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Use of LiDAR in Topographic Map Mapping or Surface Mapping

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ABSTRACT

Topographic maps are mapping schematics that describe the shape of the Earth's surface through a number of elevation lines related to the slope of the land and the slope of the slope in the surface of the planet Earth (Suparno and Endy (2005). Accurate and efficient topographic mapping is becoming increasingly important as the needs of infrastructure development and regional management develop. LiDAR (Light Detection and Ranging) technology is present as a breakthrough in this field. LiDAR uses laser beams to measure distances, resulting in detailed data on the elevation and shape of the earth's surface. LiDAR's advantages in topographic mapping LiDAR can penetrate dense vegetation cover, produce accurate data in all light conditions, and offer wide area coverage. With LiDAR data, a digital elevation model (DEM) and a detailed contour map are produced. The use of LiDAR along with other mapping methods, such as aerial photogrammetry, further improves the accuracy and completeness of topographic map data. Finally, it emphasizes the role of LiDAR in providing valuable information for various purposes, such as development planning, disaster mitigation, and natural resource management. This technology uses lasers to collect information and data about the surface. The data is processed and the result is in the form of a 3D model and produces highly detailed and accurate point cloud data, which can be used to create a variety of mapping products, such as Digital Elevation Models (DEM), Digital Surface Models (DSM), Feature Maps and Orthofo Maps.

Keywords: *Map, Topography, LiDAR*

1 Introduction

3D models make topographic map analysis easier by making objects on the map appear clearer as they actually exist in nature (Khoerutunnisa, 2022). The content of the book includes the definition of photography, types of cameras, photo studio equipment, photography techniques and various photo concepts, as well as the use of light and the use of white balance. Liantoni, United States (Schreiber, 2022) Photography.

With a three-dimensional model, the objects on the map are seen more vividly as in the real state in nature, so that analyzing a topographic map can be easier to do (Lixinski & Morisset, 2024) Keywords: Map, Topography, Geography, Three-Dimensional. (Silvia Rostianingsih et al., 2004) When viewed from above, digital 3D contour lines look similar to traditional paper-based topographic maps, except in certain

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rare cases, where contour lines touch each other, overlap, and overlap. vertical slope exists or is depressed (Deline, B., Harris, R., & Teffend, 2015).

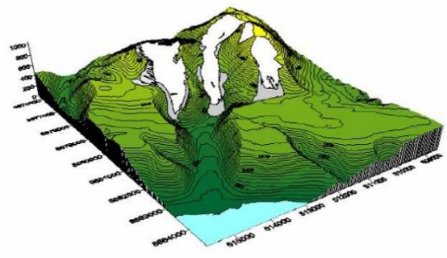


Figure 1 Topographic Map

Traditional mapping techniques have limited ability to capture in detail the detailed niche of the landscape. Technological advances have given rise to a new breakthrough, namely lidar that can collect information and data about surfaces, the result is a 3D model(Nugroho, 2021). One of the main uses of LIDAR in topographic mapping is to collect data on the relief of the earth's surface (Baitullah & Amin, 2015).

2 Research Methodology

Lidar technology can help in topographic map mapping. Setting clear and specific mapping goals can help in determining the type of lidar data needed, data reduction, and collection methods. Before choosing an area to be mapped, make sure the area is accessible and legal.also determine the time of data collection, flight altitude, and flight speed of lidar aircraft. to measure the distance from an object or surface. The Leader drone will fire a high-voltage laser containing laser pulses at the target to be mapped. These laser pulses are reflected back to collect information and data about the mapped area. (Putra, 2016)

For lidar data processing, the raw laser pulse will be converted into 3D dots and then calibrated the lidar data to eliminate noise and unwanted data. The results of the data calibration produced a DEM. It is then analyzed to identify topographic features, such as elevation, slope, and aspects. And topographic maps are ready to be made from DEM data and other reference data. Interpret the mapping results to understand topographic features and their characteristics. (Ruzgienė, 2010)Hassil mapping is presented in the form of maps, reports and presentations. Additional considerations in the process of mapping this topographic map,

