Lidar Cone Detection (LCD)

January 07, 2026
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Week 1: Introduction to Machine Learning

Machine Learning (ML) is a part of Artificial Intelligence that helps computers learn from data. Instead of giving the computer fixed rules, we provide data and let the system learn patterns on its own. As it sees more data, it becomes better at making predictions or decisions.

Types of Machine Learning

Supervised Learning

The model learns using labeled data, where the correct answer is already known. Example: spam email detection.

Unsupervised Learning

The model works with unlabeled data and finds patterns or groups on its own. Example: customer grouping.

Reinforcement Learning

The model learns by trial and error using rewards and penalties. It is commonly used in games and robotics.

Supervised Learning (SL)

Overview

Supervised Learning is a type of Machine Learning where the model is trained using labeled data. This means that for every input, the correct output is already known. The goal of the model is to learn the relationship between inputs and outputs so it can make correct predictions on new data.

How It Works

The model is given input data along with the correct answers. It makes predictions and compares them with the actual outputs. The difference between the prediction and the correct answer is called an error. The model then adjusts itself to reduce this error. This process is repeated until the model performs well.

Types of Supervised Learning

- Classification: Output is a category (e.g., spam or not spam)

- Regression: Output is a numerical value (e.g., house price)

Applications

Supervised Learning is used in email spam detection, exam score prediction, image classification, and fraud detection.

Unsupervised Learning (USL)

Overview

Unsupervised Learning is a type of Machine Learning where the data is not labeled. The model does not know the correct output. Instead, it tries to find hidden patterns or structures in the data by itself.

How It Works

The model analyzes the input data and looks for similarities and differences. Based on these patterns, it groups similar data points together or finds useful structures. There is no feedback about correct or incorrect answers.

Main Techniques

- Clustering: Grouping similar data points
- Pattern Discovery: Finding relationships in data

Applications

Unsupervised Learning is used in customer segmentation, market analysis, recommendation systems, and data exploration.

Week 2: Clustering in LiDAR Cone Classification

For Week 2 of our LiDAR cone-classification project, we studied two important clustering techniques: **K-Means** and **DBSCAN**. These are unsupervised learning methods that help group similar data points without using labeled data. Understanding these methods is essential for separating cone structures from LiDAR point clouds in our project.

Clustering - Clustering is a way to group data points so that:

- Points in the same group (cluster) are very similar, and
- Points in different clusters are quite different.
   This helps find hidden patterns in data when we do not already know labels or categories.

K-Means Clustering

K-Means is one of the simplest and most commonly used clustering algorithms. It works by dividing data into a fixed number of clusters, where each cluster has a central point called a centroid. The algorithm starts by placing centroids randomly and then assigns each data point to the nearest centroid based on distance. After this, the centroids are updated to the average position of all points assigned to them. This process is repeated until the centroids stop changing.

K-Means works well when clusters are compact and evenly spaced. However, the number of clusters must be chosen in advance. In LiDAR cone detection, K-Means can help group nearby points that may belong to the same cone structure.

DBSCAN Clustering

DBSCAN stands for Density-Based Spatial Clustering of Applications with Noise. Unlike K-Means, it does not require the number of clusters to be specified beforehand. Instead, it groups points based on how densely they are packed together. Areas with a high concentration of points form clusters, while isolated points are treated as noise.

DBSCAN is especially useful for LiDAR data because cone shapes are not perfectly regular, and LiDAR scans often include a lot of background noise. DBSCAN can detect clusters of any shape and naturally remove unwanted noise points, making it very effective for separating cone structures from the environment.

K-Means vs DBSCAN in LiDAR Applications

K-Means is easier to understand and faster to compute, but it struggles with irregular shapes and noise. DBSCAN is more flexible and robust, as it can handle varying shapes and automatically ignore noise. For LiDAR cone classification, DBSCAN is often more reliable, especially in real driving environments where data is messy and unstructured.

Introduction to RANSAC

As additional learning for this week, I watched two short videos on RANSAC (Random Sample Consensus). RANSAC is an algorithm used to find a correct model from data that contains a large amount of noise or outliers.

The main idea of RANSAC is to randomly select a small subset of data points and fit a model to them. This model is then tested on the full dataset to check how many points agree with it. Points that fit the model are called inliers, while the rest are treated as outliers. This process is repeated multiple times, and the model with the highest number of inliers is chosen as the best one.

RANSAC is especially useful when data is noisy, which is common in sensor-based systems like LiDAR. It helps in identifying meaningful structures, such as lines or planes, even when many incorrect or random points are present.

In the context of LiDAR cone classification, RANSAC can be useful for filtering out noise and detecting geometric structures before or after clustering. This makes it a valuable supporting technique along with clustering methods like K-Means and DBSCAN.