An unmanned vehicle object recognition algorithm based on LIDAR

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Abstract: Lidar unmanned vehicles, point cloud segmentation, point cloud clustering, pattern recognition, target tracking. The lidar is completed by dividing the cluster of non-ground and ground obstacles, and the obstacle detection is realized. After clustering, feature recognition is realized, the end-to-end detection algorithm of deep neural network is used, the target tracking is completed by Kalman filter, and the lidar unmanned vehicle driving technology is finally completed

1. Introduction

With the rapid development of new technologies, the trend of intelligent development is increasing, especially in the past decade, the wave of unmanned car driving technology has become more and more intense, so that the intelligent recognition algorithm about unmanned cars is also developing day by day. The identification of unmanned vehicles has become very difficult due to the different characteristics of different countries, different regions and different objects. Data that is more converted by intelligent identification cannot be properly identified and processed, which can lead to the death of unmanned vehicle technology. The identification and processing of different categories of data is the key.

For many environmental awareness schemes, there are most methods in the world, for example, depending on the sensor, resulting in different algorithms. There are purely image-based visual methods, but also LIDAR-based methods, and LIDAR is used for its stability and reliability, high precision and can be widely used for positioning. Processes are generally ground segmentation, point cloud clustering, pattern recognition, and target tracking.

Among the many object recognition algorithms, the unmanned vehicle object recognition algorithm based on LIDAR can greatly improve the accuracy of extracting data and grade the data. By clustering, identifying categories, and ensuring that different categories of data are treated differently during subsequent analysis, the identification of objects is realized. For radar data collection, the point cloud of the ground point and the target above the ground will have an impact on clustering, so dividing the radar point cloud ground is a necessary optimization step. Therefore, the pcl-ros cloud will be used to implement Voxel Grid Filter on the input point cloud, on the basis of which the point cloud ground and non-ground segmentation nodes will be realized.

2. Data Preprocessing

2.1 Point cloud data downsampling

For point cloud processing, point cloud processing is performed through PCL. PCL is a point cloud processing library with a large number of point cloud-related common algorithms and efficient data structure, and is a large cross-platform C++programming library. Point cloud processing includes a series of operations such as point cloud acquisition, filtering, segmentation, alignment, retrieval, feature extraction, identification, tracking, surface reconstruction and visualization. Point cloud data can be created by introducing PCL libraries into ROS projects.

First, link to the PCL library and use the PCL's built-in Voxel Grid Filter to down sample the original point cloud, which splits the input point cloud by setting a small cube with a smaller edge length, eventually representing a bit of the cube with a small cube's center, and saving the results of the sampled point. Secondly, the use of callback function points to two point cloud space, one is pointing to a point cloud data (a collection of points), the other points to a three-dimensional spatial point, because different colors of objects for the laser reflection intensity is also different, this three-dimensional space point can show the point cloud data through the reflection of the state, in other words, is the laser transmitter laser launch laser after encountering different obstacles finally received the intensity of reflection. Finally, the center of these small cubes is output, representing the result of the down sampling.

2.2 Point Cloud Data Filtering

Because ground obstacles can affect the automatic driving of unmanned vehicles, and points on the ground can have a significant impact on the clustering of obstacles, it is necessary to extract ground points and non-ground points for the purpose of LIDAR Obstacle Detection.

Ray Ground Filter's road filtration method can solve the separation problem very well, first of all, it can reduce the three-dimensional space of the point cloud to the two-dimensional space of the point cloud, calculate the angle between the laser and the direction of the vehicle to make several equal points. Secondly, for the judgment of obstacles, for areas too high need not be treated, for obstacles above a certain height threshold cannot be driven by unmanned vehicles caused by a measure of damage, so can be directly cropped to remove some non-ground point clouds.

Thus, the ground filtering pseudo-codes for distinguishing between ground and non-ground point clouds are obtained as follows:

// Ground filter pseudo-code description

Step 1 the original point cloud P input;

Step 2 Filter outlier points based on density distribution P*;

Step 3 Extract seed point set Pseeds point-to-point cloud P. P. Psorted by height.

order; Take the Nlpr point set Plpr with the smallest height; The height average of Pplpr is obtained as the seed point set Pseeds with a height less than (LPR. height and Thseeds) in LPR.height original point cloud P;

Step 4 According to the seed point set Pseeds, the fitted plane equation obtains the plane model model model;

Step 5 the original point cloud P and the plane model model model is smaller than

Theist’s ground point set Pg, otherwise it does not belong to the ground mark Png;

END

In addition, due to the influence of radar launch of the body itself, the radar laser that is too close will produce incorrect obstacle judgment due to the 0-distance reflection of the body, so the close point cloud is filtered, and the close range is still cropped to eliminate the inevitable error factor.

