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Development of low-cost electronic distance measurement equipment in surveying lab

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Abstract

All projects of Civil Engineering require planning and design. Surveying measurements play vital role while planning or designing of a project. One of the major fundamental surveying measurements is to measure the distance between two points. Currently, in addition to the conventional measurement systems– tap, theodolites, electronic distance meters (EDM), total stations and GPS units, are levels the most frequently employed instruments to find the angle or distance in surveying practice. The main objective of this topic is to develop low-cost electronic distance measurement equipment with a simple technology. The equipment will be used to measure the distance between two points. The equipment has been made based on numerology with respect to uniform angular velocity. Lots of natural numbers are counted very first setting a C program into the microcontroller with respect to angular rotation of a DC motor. The distance will be determined by the ratio of these natural numbers easily by this equipment.

Keywords: Natural number, angle, distance, tap, EDM.

1. Introduction

Distance measurement is an important part of plane or traverse surveying. Distance measurements are carried out by many different methods such as pacing, odometer, stadia (tacheometry), subtense bar, taping, electronic distance measurement (EDM) and others. Of these, taping and EDM are the most commonly used methods by surveyors today. Using tap has been both the simplest and the most precise method of measuring distance until the development of EDM. But Tapping is a direct measuring method and it does not give any idea of angle, the distance is not always correct for higher length as tension and deflection at downward occurred. Weather like humidity, temperature etc. effects on the result. It is not suitable in the hilly areas. EDM instruments have made it possible to obtain accurate distance measurements rapidly and easily. But the cost of EDM is high, where angle is measured with electronic theodolite and distance with EDM separately and it takes time to process the results and its operation is not so easy and reliable. On the other hand, using sub tense bar for indirect measurement is well known. But manual calculation and operating procedure being lengthy could not make it so popular. EDM is clearly ahead to measure the distance from above discussion. So, in this study an attempt is made to develop low-cost distance measuring equipment with the angle by simple technology which may be groundbreaking system in the area of measuring purpose surveying. The equipment has been made based on only uniform angular velocity and counting the natural numbers at the same time during its angular movement. For the purpose of distance measurement two alidades were used to target the point of which distance will be determined from a station. A dc motor was used there for the angular movement and a microprocessor performed counting natural numbers and all calculations. An attached LCD shows the distance and others results quickly. The equipment is able to measure the distance up to 12m accurately as it produces the smallest angle up to one third of a minute at this stage.

2. Methodology

2.1 Principles of finding the value of an unknown angle

Let an arm OA of a wall clock started to rotate from A and at the same time a counter started counting the natural numbers (1, 2, 3…) N1 until it reaches to the point B along the periphery of the circle. The counter stopped counting at B. Similarly, it started rotating from B and the counter started counting the natural numbers N2 from the point B and stopped at the point A.

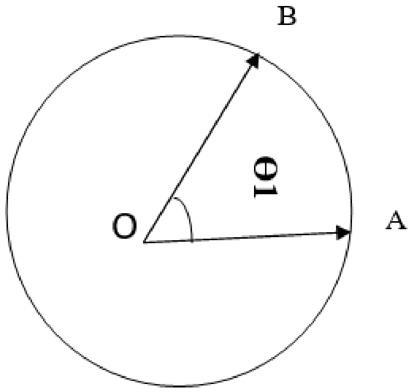

Fig. 1. Angular motion of the motor arm

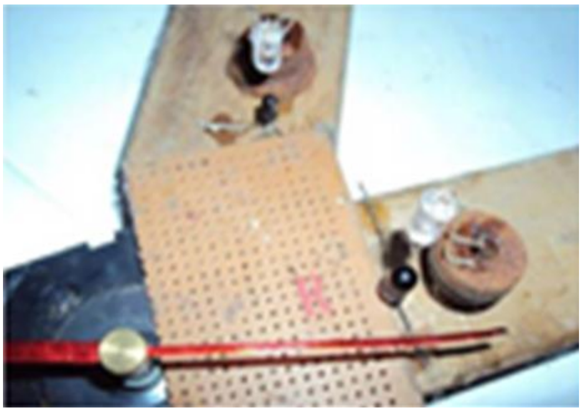

Fig. 2. Rotating arm through the sensor.

Fig. 3. Both LCD showing the counted natural number, the ratio (R) and the distance.

