

Improvement of Accuracy of Field-Line out and Obstruction Free Location of Objects using Trilateration and Radio Signals

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ABSTRACT: Stake-out or line out process is extremely tedious prone to errors, also the techniques present currently require the sighting of the target so as to obtain the location of the object. While working at a construction site it is natural that the sight vision to be obstructed by other objects making the entire task difficult and prone to errors. So in our paper we make an attempt to define another concept of stakeout or positioning of objects that could be simple, free from errors and could also be automated. The working of this technique is analogous to the principle that runs GPS, but to a local level. By using the radio waves and their transmission lag as an advantage to locate an object by means of trilateration we intend to define our concept of stakeout that could be used to outdoor as well as indoor lineout of objects. This concept could reduce the tedious group task to a single man mission maintaining the required precision and improving the ease of work.

KEYWORDS: Survey, construction line-out, locating objects, stakeout, error mitigation, trilateration, RF ranging

1. INTRODUCTION

Stake out work on construction sites is extremely important and costly but it is extremely essential to have it done with great precision else the entire project is a failure. This setting procedure requires a great co-ordination and is extremely tedious. Basically we intend to define a new concept which involves automating the line-out work reducing it to a single man's work which presently is a team task. The concept could be used for indoor positioning of objects or extending reference zones as done by aligning using strings. It doesn't require any physical line of sight for the object to be located and can also be used beyond obstructions such walls or glass, etc. It is analogous to the principle used by GPS and RADAR. Reducing the efforts required to co-ordinate the locations and the errors in communication is the prime motive of this paper.

Currently, at construction sites this work is being done by using the Total Stations, Line Dori (Mason's string), etc. The work involves a lot of labour efforts and is certainly prone to some errors. The total station used on site provides a good precision but requires the sighting of the target in order to position the object, but many times it happens that there are obstructions in the sight like while working on a construction site there could be exposed steel bars, formwork, etc. So it requires the shift of instrument from one position to the other and this may add up to human errors that are caused while changing the position. Our concepts defines a new technique that won't be affected by obstructions and focus on minimizing human errors.

II. RELATED WORK

[1] On the Ships, Marine Satellite Tracking Antenna (MSTA) is a component for the satellite communication with ships and vessels. In order to maintain the communication link, the antenna line of sight has to be directed toward the satellite.

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This is not a difficult task when the antenna is used on a static platform. Once the antenna is mounted on ships, which would sway heavily during heavy sea states, a high-precision attitude control system is needed to stabilize the antenna to obtain a tracking error of less than a fraction of a degree. In this system, high accuracy attitude measurement is a key issue. So by using the Gyro sensor to counter the defects produced under dynamic conditions and the unavailability of direct line of site.

[2] A surveyor pole equipped with GPS receiver and antenna mounted. The tilt sensor and the direction sensor provide information about the vector that lies between the top and the bottom. A variable length, telescope range pole includes a linear transducer for automatically measuring the overall length of the range pole and contributing that length information to the vector calculation.

[3] A setting out device comprises of a rod which can be supported at a target point in the areas surrounding a point to be set out, a reflector which is arranged on the rod for tachymetric detection of the target point.

[4] A method of staking out a point on the ground using the satellite positioning system comprising following steps two reference points near a target point relative to the two reference position is marked on the ground, and the staking out is done at this point.

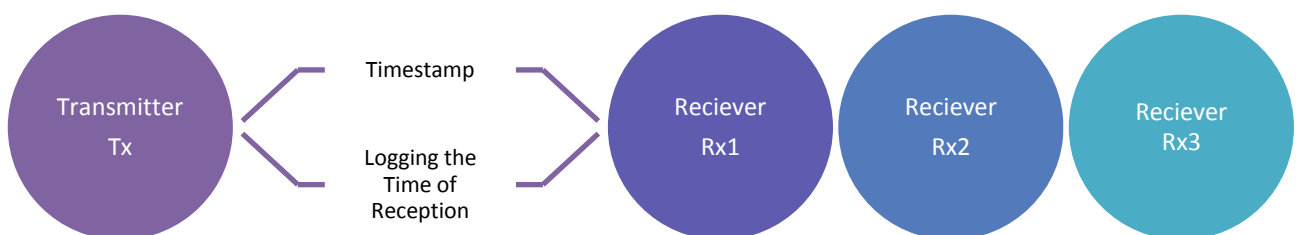
III. PROPOSED CONCEPT

Using the concept of trilateration along with the advantage of delay in transmission for availing the difference in length to attain three different dimensions so as to locate the object being played as the target spot.

