Instrumentation of 3D Positions for Topology Mapping Using Global Positioning System (GPS) and Barometric Pressure Sensors

by Jatmiko Endro Suseno

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ABSTRACT

A research on topographic mapping in certain areas has been conduced, with the final result of a contour. The contour parameter is latitude, longitude that obtain from the GPS (Global Positioning System) receiver, and altitude. GPS receiver is used Ublox Noe 6 M. In additionally it's also added an altitude parameter, which is obtain by converting the changes of air pressure. Sensor BMP180 used to measure air pressure. Both of these devices are read and controlled by a microcontroller ATmega328 with Arduino software. The GPS receiver to get latitude and longitude coordinates from the satellite. Coordinates data is sent to a microcontroller, combined with altitude data, then it processed using GUI (Graphical User Interface)on MATLAB (Matrics Laboratory. In MATLAB application the data of each point will be taken with ten data retrievals which then automatically calculate as the best value from that point. Latitude, longitude, and altitude data are then reprocessed using a surfer application into a contour. The contours formed on the surfer will be differentiared by color, where they will differentiate the position of the height of a point. Based on the results of validation latitude and longitude coordinates from the GPS receiver with GARMIN GPS devices with the GPSMAP 78s series, this GPS receiver has the highest standart deviation ± 0.000006 degrees for the longitude and ± 0.000012 for latitude. The contour results of this study will be compared with the contour obtained from standard mapping data from geodesy technique of Diponegoro University. The disadvantage of this system is contour media is still manual with laptop or computer and controlled by user so that if user can not process it and there is no means of laptop or computer, will cause failure in making contour.

Keywords: GPS, MATLAB with GUI, altitude position, contour, latitude longitude

Introduction

Mapping measurement which is usually used is theodolite and waterpass equipments and getting positions of 3 Dimensions (3D) coordinates after through some measurement. The measurement is carried out for some locations in an area, after that the data are processed in mapping software application, ie. Autocad, surfer etc. The mapping measurements which is more accurate, are using GPS in the theodolite equipment to getting 2D coordinates, they are latitude and longitude positions. But to get the altitude position it need some steps with more persons, and equipments. The processes are still not efficiency.

An integration equipment with included sensors that can detect latitude, longitude and altidue in one device, can reduce processes to get data of mapping and the equipment becomes simpler and cheaper. In this resesarch, it has realized these integration mapping equipment. The data aquisition system consists The 3D positions sensors, Analog to Digital Converter (ADC), Arduino processor, and USB interface. The latitude and longitude position is detected using GPS sensor and the altitude is detected using barometric sensor. This data can be monitored, saved and processed at computer with Matlab software. This mapping equipment is special because it is portable, accurate and fastly and we hope it can remove the ordinary equipment, ie. theodolite atau waterpass with same result.

THEORI

Tophography Map

Generally the topologhy mapping methods are 3 (three) main methods. They are methods of terrestrial, photogrammetric and aerial photographs (Silvia, 2016).

Terrestrial method has 3 (three) experiments, such as topography measurement, data processing, map printing. All of experiments is done in outside ground with mapping equipment, such as theodolite, waterpass, length measurement and other equipment (GPS, total station etc). Tophography measurement measure position and the height of the mapping skeleton points and detail tophograhy, so that it can be depicted on a plane in a certain scale. The mapping skeleton means control pont network (x,y, z) that will be used as measurement refference and measurement control points.

The photogrammetric method can be done in the outside field and also aerial photographs thenique therefore it can be measured with wide area fastly. It is still necessery to determine the control point for next photogrammetric process. Photogametric metrics is a science and image measurement techniques, while the interpretation of the image is the recognition and identification of an object in the photo. With this photogametric method, the measurement does not need to be done directly in the field but it is sufficiently done in the laboratory through measurement on the image image. To be able to carry out these measurements, it takes several control points on each aerial photograph. This control point can be generated from the next photogametric process which is an air triangulation process that aims to multiply the photo control points (minor control points) based on the existing ground control points.

