. Prism isinstalled on the camera in such a way that position of the prism, as measured by ETS, is the midpoint of the resulting aerial photographs.

Figure 4. Setting of ETS prism on camera

2.2 Data Acquisition Problem

The unarrival transmited wave from ETS onto prism problem is not only causing the difficulty in prism/UAV position hard to be determined, and furthermore, ETS can not keep up with the prismtrack, leading ETS to rotate on horizontal and vertical directions to search for the position of prism. To address these issues, prismposition was modified, the prism mounted on UAV in horizontal positionin order to make signal transmitted by ETS can reach prism and receive reflected signal from prism, it is expected performe at all heights of UAV on the ground.

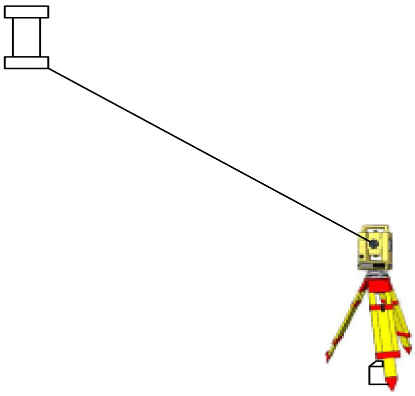

Figure 5. The hindrance of ETS signals by 360^o prism body

At horizontal position prism, the ETS can continuously keep up with the track of UAV and prism's coordinates can be determined at the same time.The problems with UAV are it is rotating on its axis due to wind, leading the position of plastic prism part to block the propagation of signals to ETS. Under such condition, the measurement is stopped, but the required coordinate data for this study have been obtained, this situation as new issue in modifying a new shape of prism.

Other problems persistin determination of distance andbearing of each photograph is synchronization between image acquisition/camera exposure timeon vehicle with the distance and direction angle data collection by total station, so that in next step researchspecific design and planning related to the photography by setting timer and photographic interval on the camera and the signalization application in the form of blitz ray emission being reinforced as a cue for surveyors on the ground to take the distance data and the direction angle of camera position on the vehicle are necessary. Similarly, the better design for the distribution of control points must be used to reduce the effects of the instability of UAV. However, in this research to produce such design is a difficult task and, therefore, ETSwas set to perform continuous measurementsat 2 seconds interval.

3. Result and Analysis

Initial activity in the studio isthe synchronization ofaerial photo collection period by a camera with ETS position determination. Times for initial activities of camera and ETS are at 23:47:22 and 12:23:57, respectively. The difference is**11:23:25.**Times for last activities of camerais 0:50:13 and ETS1:26:47, respectively**.** Aerial photo capturing time synchronization with the positioning of camera coordinates by ETS was perform by time comparison between them and analyzed to obtain synchronized data pair on two sources simultaneously. Since the image recording by camera istaking place continuously for one position, there are several images in a certain time, as shown in Table 1.

Table 1. Synchronization of times on camera and time for observing of the point by ETS

Label	Size	Alig	Qua	Date & time	Make	Model	Focal length
DSC06244.JPG	4912x3264			2016:01:07 00:15:53	SONY	NEX-5N	20
DSC06259.JPG	4912x3264			2016:01:07 00:16:33	SONY	NEX-5N	20
DSC06265.JPG	4912x3264			2016:01:07 00:16:51	SONY	NEX-5N	20
DSC06274.JPG	4912x3264			2016:01:07 00:17:33	SONY	NEX-5N	20
DSC06288.JPG	4912x3264			2016:01:07 00:18:08	SONY	NEX-5N	20
DSC06299.JPG	4912x3264			2016:01:07 00:18:35	SONY	NEX-5N	20
DSC06310.JPG	4912x3264			2016:01:07 00:41:58	SONY	NEX-5N	20
DSC06325.JPG	4912x3264			2016:01:07 00:42:30	SONY	NEX-5N	20
DSC06336.JPG	4912x3264			2016:01:07 00:42:57	SONY	NEX-5N	20
DSC06348.JPG	4912x3264			2016:01:07 00:43:32	SONY	NEX-5N	20
DSC06364.JPG	4912x3264			2016:01:07 00:44:06	SONY	NEX-5N	20
DSC06382.JPG	4912x3264			2016:01:07 00:44:44	SONY	NEX-5N	20

