Evaluating the GPS Coordinates of Far Target by Using Laser Range Finder

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Abstract—**The GPS coordinates of a far target obtained using a laser range finder that gives the precise geographical location of a distant object or point of interest determined through the use of a laser-based device and combining this information with the device's orientation and positioning data to calculate the exact latitude, longitude, and elevation coordinates of the target. This paper presents a study on the evaluation of GPS coordinates of far targets using a laser range finder. The research focuses on the accuracy and reliability of GPS coordinates obtained through the use of laser range finders in various environmental conditions. The methodology involves comparing the GPS coordinates obtained through traditional methods with those acquired using a laser range finder. The results of this study provide valuable insights into the effectiveness of laser range finders in determining the GPS coordinates of distant targets, highlighting their potential applications in fields such as surveying, geolocation, and navigation.**

INTRODUCTION

The accurate determination of GPS coordinates for far targets is essential in various fields such as surveying, geolocation, and navigation. Traditional methods of obtaining GPS coordinates may face limitations when dealing with distant objects, leading to potential inaccuracies and inefficiencies. In recent years, the use of laser range finders has emerged as a promising technology for evaluating the GPS coordinates of far targets, offering improved precision and reliability in location determination [1].

Evaluating the GPS coordinates of far targets using a laser range finder is important for several reasons. Firstly, it allows for enhanced accuracy and precision in determining the exact location of distant objects or points of interest. This level of accuracy is crucial in fields such as surveying, geolocation, and navigation, where precise spatial information is essential for decision-making and planning. Furthermore, the use of a laser range finder for evaluating GPS coordinates of far targets can significantly improve efficiency and productivity in data collection processes. By enabling quick and reliable measurements over long distances, this technology streamlines the data acquisition process and reduces the time and resources required for mapping and monitoring activities. Moreover, the evaluation of GPS coordinates using a laser range finder can provide valuable insights into the performance and capabilities of the equipment in different environmental conditions. Understanding the accuracy and limitations of the technology in various settings is essential for optimizing its use and ensuring reliable results in real-world applications [2].

Overall, the importance of evaluating GPS coordinates of far targets using a laser range finder lies in its ability to enhance accuracy, efficiency, and reliability in geospatial data collection, making it a valuable tool for a wide range of applications across different industries.

This paper aims to investigate the effectiveness of using a laser range finder for obtaining GPS coordinates of far targets and compare the results with those obtained through traditional methods. By evaluating the accuracy and reliability of GPS coordinates acquired using a laser range finder in different environmental conditions, this study seeks to provide valuable insights into the potential applications and benefits of this technology in geospatial data collection and analysis. Through a systematic evaluation of the GPS coordinates of far targets using a laser range finder, this research aims to contribute to the advancement of location-based technologies and enhance the capabilities of professionals in fields that rely on precise spatial information. By addressing the challenges and opportunities associated with this innovative approach, this study aims to shed light on the importance of leveraging laser range finders for improving the accuracy and efficiency of GPS coordinate evaluation for far targets.

The structure of the paper will be as follows, section 2 discusses related work investigation, section 3 provides a methodology background of Laser range finder, section 4 will give a simulation scenario design and generated parameters and the final result will be showed in section 5, finally, in section 6 the conclusion and future work of the paper will be presented.

RELATED WORK

Previous studies have explored the use of laser range finders for evaluating GPS coordinates of far targets in various applications. In a study by [3], the authors investigated the accuracy and precision of GPS coordinates obtained through laser range finders in forestry applications. Their research highlighted the potential of laser range finders in improving

DOI:http://doi.org/10.24086/cocos2024/paper.1498

the efficiency of forest inventory and mapping processes by providing accurate location data for distant trees and vegetation. Similarly, [4] conducted a study on the use of laser range finders for determining GPS coordinates of far targets in military applications. Their research demonstrated the effectiveness of laser range finders in enhancing target acquisition and location accuracy in challenging battlefield environments, showcasing the importance of this technology in military operations. Furthermore, a study by [5] and [6] focused on the integration of laser range finders with unmanned aerial vehicles (UAVs) for evaluating GPS coordinates of far targets in agricultural monitoring. Their findings highlighted the potential of this integrated approach in improving crop management practices by providing precise location data for remote sensing and analysis.