There are different types of LiDAR data available, with their own advantages and disadvantages. The most appropriate type of LiDAR data to use will depend on the purpose of the mapping and the characteristics of the mapping area. The resolution of LiDAR data determines the level of detail of the data. Higher data resolutions will result in more detailed data, but they will also result in larger and more expensive data files to process. (Arrofiqoh et al., 2022) Data accuracy: The accuracy of LiDAR data depends on various factors, such as the type of LiDAR data, data resolution, and collection method There are various software available for processing and analyzing LiDAR data. To calculate the distance on LiDAR you can use the following formula:

$$\mathbf{d} = \frac{c \times t}{2}$$

Description: D : Distance between sensor and object measured (m)
c : Speed of Light (3 x 108 m/s)
t : signal travel time (s)

LiDAR can produce highly accurate data with high resolution. can collect data quickly and efficiently, even in hard-to-access areas. This technology can produce accurate, detailed, and comprehensive data quickly and efficiently. It is used in a variety of applications, including infrastructure planning, natural resource management, and archaeology.

3 Results and Discussion

Topography is information that contains information about the surface height of a location relative to sea level, which is represented by contour lines. LiDAR is a remote system that uses the properties of scattered light to determine the distance and information of an object (Fikri, 2019) The results of the LiDAR recording are in the form of point clouds in the form of x, y, z coordinates which represent a set of points measured on the earth's surface. LiDAR point cloud density, or point density, is determined based on flight altitude and flight speed. Lidar *(Light Detection and Ranging)* is an active remote sensing system that was developed in the early 1960s after the invention of laser technology and is used for distance measurement (Thenkabail, 2015). LiDAR is a remote sensor technology that uses a continuous laser beam emitted diffusely from the transmitter to measure the distance of an object (Alistair Pace, 2008). Topographic LiDAR uses infrared lasers for terrestrial mapping, while bathymetric LiDAR uses green light that penetrates water to measure the height of the seafloor and riverbed (Silvia Rostianingsih et al., 2004). The basic principles of LiDAR are presented on the working principles of LiDAR.

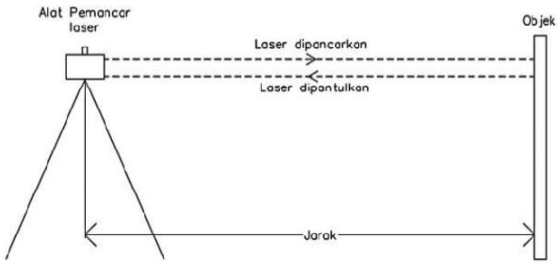


Figure 2 Basic Principles of LiDAR

The working principle of a LIDAR system is that the sensor emits a laser beam at a target that is at ground level. LiDAR devices consist of a combination of laser transmitters *(Laser Rangefinder*) and a scanning mechanism that can measure the distance to a target and its direction using a laser beam (Jaboyedoff et al., 2012).

The result of LiDAR is in the form of points (cloud points) that have coordinate values and are high. The advantage of this system is that it can be used to measure the height of the earth's surface following a detailed description of vegetation elements and their canopy, accurately, instantly, comprehensively, and produce dense data without much effort. (Nugroho, 2021) So that LiDAR technology can be used in various fields, such as archaeology, meteorology, geography, geology, forestry, geomorphology, seismology, environment and other fields ((Arun et al., 2016)

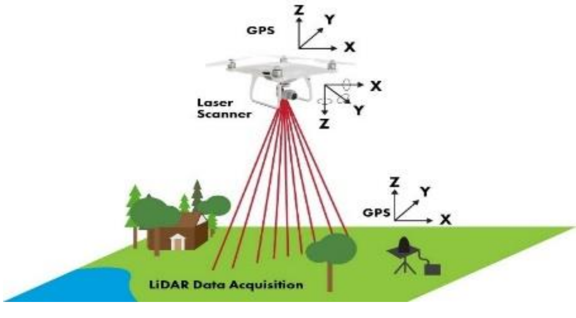


Figure 3 Data collection process using *Drones* Lidar

3.1 Types of Photography Mapping Tools

3.1.1 Total Station

Total Station: is a mapping tool that combines a theodolite (angle measuring device) with an electronic caliper. This tool is used to measure horizontal and vertical angles, distances, and slopes (Cosser et al., 2003)