Finally, the ground and non-ground are judged by angle division, when 360 degrees are divided, the angle is equal, the isogram can be regarded as ray, and finally in the form of ray Ray to organize point clouds. It sets the slope threshold of two points adjacent to the same ray and the slope threshold of the whole ground, and finally determines whether the slope of the two points before and after the ray is greater than the set slope threshold to determine whether it is ground point and non-ground point. LIDAR can be detected when ground points and non-ground points are separated.

3. Clustering and Recognition

3.1 LIDAR Environmental Awareness

LIDAR environmental perception is divided into four parts. First, the ground is divided, thereby reducing the impact of the ground points on target detection. Second, point cloud clustering, the distribution of the target installation point is clustered, thereby reducing the calculation of subsequent calculations. Third, pattern recognition, feature extraction of split point clouds, pattern recognition using extracted feature training or end-to-end detection algorithms of deep learning neural networks. Finally, after the target tracking, after the pattern recognition is completed, not only the static target obstacles are analyzed and saved in categories, but also the dynamic obstacles are analyzed and preserved. Unmanned vehicles in the course of driving, in the image display is every frame is changing, when the target if stay in the previous frame, it will have a huge impact on the planning processing behind, so not only to cluster obstacles, get the outline of obstacles, location, more unique obstacles, and can continue to track obstacles, such as the use of Kalman filtering and other techniques to achieve.

3.2 Euclid Clustering

Euclid clustering uses a basic data structure - KD Tree. Because of the three-dimensional properties of the point cloud, a 3D tree will be used, and because in order to speed up clustering to meet the real-time needs of unmanned vehicles, the point cloud cluster compresses the Z-direction, focusing on the search in the x,y direction.

A spatial sphere is clustered into a point cloud cluster using the KD Tree data structure, while KD Tree defines a radius threshold and a maximum minimum clustering point threshold. The KD Tree data structure not only collects the point clouds within a certain radius threshold, but also forms the concept of clusters, which reduces the randomness of the point clouds caused by LIDAR due to randomness, and accelerates the search speed for clustering.

After the data pre-processing is completed, the results of the point cloud data on down sampling are obtained, and then the point cloud is divided by distance, and the key clustering radius threshold is set in the Euclid algorithm, and the concept of the set radius threshold plus cluster forms a new data structure of the point cloud cluster, in addition to Areas at different distances use different clustering radius thresholds to form a structure similar to a con center circle, in each ring, will eventually get a cluster of point clouds, and calculate the center of the shape as the center point, while calculating the length and width of the point cloud cluster, Make sure that a 3D Booking Box wraps the point cloud cluster. Finally, the three-dimensional point cloud cluster is flat into two-dimensional to speed up the detection of obstacle information.

From this we can get pseudo-codes about European clustering:

// Euth like-for-like split pseudo-code description

Step 1 Use Voxel Grid to down sample the point cloud;

Step 2 Split point clouds by distance, using different clustering radius thresholds at Different distances;

Step 3 Cluster and calculate the center of the obstacle and Bounding Box;

Step 4 Post the Booking Box of detected obstacles to the /detected_ bounding_boxs topic;

END

3.3 Pattern Recognition

Pattern recognition generally has two methods, the first for clustered points cloud direct pattern recognition, but because only dense point clouds can achieve stable and reliable pattern recognition, so the use of high-line radar or multi-radar combination to collect dense point clouds. The second is to use the camera for pattern recognition of the target, fusion image detection and point cloud clustering results to achieve target detection and classification, but this kind depends on the accuracy of image detection. Therefore, the optimization of point cloud clustering to reduce the error of pattern recognition is the most important.