These related works underscore the significance of evaluating GPS coordinates of far targets using laser range finders across various domains, showcasing the versatility and effectiveness of this technology in enhancing geospatial data collection and analysis capabilities.

SYSTEM METHODOLOGY

GPS (Global Positioning System) and laser technology are both used in various applications, including in the context of local coordinate systems. GPS relies on a network of satellites to determine the precise location of a receiver on Earth. It provides global positioning information, allowing users to determine their exact coordinates anywhere on the planet.

On the other hand, laser technology can be used for more localized and precise measurements. Laser systems can be used for tasks such as surveying, mapping, and alignment, providing highly accurate distance and angle measurements.

When it comes to local coordinate systems, both GPS and laser technology can be used to establish and reference points within a specific area. GPS can provide a broader view of positioning on a global scale, while laser technology can offer more detailed and precise measurements within a smaller area [7].

Overall, the relationship between GPS, laser technology, and local coordinate systems lies in their complementary roles in providing accurate positioning and measurement information for various applications.

1. Global Positioning System

GPS was initially intended for military use whenever anyplace on the surface of the earth. It soon became evident that GPS might be used by civilians in addition to military personnel for purposes other than personal positioning, as soon as the initial ideas were made. Surveying and sea navigation were the first two significant civilian uses to appear. recent applications range from in car navigation through truck fleet machinery [8]. a constellation of satellites that communicates coded data continually, allowing exact location determination on Earth using distance measurement from the satellite. One way to define position determination is as a triangulation procedure based on the user's measured range from four or more satellites. The ranges are inferred from the propagation time of the signals that was radiated form the satellite. Four satellites are required to determine the three coordinates of the target location.

Time is involved in the correction to the receiver clock and is ultimately eliminated from the measurement of position [9].

The total GPS configuration is encompassed of three following distinct segments: -

a. The space segment - satellites orbiting the earth.
b. The control segment - equator to control the stations positioned on the earth's satellites.
c. The user segment - anybody that receives and uses the GPS signal [9].

The earth is viewed from space as a uniform sphere, the surface is not uniform. Giving the coordinates for GPS at any point on the surface of the earth, a geodetic coordinate system based on an ellipsoid can be used. An ellipsoid commonly referred to a spheroid which has been flattened or squashed sphere.

The shape of the earth is most approximately as a sphere as estimated. Although this ellipsoid is mathematically defined, it lacks a physical surface. There are actually a lot of different ellipsoid or mathematical definitions of the earth's surface. The ellipsoid used by GPS is known as WGS 84 or World Geodetic system 1984 [10].

We can use latitude, longitude, and ellipsoidal height to define any point on the earth's surface (this is not the same as the surface of the ellipsoid).

An alternative method used by GPS for defining the position of a point is the Cartesian coordinate system, this method uses the distances in the X, Y and Z axis from the origin or center of the spheroid. This system is mainly used to specify the location of a point in space.

2. Local coordinate system

Local coordinate system (such as GPS coordinate) or coordinates aimed to be used in a particular country where maps are based on a local ellipsoid, designed to match the geoids in the area. Generally, In order to provide grid coordinates, these coordinates will have been projected onto a plane surface. In most of local coordinate systems, the ellipsoids, which were initially defined many years ago, were utilized all over the world, before the advent of space techniques [11].

It tends to fit the area of interest acceptable but could not be applied in other areas of the earth. Based on local ellipsoid of each country, mapping system and reference frame were defined. Once using GPS, the calculated positions from the coordinates are founded on the WGS 84 ellipsoid. Existing coordinates are usually in a local coordinate system and therefore the GPS coordinates have to be transformed into this local system [10].