Figure 4 Total Station

3.1.2 Global Positioning System (GPS)

GPS is a satellite navigation system to determine geographic positions with high accuracy using signals from satellites. The future of GPS analytics will involve further device miniaturization, longer battery life, and the integration of other inertial sensor data.(Aughey, 2011)

Figure 5 *Global Positioning System* (GPS)

3.1.3 LiDAR (Light Detection and Ranging)

This tool generates high-precision point data, which is used to create highly detailed topographic maps. For large areas, lidar uses airplanes or helicopters to record its area. For air-based ALS and for ground-based TLS (Jaboyedoff et al., 2012) Mapping Drones. Drones with cameras or Lidar sensors to collect topographic mapping data. Drones allow for fast and flexible mapping of hard-to-reach areas, and can generate accurate visual and spatial data(Buahbaranta Ginting et al., 2024)

Figure 6 LiDAR Detection and Ranging

3.1.4 Photogrammetry

It involves the use of aerial photographs or satellite imagery to obtain topographic information.

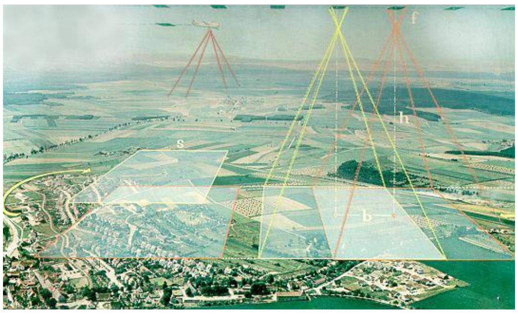


Figure 7 Photogrammetry

3.1.5 Distance Measuring Device

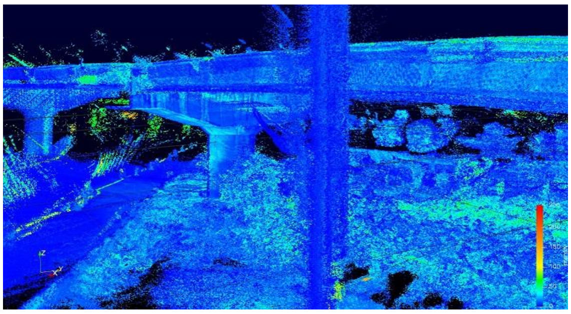
such as calipers, measuring wheels, or electronic devices such as EDM (Electronic Distance Measurement) are used to measure the horizontal distance between points on the Earth's surface.

3.1.6 Leveling Instrument

such as waterpasses, used to measure the difference in height between points on the Earth's surface.

3.2 Benefits of LiDAR for Topographic Mapping

Lidar can present 3D objects for the targeted surface, where from the results of this 3D information users can get output in the form of header height, vegering density to an image of other objects. In the process of data acquisition, laser beams are released from an aircraft onto the earth's surface with a certain beam angle. It is possible to accurately map locations on the earth's surface by knowing the location of aircraft and their distance from the earth's surface through GPS and IMU observations (Data from Edoa Buah baranta Ginting, 2024).



Picture 8 3D Objects on LiDAR

The advantages of LiDAR Topographic Mapping are:

1. High accuracy that has mapping with fine details and narrow median variation with vertical accuracy submeter and horizontal Centimeter level.
2. A large coverage of LiDAR data can be collected from a variety of sources, so it can cover a large area in a short time at a low cost.
3. Data processing can be processed to produce high-resolution digital elevation models that can be used for various terrain analysis.

The disadvantages of LiDAR in Topographic mapping are as follows

1. The use of LiDAR, especially through drones can lead to high operating costs
2. Heavy rain reduces the LiDAR's ability for continuous mapping.
3. LiDAR data needs to have storage capacity, high power, and procedures for sorting and validating data.

4 Conclusion

Mapping techniques and ray networks *LIDAR (Light Detection and Ranging)* has transformed topographic mapping with high precision and the ability to identify objects well. By using a laser beam, *LIDAR* can produce data on the topographic characteristics of the ground surface in both horizontal and vertical positions (Arrofiqoh et al., 2022).

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