Extrinsic Calibration of 3D LiDAR Using Sphere Targets and Target-Centered GPS

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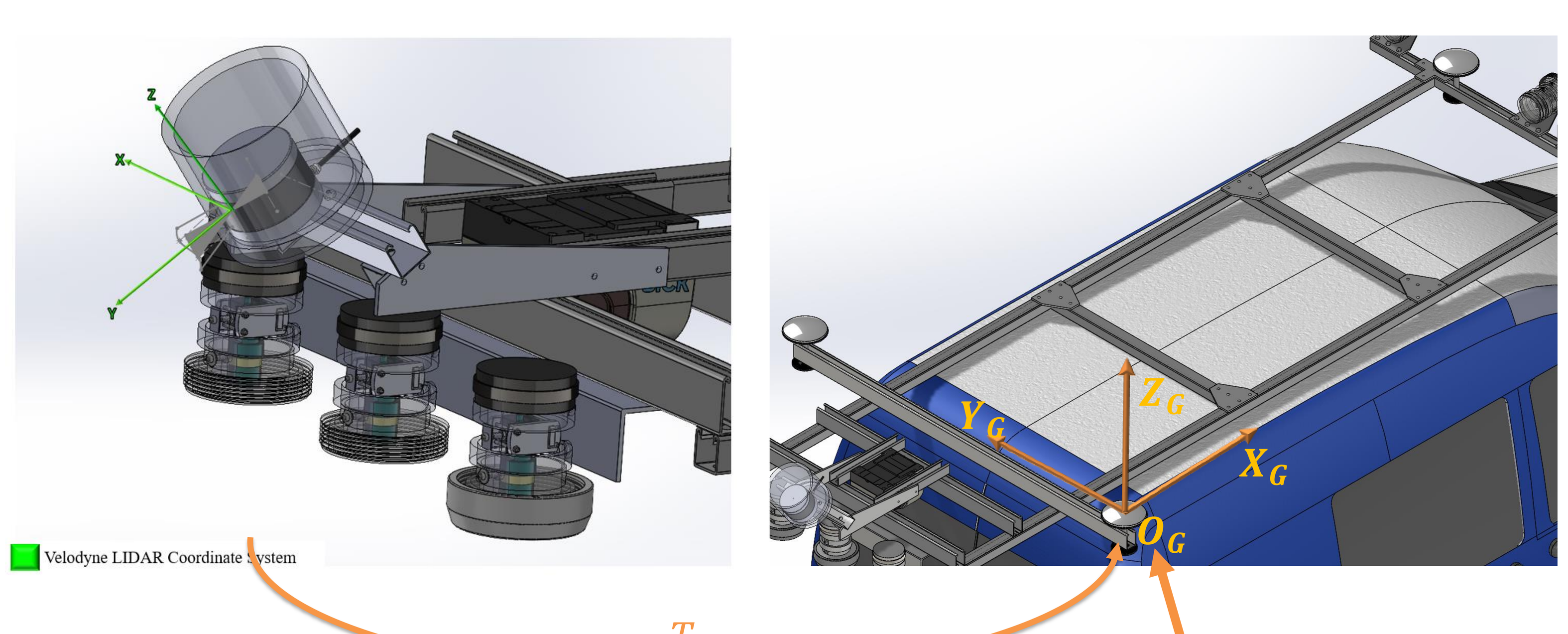
Introduction

- **Importance of Extrinsic Calibration:** Accurate road information is essential for autonomous vehicles and mapping systems. Extrinsic calibration for 3D LiDAR sensors involves aligning the sensor's coordinate frame with the vehicle's moving coordinate system and the ground reference frame. This process ensures precise point cloud data, which is crucial for navigation, object detection, and environmental mapping.
- **Challenges in Current Methods**: Existing calibration methods often face issues such as sensor misalignment, installation errors, and environmental factors that can affect measurement accuracy. These challenges can lead to inaccuracies in point cloud data, impacting the performance of autonomous systems.
- **Objective**: This study introduces a hybrid calibration approach that combines spherical targets, road surface data, and a differentially-corrected Global Positioning System (GPS). The goal is to enhance the precision and reliability of LiDAR-based data, making it suitable for real-world applications in autonomous driving and intelligent transportation systems.