GPS (Global Positioning System) Sensor

GPS (Global Positioning System) is a system for determining the location on the surface of the earth with the help of synchronization of satellite signals. This system uses 24 satellites that transmit microwave signals to Earth. This signal is received by the receiver on the surface, and is used to determine the location, speed, direction, and time (Taufiq, 2010).

There are three important parts of this system, namely the control section, the space section, and the user section. In the control section, as the name implies, this section to control. Each satellite can be slightly out of orbit, so this section tracks satellite orbit, location, altitude, and speed. The signals from the satellites are received by the control section, corrected, and sent back to the satellite. Correct location data corrections from these satellites are called ephemeris data, which will be sent to the navigation tool. In space, consisting of a collection of satellites in orbit of the earth, about 12,000 miles above the earth's surface. These satellites are arranged in such a way that navigation devices can receive at least every signal from four satellites. This satellite signal can pass through clouds, glass, or plastic, but can not pass through buildings or mountains. The satellite has an atomic clock, and will also emit this 'time / clock' information. This data is transmitted with the code 'pseudo-random'.

Barometric Air Pressure Sensor

The atmosphere contains all the elements of air we need to live. The atmosphere has several layers, the troposphere, which has a thickness of 11 kilometers, and the condition is always changing. The next layer is a stratosphere that has a thickness of 32 kilometers, with air conditions did not change significantly. In this layer contains a lot of ozone, which absorbs UV light. The upper layer of the mesosphere with a thickness of 42 kilometers and the last layer is a thermosphere with a thickness of 20 kilometers. In the upper two layers of this atmosphere, the air is very thin, and the distance between air molecules is very far apart. Above the atmosphere layer is a vacuum (Fleisher, 2011).

The force of gravity draws the air to stay close to the earth. Earth's gravity also causes air to have gravity, so the air presses the surface of the earth and all that is there. This is called air pressure. The greatest pressure is in a position close to the surface of the earth. This air pressure will decrease as the altitude increases with the earth's surface. The tool used to measure air pressure is a barometer (Fleisher, 2011). BMP180 is a pressure sensor with a pressure range of 300 - 1100 hPa or equal to a depth of 500 meters to a height of 9000 meters relative to sea level. This sensor is a digital sensor using piezo-resistive technology that has high accuracy and linearity.

Methods

Data Acquisition System

The part of the system that requires the hardware is the data acquisition system. This data acquisition system will be installed at certain points where the location is to be mapping. In this study the point is a blue stakes. This data acquisition system serves to determine the position of altitude and longitude by using GPS and altitude with pressure sensors. This data acquisition system, designed to meet the following specifications:

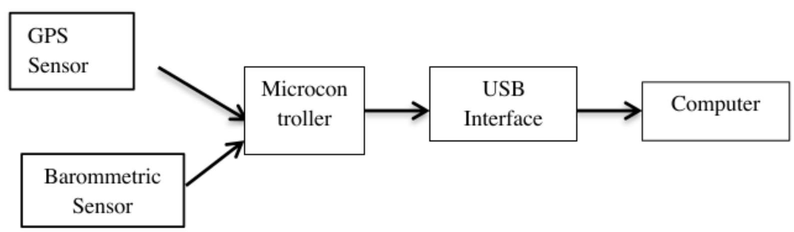


Figure 1. Data acquisition system architecture

The data acquisition system extracts the information sent from the GPS receiver and reads the data from the sensor. When the data acquisition system is active, the microcontroller reads the GPS receiver transmits data of latitude and longitude position. If latitude and longitude data are obtained then the microcontroller reads the data from the pressure sensor which will be the altitude data. Then all coordinate data position and coordinate this height will be sent automatically into the software matlab and the software matlab repetition will occur automatically as much as ten times in each point to be mapped. After ten times the accumulation will occur from the tenth of the data into an average value or the best value of the tenth data, which will be the best value of each point will be automatically deviated on matlab available in the form of excel file format.