If the angular motion of the wall clock is more uniform and the counter counts the number uniformly with respect to the movement of the arm. It can be said,

Angle $\Theta1=N1*360/(N1+N2)$ or

$$\Theta1=R*360 \quad (1)$$

Where the subtended Ratio, $(R) = N1/(N1+N2)$

The counted numbers changed slightly due to the variation in speed of the motor but the ratio of the h kept approximately same. Some of the Figures was given below,

2.2 Geometrical figure and equation for the distance measurement

There is a main frame where X is considered as the base of a triangle. Two alidades are attached to the both end of the frame to target the point P. One is attached at a ϴ2 degree and the other is at an angle ϴ1 with the frame.

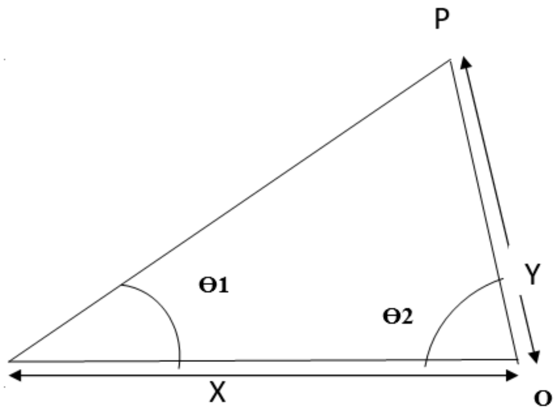

Fig. 4. Triangle form of the equipment.

Considering the triangle in Figure 4, if the both angle ϴ1, ϴ2 and the length of the base X is known, then the distance Y from O to P can be determined by the following equation using Sin() function.

$$Y/\sin(\theta 1) = X/\sin(180-\theta 2-\theta 1) \text{ or}$$
$$Y = X*\sin(\theta 1)/\sin(180-\theta 2-\theta 1) \quad (2)$$

ϴ1 will be determined with the above Equation (1) and ϴ2 will be assumed and finally ϴ2 will be determined from the graph by trial-and-error methods.

2.3 Fabrication of the equipment

There were two plain alidades on a steel box one can be rotated and the other is fixed at an angle less than 90 degree with steel box. The length of the steel box is known and it is considered as the base of the triangle. This equipment is held upon a tripod stands. A motor is attached through the center of the rotating alidade. The center line of the steel box is considered as the 0 degree. The angle between the center line of the steel box and the center line of the rotating alidade is to be considered as the determining angle. Sensor is attached with the microcontroller. Microcontroller is attached with the LCD. A number of buttons is attached with the microcontroller to reset the microcontroller quickly.

2.4 Field measurement

Firstly, the equipment will be attached on a tripod stand at a level place by fixing a screw. Then the target point will be sighted by the fixed alidades and then by the moving alidades carefully. Then the DC motor will be connected with the source and it starts rotating through the IR sensor. LCD and the microcontroller also will be connected to the power supply. After pressing the reset button, it will show the desired distance between two points besides angle and counted natural numbers. Every time after pressing the reset button it will show the distance in a moment. In the same way, we can measure the distance of many points from one station by targeting these only.

Fig. 5. Complete appearance of the equipment.

3. Analysis of the results

3.1 Phase-1(calibration)

Triangle base length, X=0.545m, Total angle = 359.8 degree approximately less than 360 degree as the counted numbers were less due to interrupted after the first counting and before the second counting. Primarily ϴ2 (assumed) less than 90 degree. Then the obtained distances(Y) of some object from the equipment (following the above Equation 2) were given below. Only the ratios have been taken in the first table except the counted numbers (N1, N2). The actual distances of the object were measured with the tape.

Table 1
Obtained distance vs actual distance

N1	N2	Ratio (R)	Total Angle= 359.8	Angle (ϴ1) deg.	Obtained Distance (Y)	Actual Distance (Y1)
		0.1323	360~359.8	47.443	0.565 m	0.602 m
		0.1750		62.755	0.971 m	1.000 m
		0.2152		77.171	1.988 m	2.000 m
		0.2293		82.227	2.978 m	3.000 m
		0.2365		84.809	3.966 m	4.000 m
		0.2410		86.423	4.994 m	5.000 m
		0.2440		87.498	6.035 m	6.000 m
		0.2460		88.216	7.006 m	7.000 m
		0.2483		89.022	8.554 m	8.610 m
		0.2497		89.542	9.973 m	10.000 m