Methodology

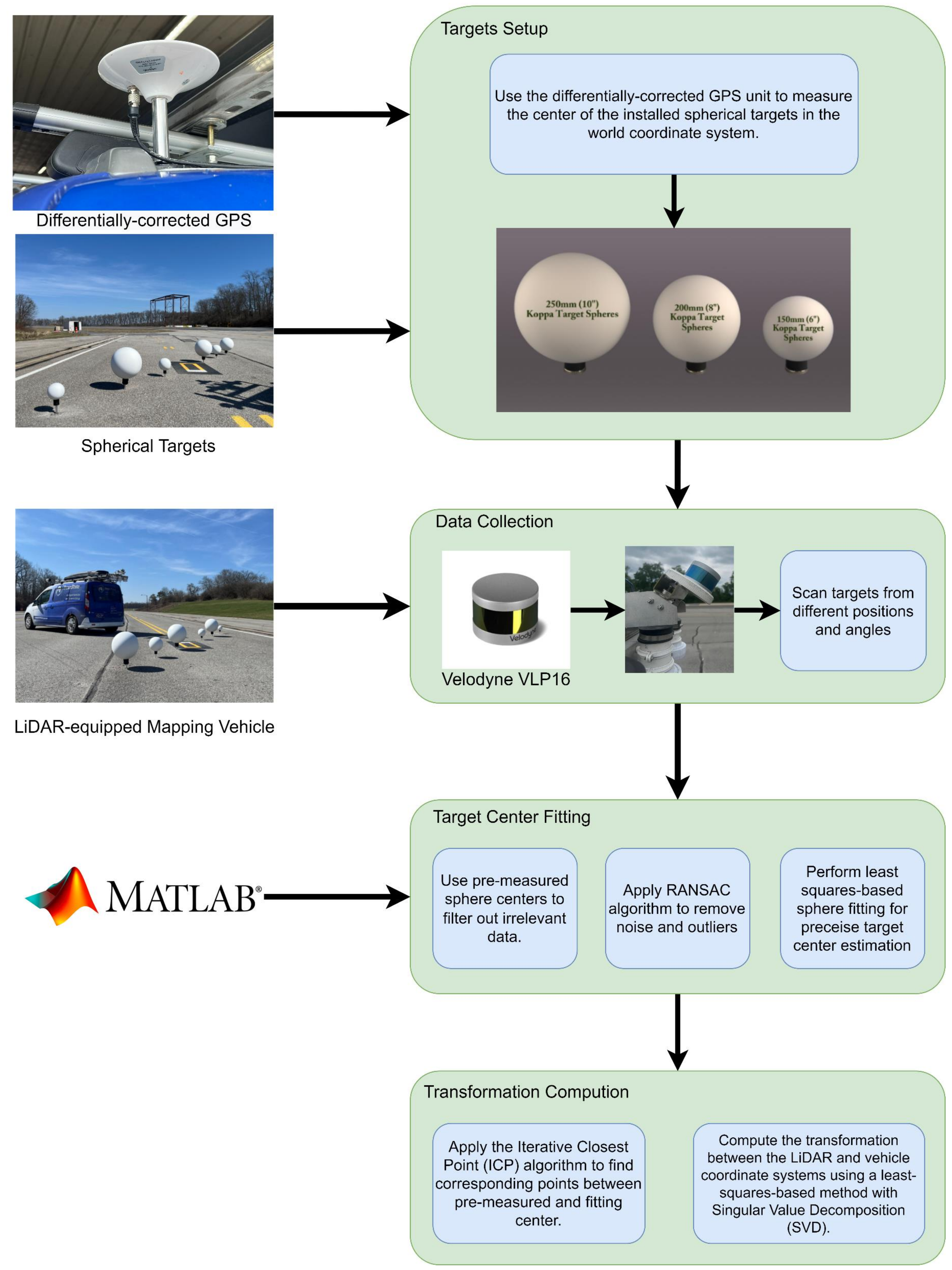
The relative pose of our Velodyne LiDAR to the vehicle origin is difficult to measure accurately, and directly obtaining the coordinate transformation between them is challenging. To address this, an intermediate coordinate system, rear right GPS coordinate system is established, which helps in determining the complete transformation. In previous research, the transformation from the GPS to the vehicle coordinate system has already been established. The goal now is to obtain the transformation from the LiDAR to the rear right GPS coordinate system.



O_G is the origin of the rear right GPS coordinate system, located at the rear right GPS antenna