For the data transmission process that occurs

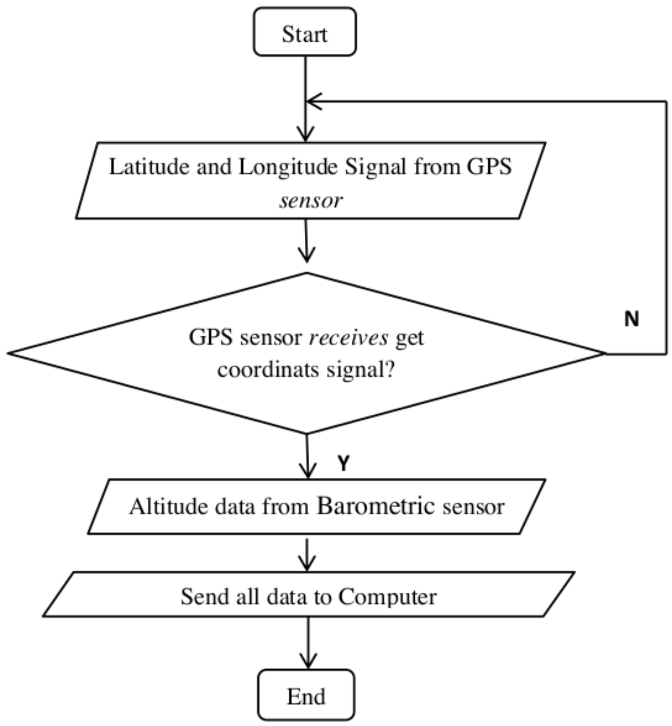


Figure 3 Data Transmission by data acquisition system

After data can be sent to computer then next will start taking data using matlab.

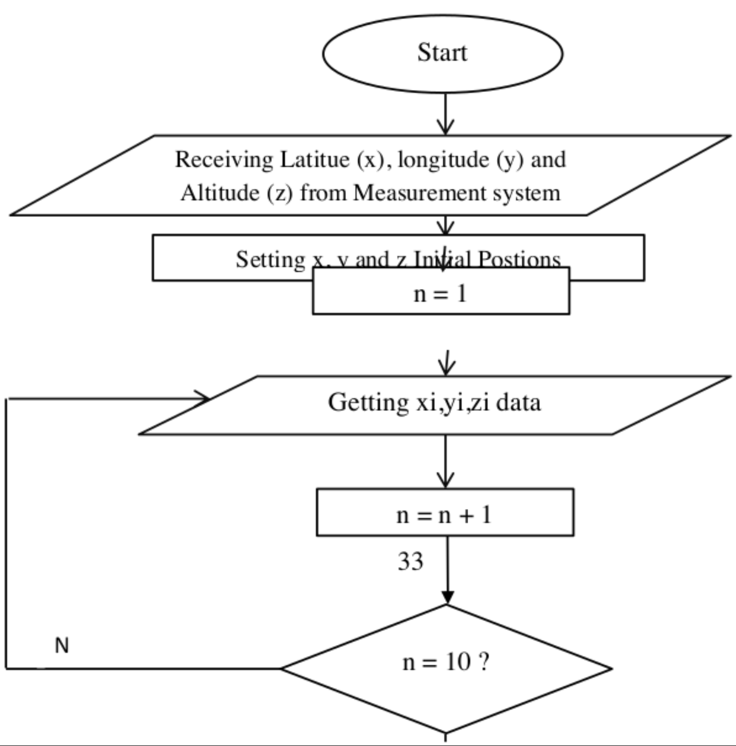


Figure 3. The working system on arduino

RESULTS AND DISCUSSION

In the data acquisition system is managed by using matlab applications that are easy and fast. To access data from acquisition system on matlab system only need to connect arduino to laptop / PC then do "Run" on matlab system which have been prepared then at project view automatically read the existence of COM4 connection and press "connect" button then stay set pause time data retrieval in seconds and then press the "Read Coordinate" then GPS will do the repetition in the data retrieval.