Table 2
Finally obtained distance vs actual distance

N1	N2	Ratio (R)	358.60	Angle (ϴ1)	Measured Distance (Y)	Actual Distance (Y1)
6765	20931	0.2443	360~359.8	87.591	6.145 m	6.350 m
6741	21264	0.2407		86.318	4.912 m	5.000 m
6558	21184	0.2364		84.770	3.946 m	4.000 m
6346	21360	0.2290		82.137	2.952 m	3.000 m
6776	20834	0.24542		88.007	6.693 m	7.000 m
6598	21340	0.23617		84.689	3.906 m	4.000 m
6958	21306	0.24618		88.280	m	m

Assuming the various value of Θ2, the obtained distance and the actual distance were matched from the graph Θ2 confirmed as **87.325** degree by the trial-and-error methods.

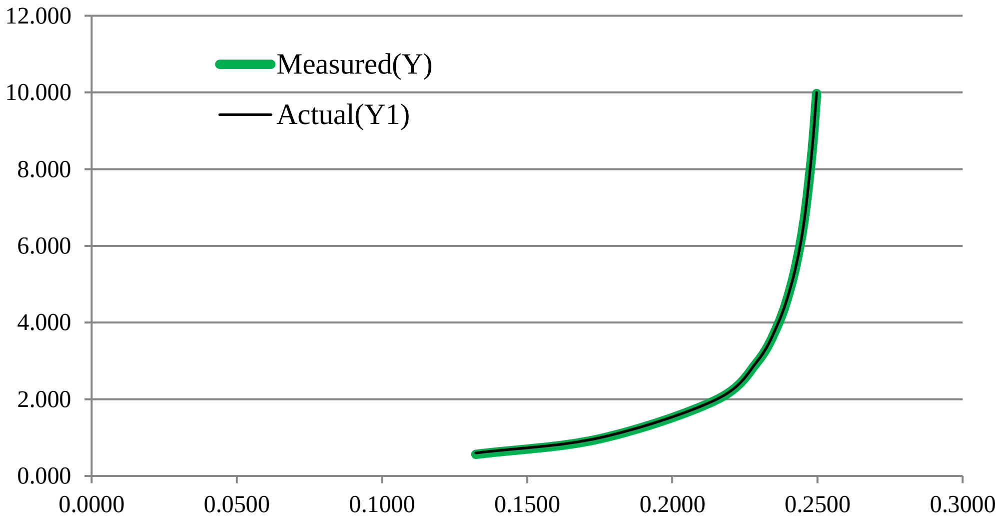

Fig. 6. Graph obtained distance vs. actual distance.

3.2 Phase-2 (final)

Finally setting all the values in the program the distance obtained from the equipment has been taken and the distances obtained from the tap were given in the table.

4. Results and discussions

Obtained distance between two points by the equipment in the above Table 2 is clear and very close to the actual distance obtained from the tape. It is seen that the equipment presents the natural numbers, ratio and subtended angle spontaneously at a glance as soon as pressing the reset button after locating the object by the alidade. The distance and the corresponding angle never change too much if it is observed for a certain point, though the reset button was pressed repeatedly. But the counted natural numbers vary in every time due to changes in speed slightly of the DC motor. So, the equipment was made simply based on the ratio of the natural numbers where the ratio of the arc or angle will be constant. Such excellent result with the simple technology and arrangement made it low-cost equipment or EDM than the conventional EDM.

5. Conclusions and implications

The difference is more between actual distance and obtained distance when the angle is higher. Because more difference in distance usually occurred for the higher angle due to the small difference in angle. The distance by the equipment can be developed at higher accuracy locating the target point properly to some level. At this stage the equipment can produce the smallest angle up to one third of a minute. So, it is not fit for the long length. The efficiency of the equipment can be higher by developing the motor, counting more number quickly than the present condition. By developing the program and form up the result can be more accurate also. The equipment may be groundbreaking in the various area of surveying by developing it from all respect. It is can be suit easily in the various areas of surveying as it is developed by programming and directly mathematical formulae. It is clear that a number of data will be helpful to proof the actual distance which is not possible by the tap with a single data only. On the other hand, EDM take some time to give the distance between two points though it is costly.

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