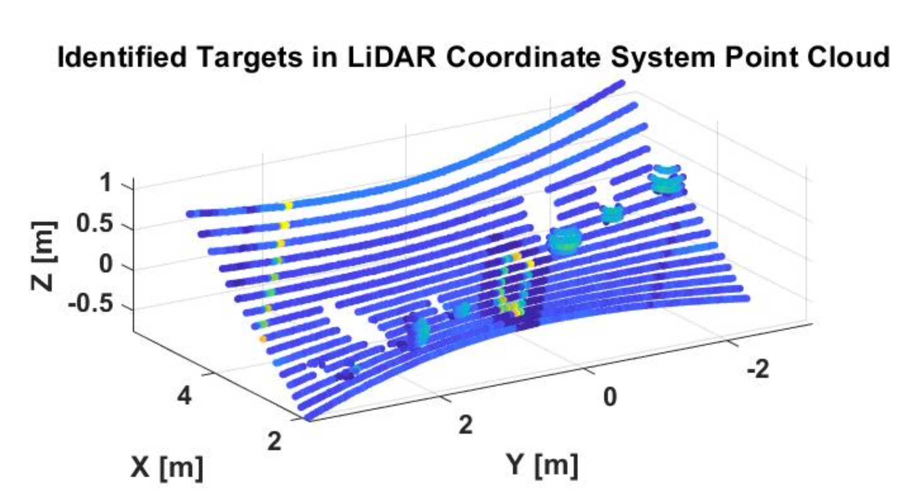
Methodology

Process Pipeline



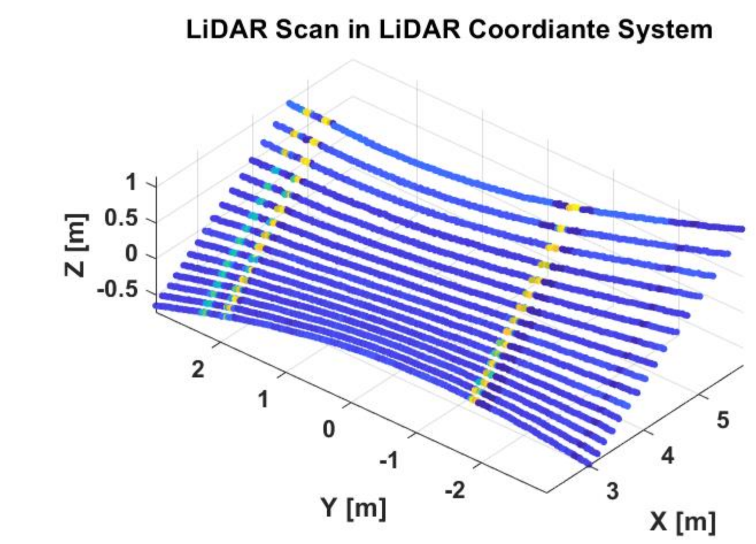
Experiments and Results

Experiment Setup – Scan Targets



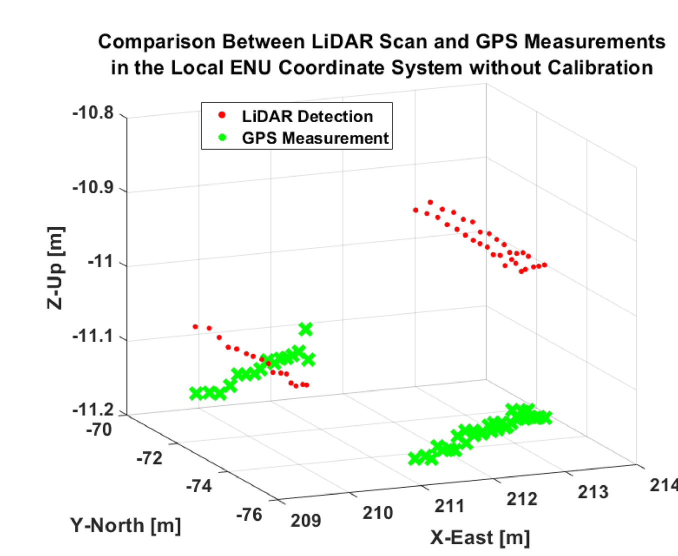
Experiments and Results

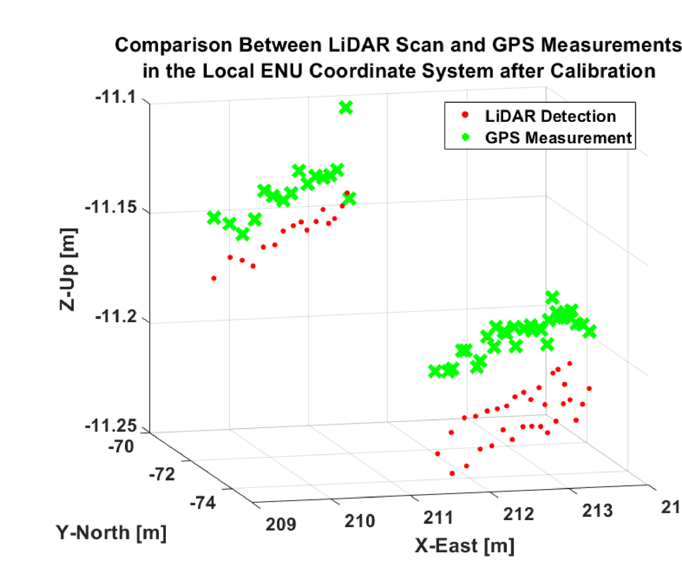
Experiment Setup – Data Collection and Analysis



- A differentially-corrected GPS unit was used to measure the centers of the lane markers.
- A lane marker detection algorithm was developed to extract the centers of lane markers.
- Compare the error between detected points and hand measured points.

Experiment Results





Comparison of LiDAR Scan and GPS Measurement				
Measurement Errors	X Error (cm)	Y Error (cm)	Z Error (cm)	Total Error (cm)
Minimum Error	0.11	0.01	0.42	3.30
Maximum Error	6.61	4.29	7.19	9.00
Mean Error	2.69	1.54	4.53	5.94
Standard Deviation	1.59	1.08	1.75	1.22

Conclusions

- This poster proposed a hybrid calibration approach, which combines spherical target detection, RANSAC filtering, least squares sphere fitting, and the ICP algorithm, effectively aligns the LiDAR sensor with vehicle and ground coordinate systems.
- Experimental results indicate that the proposed calibration method significantly reduces alignment errors between the LiDAR and GPS measurements, enhancing the reliability of spatial data and supporting precise mapping.