By using two modules transmission and reception, the transmission sends the signal as the timestamp. At the receiver end there would be three different receivers to receive the signal and the reception time at these three points won't be the same. So the at the reception as there are three receivers there would be a delay of reception at every receptor and this delay when multiplied with the speed transmission would provide us with the distance of the object from each of the receiver. After having the three distances it would be possible to estimate the position of the object by using the concept of trilateration which would be applied by using solid geometry.

Set-up:

Under the current concept we propose to use two modules of transmission and reception, module A i.e. transmitter would be the rover of mobile module. Module B i.e. the receptor(s) would be the stationary module. Module B would be comprising of three set of receptors separated at a finite distance apart from one another. All the three receptors in the system would be having a relatively arranged and are assigned with a coordinate.



Operation:

As seen from the above figure the transmitter emits the timestamp as the signal and at the receiver module the signal reception is logged, after logging the signal the difference in the logged time and the timestamp is estimated. This difference is then multiplied with the speed of signal transmission to obtain the distance of the transmitter from the receiver.

Flow Diagram:

To provide a better idea of the concept of flow of this set-up we've broken the complete procedure into three modules.

Module A: The receptor level

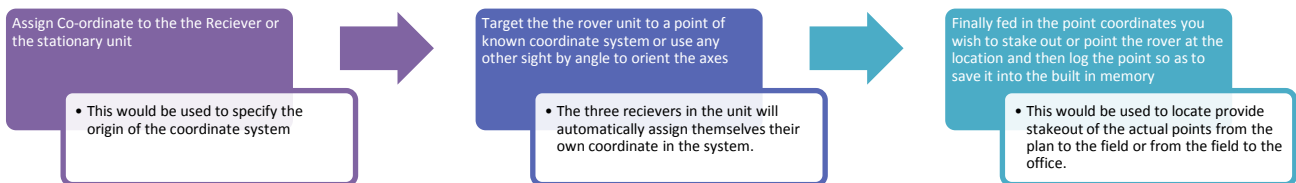
Module B: The Transmitter Level

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Module C: Combined Processing Stage Module A: The receptor level



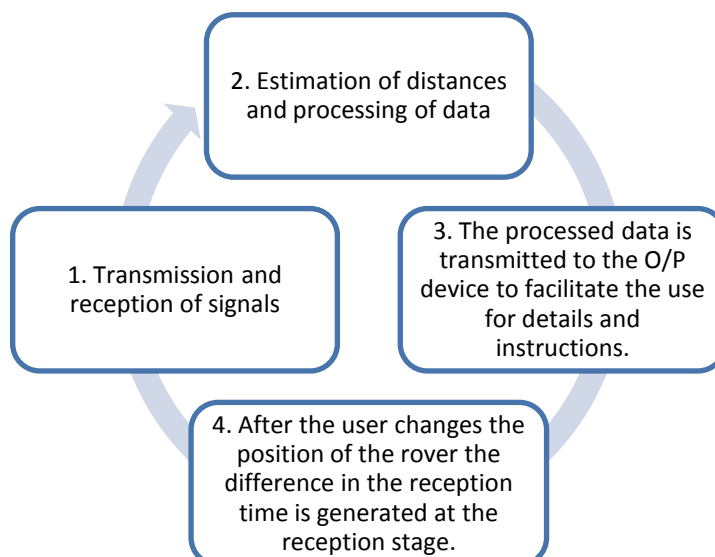
As displayed in the above flow diagram the stationary unit is to be positioned at the point whose coordinates are known or arbitrarily considered and the values are fed into the system by input module. Once this is done the origin or the position of the system is located with reference to the Cartesian coordinate axes, now the remaining part is to orient or provide direction to the axes. This provision of the direction is similar to the orientation of the total stations or plane table wherein the target or a point of known coordinate is to be sighted. Once this sighting is completed the values will run through the algorithm and all the modules would orient themselves for the operation. After the positioning and orientation the cycle of reception and transmission shall be commenced. Based on the algorithm mentioned below the procedure would work and the result shall be obtained.