Point No.	Northing	Easting	Time	Date	Cam Time
UAV111	9233606.774	805877.686	12:52:27	2016-01-07	00:15:53
UAV112	9233606.800	805877.634	12:52:28	2016-01-07	00:15:53
UAV149	9233588.776	805876.636	12:53:07	2016-01-07	00:15:53
UAV166	9233571.136	805877.221	12:53:25	2016-01-07	00:15:53
UAV167	9233571.202	805877.091	12:53:26	2016-01-07	00:15:53

Aerial photo position based on measurement isset as follows.

Station	Image	X	Y	Z
	Image001	877.88075	607.30441	107.90663
2	Image002	876.51870	587.51418	106.66331
3	Image003	877.58293	571.70709	107.72192

Following are 3 examples of adjustment result of image position.

```
Results for Station  Image001
 Station    Initial     Total        Final     Initial       Final
 Variable    Value    Adjustment     Value   Standard Error  Standard Error
    X       875.4031    2.4777     877.8808   1.0000E+003    2.1004E-001
    Y       606.7857    0.5187     607.3044   1.0000E+003    2.3636E-001
    Z       103.1511    4.7556     107.9066   1.0000E+003    5.1834E-001

Results for Station  Image002
 Station    Initial     Total        Final     Initial       Final
 Variable    Value    Adjustment     Value   Standard Error  Standard Error
    X       873.2962    3.2225     876.5187   1.0000E+003    2.1835E-001
    Y       586.9338    0.5803     587.5142   1.0000E+003    1.9182E-001
    Z       102.1267    4.5366     106.6633   1.0000E+003    5.1738E-001
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Results for Station  Image003
 Station    Initial      Total        Final      Initial         Final
 Variable    Value     Adjustment     Value    Standard Error  Standard Error

    X       871.8716      5.7113    877.5829    1.0000E+003    2.7092E-001
    Y       565.3400      6.3671    571.7071    1.0000E+003    2.3686E-001
    Z       103.4041      4.3179    107.7219    1.0000E+003    5.1103E-001
   AZ       136.7323      0.8480    137.5803    1.0000E+003    2.6328E+000
   EL       -83.6703      3.7942    -79.8761    1.0000E+003    1.3546E+000
 ROLL        41.4095     -0.9171     40.4924    1.0000E+003    2.6512E+000
```

There are 12 aerial photo images involvedin adjustment processes and producing residual value of each image as follow:

Citra	RMS Residu Citra (mm)			Citra	RMS Residu Citra (mm)		
	x	y	xy		x	y	xy
Image001	0.50	0.71	0.61	Image0013	1.03	1.22	1.13
Image002	1.05	0.88	0.97	Image0014	0.86	0.84	0.85
Image003	0.95	0.89	0.92	Image0015	0.41	0.52	0.47
Image004	0.71	0.50	0.62	Image0016	0.88	0.61	0.76
Image005	1.61	1.33	1.48	Image0017	0.68	0.61	0.65
Image006	0.41	0.53	0.47	Image0018	0.95	0.81	0.88

At total residue (RMS):

x	y	xy	σo	Degree of Freedom
0.89	0.82	0.86	1.921	672

And the overall standard errors are:
Summary of Limiting Standard Error Estimation

	x	y	z
RMS	0.0022	0.0023	0.0091
RMS Minimum At	0.0013 17	0.0013 15	0.0081 15
RMS Maximum At	0.0033 1	0.0035 6	0.0114 2

Summary of Standard Error Estimation

	x	y	z
RMS	0.0051	0.0051	0.0107
RMS Minimum At	0.0036 16	0.0036 22	0.0095 27
RMS Maximum At	0.0069 31	0.0070 31	0.0136 1

4. Conclusion

Robotic Total Station applicationwith capability of*automatic tracking* can facilitate observers to get the position of a camera mounted on UAV continously. This eliminates one handicap found in previous studies about howto focusing cross hairon the target. The results of the study show that Terrestrial Direct Goereference mapping methodproduce image photo with high accuracy, better than precision given by RTK method and standard errorsare better than specified minimum standard errors.

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