The distance between two coordinate points of GPS is calculated by using the spherical Law of Cosines even for small distances

$$d = R.\cos^{-1}(\sin\varphi_1 . \sin\varphi_2 + \cos\varphi_1 . \cos\varphi_2 . \cos\Delta\lambda) \quad \dots (1)$$

DOI:http://doi.org/10.24086/cocos2024/paper.1498

Where φ_1 is latitude of the first point φ_2 is latitude of the second point, $\Delta\lambda$ is longitude difference of the first and second points, R is earth's radius (R=6371Km).
The bearing angle formula is for the initial bearing which if followed in a straight line along a great circle arc will take you from the start point to the end point.

$$\theta = atan2\,(sin\,\Delta\lambda\,.\,cos\,\varphi_2\,,cos\,\varphi_1\,.sin\,\varphi_2 - sin\,\varphi_1\,.\,cos\,\varphi_2\,.\,cos\,\Delta\lambda) \ldots (2)$$

3. Laser Range Finders

Laser range finder (LRF) is made to permit a quick measurement of the distance between the objects of interest in the field. There are LRFs are able to measure as vertical and horizontal. An LRF enables rapid distance measurement between the objects of interest at a study site. Some LRFs incorporate an inclinometer, digital compass and an angle encoder and can thus measure vertical and horizontal angles. An LRF is more portable and lighter than a TS, and a target reflector is usually unnecessary for the measurement of relatively short distances [12]. Although the accuracy of measurement by an LRF (decimeters) is inferior to that of a TS especially in terms of angular measurement, the prior is more appropriate for fast and mobile surveying. In addition, an LRF is usually much cheaper than a TS. High-resolution grid DEMs and triangular irregular networks (TINs) for small areas can be produced from a point cloud collected with an LRF [13]. If DGPS is combined with an LRF, an accuracy of the final DEM can be better than 1 m [13].

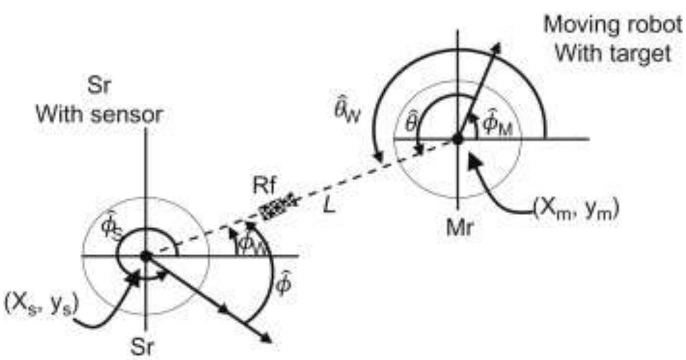

Figure 1. The range finder (RF) sensor mounted on the stationary robot (SR) observes the moving robot (MR) that carries the target.

The Specification of Laser Range Finder used in this paper shown in table 1 as follows:

Laser Range Finder	Specification
Model	H6 Laser Distance Meter
Wavelength	635nm
Power	1mW
FOV	34º

RESULTS AND DISCUSSION

In a practical analysis comparing GPS, laser technology, and local coordinate systems, it is important to consider the specific requirements of the task at hand.

GPS is ideal for providing global positioning information and is widely used for navigation, mapping, and location-based services. It offers broad coverage and can determine coordinates with relatively high accuracy, making it suitable for applications that require positioning information on a global scale.

On the other hand, laser technology excels in providing precise distance and angle measurements over shorter distances. It is commonly used in surveying, construction, and alignment tasks where high accuracy is essential within a localized area.

The distances and bearings angles are calculated from the GPS coordinates then compared with the measured distances using the laser rangefinder. The five different locations have different angles were chosen for reaching the one target object as shown in Fig. 2.