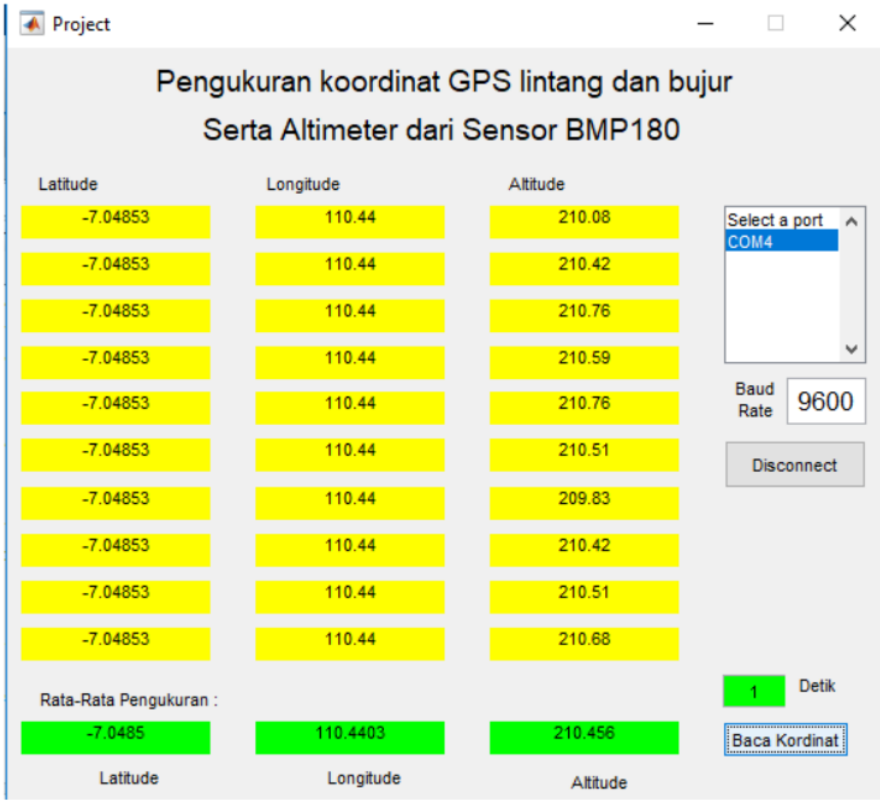


Figure 4. Example of position data from the data aquisition equipment

After each point is known the best value then automatically the value will be stored as data at that point. From the data of each point is incorporated into data tables arranged in Figure 4 where in the table obtained 5 data at different points.

data

	A	B	C	D	E
1	Waktu Pengukuran	Latitude	Longitude	Altitude	
2	08/07/2017 17:44	-7.049474	110.44236	202.009	belakang fsm
3	08/07/2017 17:50	-7.050194	110.44223	203.409	depan t.mesin
4	08/07/2017 17:54	-7.049415	110.43999	211.614	samping elektro
5	08/07/2017 17:58	-7.048515	110.44026	207.291	depan fsm
6	08/07/2017 18:00	-7.047712	110.44061	201.465	depan feb

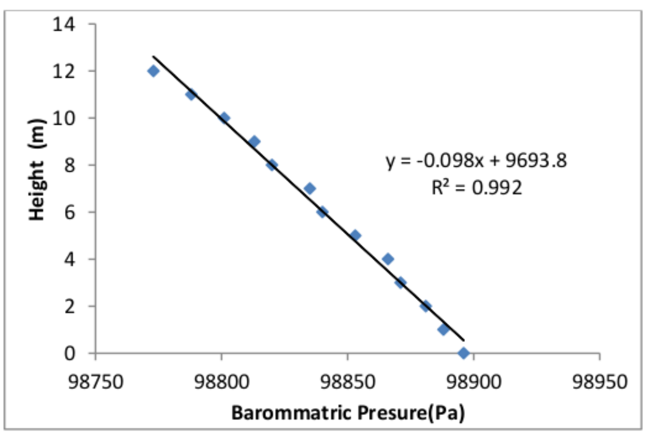
Figure 5. Data table of the average value at each point

Of the 7 point locations used for testing, the seventh point of the latitude coordinate has the highest standard deviation value, which is 0.000012 degrees. As for koodinat longitude, has the largest standard deviation 0.000006. This data is the value obtained with 15 repetitions.