Finally, the pseudo-code running process of the whole system is obtained:

// the system runs a pseudo-code description

Step 1 Radar collects point cloud data, release/velodyne topic;

Step 2 Subscriber 1 accepts/velodyne topics for ground filtering;

The filtered release/filter_points_ground and /filter_points_no_ground two topics;

Step 3 Subscriber 2 accepts/filter_points_no_ground cloud data from the topic for clustering;

Step 4 To split into the enclosing box, extract the length, width, height, coordinates and other data, to identify;

Identification result desplay;

END

4. Summary

For the flow of the general program, you can get the following flowchart:

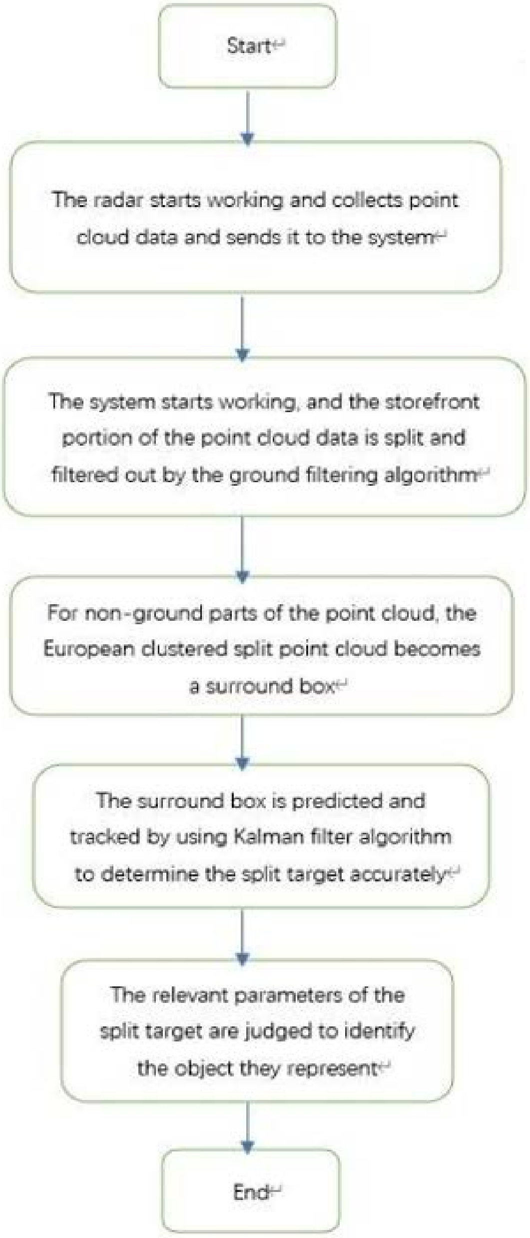

Fig.1 The flow chart of algorithm.

Results from operation and data can be obtained, if you need to collect a stable and reliable dense point cloud in addition to the use of high-line multi-radar, you can also use deep learning-based image target detection. In addition, according to Euclidean clustering, not only proposed a new concept of point cloud cluster, greatly reducing the repeated calculation operations for multiple dense points, and in the process of processing, the three-dimensional point cloud space is simplified to two-dimensional point cloud space, greatly reducing the complexity caused by dimensions.

In addition, according to the target obstacle obtained by Euclidean clustering algorithm, the target tracking using Kalman filter can not only identify the approximate type of obstacle, but also continuously correct the position and contour of the obstacle. The following Fig.2 shows the proportion of obstacle categories:

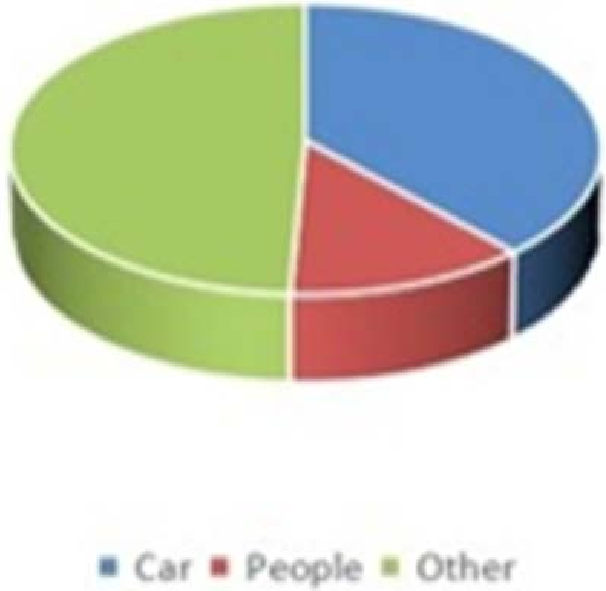

Fig.2. identify the distribution of object.

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