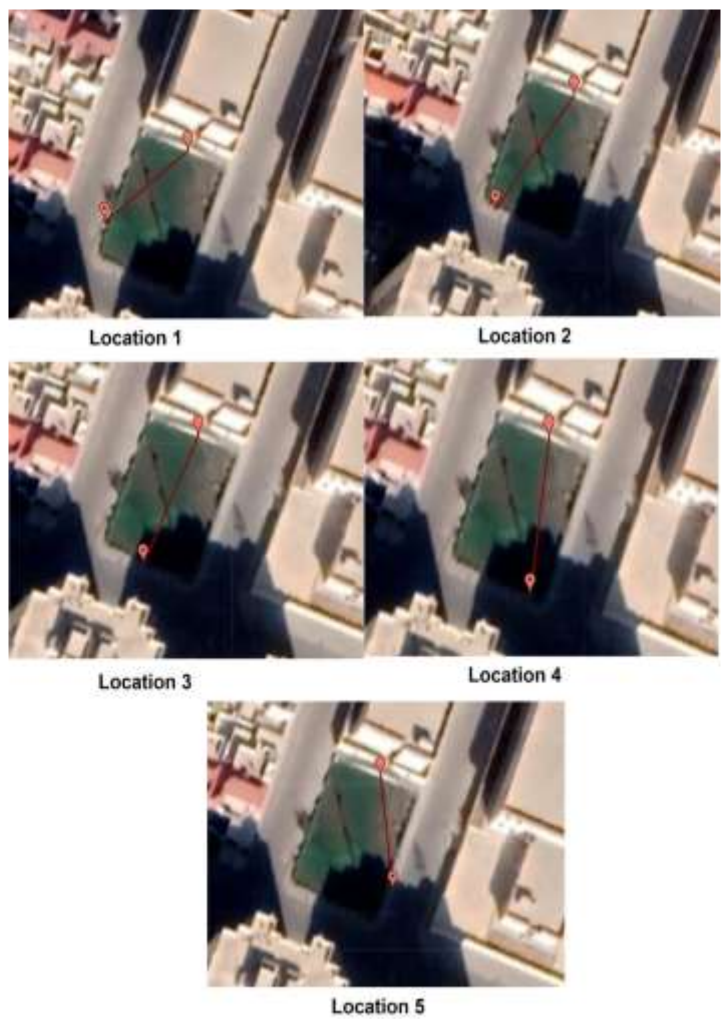

Figure 2. Three dimensional images of different locations using LRF

DOI:http://doi.org/10.24086/cocos2024/paper.1498

The information of suggested positions was given in table 2.

Table 2. Information of suggest positions

Locatio n	Latitude	Longitude	Calculate d Distance (m)	Measure d Distance (m)	Bearing Angle (degree)
1	36.29316 N	44.057999 E	21.84	21.23	51.978
2	36.29309 N	44.05801E	26.72	26.96	37.372
3	36.29307 N	44.05807E	25.85	25.65	24.806
4	36.29305 N	44.058150 E	25.95	26.83	8.141
5	36.29309 N	44.058219 E	21.39	22.16	-6.73

The calculated and measured distance vs. the bearing angle were shown in figure (3).

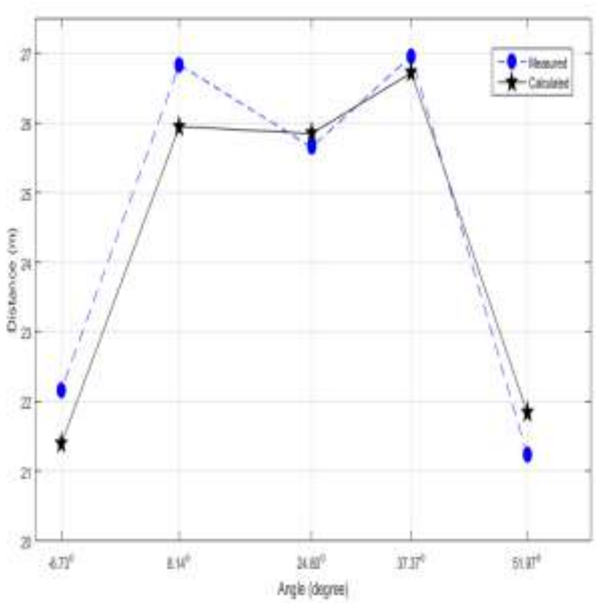

Figure 3. Calculated and measured distance vs. the bearing angle

The error percentage between theorical and measurement distances were given in table (3).