Table 1. Comparison of data acquisition position reading with GPS GARMIN GPSMAP 78s

Point	Standard		Alat Akuisisi Data			
	Latitude	Longitude	Latitude	Longitude	δ Latitude	δ Longitude
1	-7.05238	110.44307	-7.05238	110.44308	0.000005	0.000005
2	-7.05247	110.44308	-7.05246	110.44308	0.000004	0.000003
3	-7.05278	110.44295	-7.05278	110.44297	0.000009	0.000006
4	-7.05315	110.44301	-7.05312	110.44302	0.000003	0.000005
5	-7.05348	110.44295	-7.05348	110.44291	0.000005	0.000003
6	-7.05374	110.44274	-7.05375	110.44273	0.000003	0.000006
7	-7.05391	110.44272	-7.05391	110.44271	0.000012	0.000006

To test the resolution of this air pressure sensor reading, tested by measuring the air pressure from the ground to a height of 12 meters above the ground. From table 1, the change in pressure reads the sensor is ± 10.3 Pa for a height change of one meter.



From the results of the tests that have been done, the average error for the increase of one meter is ± 0.25 meters.

The latitude, longitude, and altitude coordinate position validation tests are read by the data acquisition device, by comparing the coordinate data that is read by a standard GPS device at 5 location points. Then with the location of the same point was tested using the theodolite (Geodesy Undip technique)

Table 2. Comparison of three dimensional position reading results

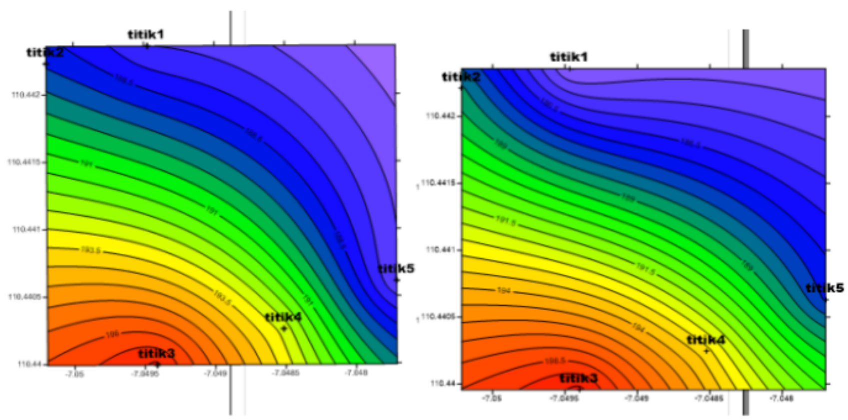
Point	Latitude		Longitude		Altitude	
	Measurement	Standard	Measurement	Standard	Measurement	Standard
1	-7.0494739	-7.049465716	110.4423606	110.4423591	187.509	184.466
2	-7.0501936	-7.050212355	110.4422319	110.4422101	188.909	188.594
3	-7.0494151	-7.049400961	110.4399919	110.4399552	197.114	197.666
4	-7.0485149	-7.048523103	110.4402574	110.4402428	192.791	193.2138
5	-7.0477123	-7.047701215	110.440612	110.4406312	186.965	187.4163

From the comparison data obtained by calculating the error value,

Table 3. Error values from standard data acquisition data comparison comparison

Point	The error value found on (%)		
	Latitude (10^{-5})	Longitude (10^{-5})	Altitude (10^{-5})
1	11.61	0.1358174	162285.54
2	26.60	1.9738826	16674.70
3	20.06	3.3230716	28004.10
4	11.64	1.3219817	21930.48
5	15.73	1.7384909	24138.21

From the data obtained, then stored in Microsoft Excel and then displayed by using the application surfer 11 in the form of a contour.



(a) (b)

Figure 4.2 Contour mapping; a) on the acquisition equipment, and b) on the geodesy data

Conclusion

A topographic mapping system has been developed using GPS and air pressure sensors, using arduino and matlab as a data acquisition processor to obtain the Latitude, Longitude and Altitude values required to obtain a topology contour.

Position data acquisition results in the form of latitude and longitude coordinate data, has an accuracy of ± 2.5 meters based on the datasheet of the GPS module. As for the accuracy of altitude, based on testing, the average error value is ± 0.25 meters.

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