Module B: The Transmitter Level



In this module we propose to provide a handheld device paired with the transmitter or the rover unit to provide information to the used and necessary guidelines so as to manoeuvre the station to the required position in the space. This module would be just transmitting the timestamp and the handheld device shall be doing the processing and providing the output. The handheld shall be communicating with the stationary unit for the estimation of parameters.

Module C: Combined Processing Stage



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This Cycle is continued at a frequency and the data being processed through the algorithm at the same rate to provide the real-time location reporting.

IV. TRANSMISSION AND RECEPTION MODULE

The purpose of this application demanded a continuous and direct communication as the lag in the signal transmission was the prime mover in the entire calculations. So to have a direct communication between the transmitter and the receiver at all times and the transmission location being of high weightage we dropped the idea of using GSM or CDMA technology as the signals would be transmitted through an intermediate server or bridge between the two modules.

In this application we propose to use the RF transmitter with multiple receivers. The 433MHz RF modules are commonly used for wireless data transmission and remote controlling over a distance of few hundreds of metre. The RF transmitter and RF receiver pair with each other on the basis of their address bytes. If an RF transmitter and an RF receiver have same address byte, they are able to transmit and receive data respectively.

These RF modules transfer 4-bit data at a rate of 1Kbps to 10 Kbps. Each nibble is transferred serially along with an 8-bit address of the transmitter. Any receiver module matching the address byte of the transmitter can receive data from the transmitter. Hence, it is possible to pair multiple receivers with a single transmitter.

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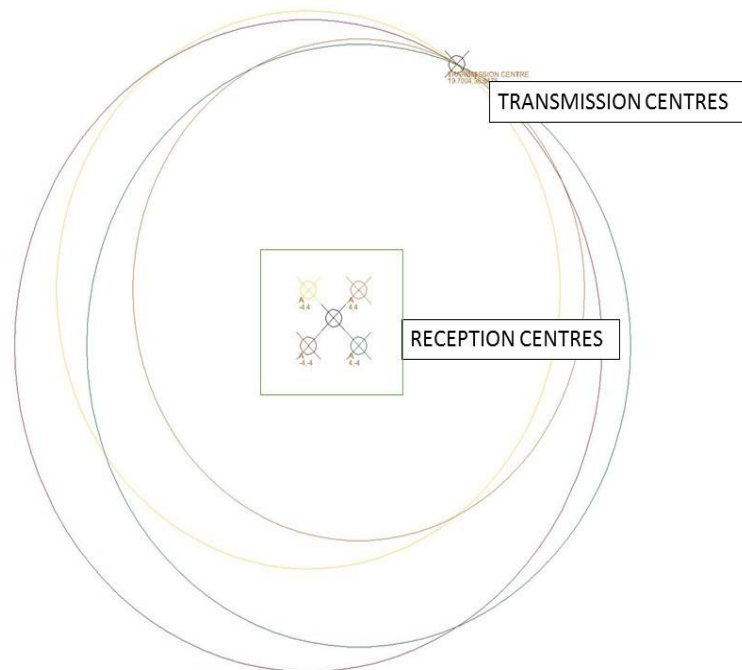


Figure 1: Geometrical Interpretation of Signals and Orientation Coordinates

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V. COMPUTATION OF COORDINATES

From the transmission centres the signals are transmitted which are sensed and interpreted at the reception centres which are having their co-ordinate id to calculation the position of the transmission unit using the below mentioned algorithm. The code was generated from a [5] mathematical equation

```
int x(x1,x2,x3,y1,y2,y3,r1,r2,r3)
{
    n1=((pow(y2,2))-pow(y1,2))+((pow(x2,2))-pow(x1,2))+((pow(r1,2))-pow(r2,2));
    n2=((pow(y3,2))-pow(y2,2))+((pow(x3,2))-pow(x2,2))+((pow(r2,2))-pow(r3,2));
    n=(y2-y3)*n1-((y1-y2)*n2);
    d1=(x1-x2)*(y2-y3);
    d2=(x2-x3)*(y1-y2);
    d=2*(d1-d2);
    return x;
}
```

Figure 2 Program(code) Used for the determination of coordinates

Program

To test the output of our logic we modelled an algorithm and programed it using C++ and verified the outputs on CAD software. The following is the screenshot of the program execution on a terminal window of virtual machine the readings from the code were the accurate and matching to that on the CAD software under the similar environments of variables.