Table. 3 Error Percentage between theorical and measurement distances

Location	Error Percentage %
1	2.8%
2	0.9%
3	1.8%
4	3.3%
5	3.5%

The percentage of error between measured and calculated distances was shown in figure (4).

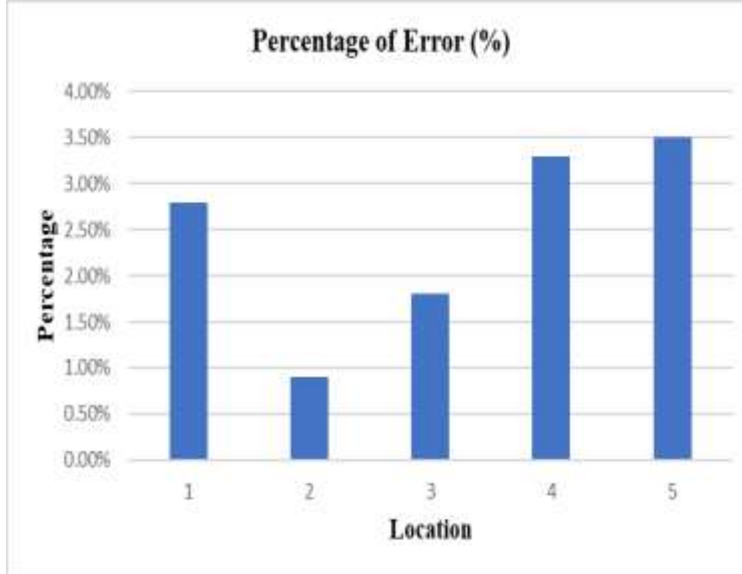

Figure 4. The percentage of error between measured and calculated distances

By analyzing the results shown in the Table.1, we found that the difference in the values of distance between theoretical and measurement. According to the different results. Table.2 and and Fig. 4 show the error percentage between theoretical and measurement values. The reason of the error percentage is misalignment of laser beam, the value of error percentage depends on the value of misalignment of course this percentage will increase with increasing the distance. the present paper took the distance within 40 meters because the limited power of laser range finder.

It is able to apply this system for furthest target distance if used a power laser range finder (several kilometer). Also, we found the effect of laser rangefinder field of view (FOV)) on the measurement.

COCULUSION

When it comes to local coordinate systems, both GPS and laser technology can be utilized to establish reference points and coordinate systems within a specific area. GPS can provide a broader context for positioning within the global coordinate system, while laser technology can offer detailed measurements for precise localization within a smaller area.

In practical terms, the choice between GPS and laser technology for a specific task will depend on factors such as the required level of accuracy, the size of the area being measured, and the availability of satellite signals. Combining both technologies can provide a comprehensive solution for tasks that require both global positioning information and precise localized measurements within a local coordinate system.

The combining laser rangefinder and viewshed technologies to improve ground surveys of invasive tree distributions. Using the laser range finder with joule work of GPS will support many civilian fields. The results of this article will be benefits for rescue teams in the middle of the ocean or rugged mountainous areas during crises. The alignment between the

DOI:http://doi.org/10.24086/cocos2024/paper.1498

target and the reference location is very Important. The size of the target it will effect on the measurement. Field of view (FOV) of laser range finder will effect on the measurement. There is a relation between the power of laser range finder and the distance of the far target.

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DOI:http://doi.org/10.24086/cocos2024/paper.1498