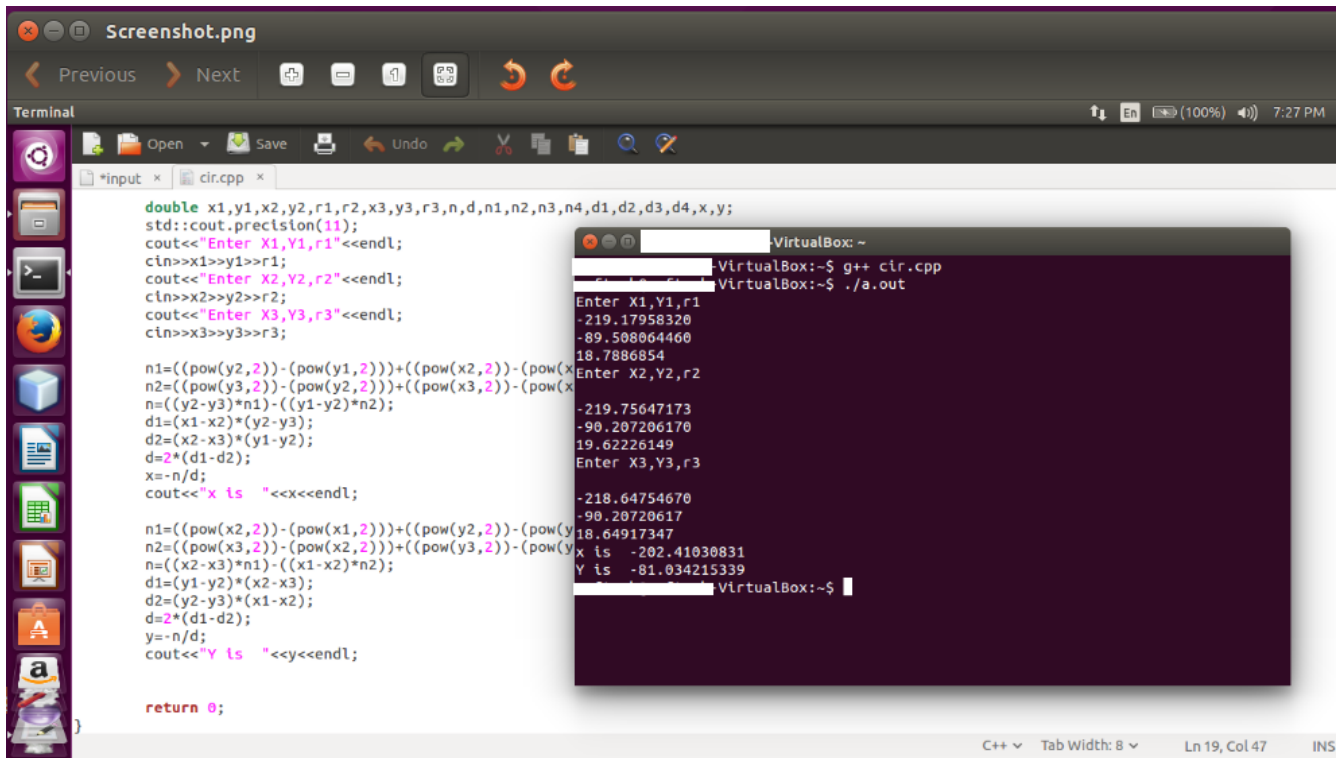


Figure 3 Screenshot

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Flowchart:

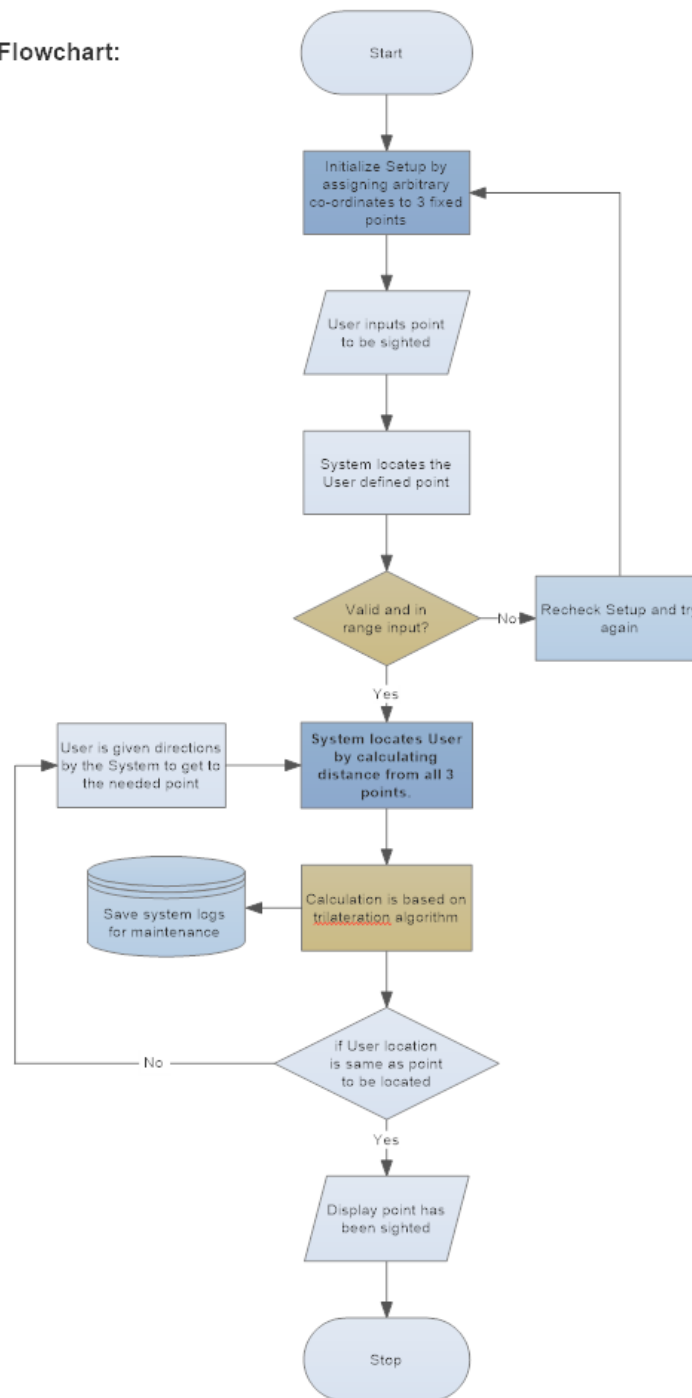


Figure 4 Flow Chart for the operation

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VI. APPLICATIONS

1. For precision position of objects in interiors of a structures at positions where GPS couldn't be applied.
2. For extensions of lines virtually to orient objects and provide other markings.
3. Use as a stakeout tool for the positioning of the dowel bar points for precast members.
4. For transmitting the points of the plan to the field for engineering and architectural purposes.
5. For tracing the path of an object.
6. For locating and position objects that are not visible or hidden behind obstructions.

VII. CONCLUSION

This technology could simplify the complex surveying works. This would also turn the projects economical, accurate and easy to perform thereby reducing the strain on the intensive labour requirement in the entire project. Though we have covered a number of points there are a number of areas with scopes of development.

VIII. SCOPES OF DEVELOPMENT

1. The tilting error of the set-up could be eliminated by adding a tilt control module that would be comprising of a gyro sensor and an algorithm to run it.
2. Error due to the difference in the medium of transmission can be eliminated by using the reciprocal mode of operation. In this paper we've mentioned only one way module. What could be done is that instead of having one pair of transmitter receiver it could be doubled and the output can be calibrated to eliminate the errors.
3. This could also be used as an IoT product for sharing and monitoring the relative positions of objects.

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