Retraction Notice

The Editor-in-Chief and the publisher have retracted this article, which was submitted as part of a guest-edited special section. An investigation uncovered evidence of systematic manipulation of the publication process, including compromised peer review. The Editor and publisher no longer have confidence in the results and conclusions of the article.

XZ either did not respond directly or could not be reached.

Laser radar-based intelligent vehicle target recognition and detection system using image detection technology

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Abstract. In recent years, with the progress of society and the development of the economy, the number of cars in China has been increasing. In wireless communication networks, the choice of wireless nodes has a greater impact on the improvement of system performance (such as channel capacity, coverage area, etc.). The intelligent vehicle target detection system can perceive and recognize the surrounding objects such as pedestrians and vehicles through sensors, which is the basis for realizing the unmanned driving of intelligent vehicles. In a wireless environment where multiple wireless nodes coexist, current research focuses on how long it takes to re-plan the selection of wireless nodes (for mobile environments) and how to allocate and manage wireless nodes, such as where under the conditions of wireless, who will wireless with whom, and in what way (such as auto focus, digital fusion, or other) wireless, etc.; the dedicated centralized controller (such as the base station of the infrastructure-based wireless access network) determines the wireless partner (i.e., centralized type selection), or the wireless node decides by itself (i.e., distributed selection); select the appropriate number of wireless nodes to take into account the system performance gain and implementation complexity. The popularity of automobiles has brought great convenience to people's lives, but it has also brought greater traffic pressure. At present, the amount of domestic automobile traffic has increased exponentially, and urban traffic congestion has become more serious, and even caused serious traffic accidents, directly affecting people's quality of life. The emergence of intelligent transportation systems has effectively alleviated road traffic pressure and reduced the incidence of traffic accidents. As an important part of the intelligent transportation system, the research of intelligent vehicles has received extensive attention. Intelligent vehicles use a variety of sensors installed on the body to sense the environment, and realize intelligent driving functions such as lane line detection, obstacle detection, dynamic cruise control, and unmanned driving, which is conducive to reducing the incidence of traffic accidents and improving the safety of vehicle driving. At present, in the research of target recognition and tracking of intelligent vehicles, the traditional target detection method is mainly based on artificial feature extraction, which is difficult to describe more complex or higher-order image features, and the tracking effect is not good, which limits the target detection. An intelligent vehicle is an intelligent system with functions such as environment perception, planning decision-making, and operation control, and is an important part of the intelligent transportation system. Identify the effect. In response to these problems, we present a study of the target recognition and tracking of intelligent vehicles based on grid map and lidar sensor technology. To verify the proposed method in the actual scene, we identify and track the vehicle ahead on the road through a car equipped with a lidar sensor. The meaning of target detection: target detection, also called target extraction, is an image segmentation based on target geometric and statistical features. The results show that the proposed research method can accurately identify the vehicle in front and detect the moving targets such as pedestrians. The tracking trajectory is also consistent with the expected route. The results show that the laser radar-based vehicle target recognition and tracking in this study is effective. In the 10 frames of images, the average time taken for the recognition of one frame of image is 9.8 ms, while the traditional method is 12.9 ms. Technology can improve reliable road information for intelligent vehicle driving and improve the transportation efficiency and safety performance of intelligent vehicles. There are two main target detection methods for lidar: detection methods based on feature extraction and detection methods based on grid maps. © *2022 SPIE and IS&T* [DOI: 10.1117/1.JEI.32.1.011203]

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1 Introduction

In recent years, with the rapid development of wireless communication technology and the rapid increase in the number of mobile users, users' demand for various real-time multimedia services has continued to increase. This requires the next generation of mobile communication systems to increase the data transmission rate while ensuring different service quality of communication business requires more advanced algorithms and technologies. To achieve this goal, researchers have done a lot of theoretical research, mainly including advanced signal processing and detection technology, channel coding and modulation technology, and various diversity technologies. For signal processing, there is no doubt that because the birth and development maturity of wired network is better than that of wireless network, which is why the wireless network is the development and extension of the wired network. It adopts electronic wireless communication technology to realize data transmission and reception, which can reduce the cumbersome connection requirements of users. Among them, because the multipath fading characteristic of the wireless channel is the main reason that affects the improvement of quality of service and the increase of system capacity, the diversity technology is very important. Since reform and opening up, China's automobile manufacturing industry has developed rapidly, and with the substantial improvement in domestic road traffic conditions, China's car ownership has increased rapidly. According to the data given by the Ministry of Public Security, the current national car ownership has exceeded 250 million, ranking the world's forefront. With the continuous increase of urban car ownership, more and more cities are facing traffic problems such as traffic jams and frequent traffic accidents, which have a serious impact on people's lives and property safety.[1] In this context, the intelligent transportation system came into being, and it has developed rapidly in recent years. Intelligent transportation system combines the four elements of transportation human-car-road-environment using modern information technology such as internet of things, cloud computing, and big data to fundamentally improve transportation efficiency, alleviate congestion problems, and reduce traffic accident. As an important part of intelligent transportation system, intelligent vehicles have always been the research focus of relevant researchers and institutions. For smart vehicles, it is always an important indicator to measure the performance of smart vehicles by being able to identify and track targets in front of vehicles and detect pedestrians or obstacles during driving.[2] What is a wireless network, i.e., on the basis of electronic information technology, a new type of computer network that combines the latest computer network and related wireless communication technology and uses wireless transmission as a medium.

Through target geometric feature extraction, the target scanned by the four-line lidar can be extracted. With the rapid development of wireless cooperative communication technology, complex algorithm protocols, and high-speed data transmission require more and more bandwidth and energy, and the network structure is becoming more and more complex. Reasonable allocation has become an urgent research issue in the field of collaborative communications. In general, vehicle target recognition is a prerequisite for vehicle tracking. It is only possible to have a correct tracking trajectory if the vehicle target is correctly identified. Vehicle target identification package for vehicle type identification, license plate recognition, vehicle position recognition, and the like. At the beginning of the 21st century, theoretical research on vehicle identification has begun to mature. Viola et al.[3] proposed an algorithm framework based on AdaBoost, which accurately identified the position of the vehicle using wavelet feature classification and sliding window. Gavrila et al. proposed a hierarchical matching algorithm. The basic idea of the algorithm is based on samples of different shapes, and by matching different templates, it achieves better real-time effects in vehicle recognition.[4] Felzenszwalb et al. proposed a direct part mark target class detection algorithm based on deformable component model,

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which includes root filter and component filter. The use of these two types of filters takes advantage of histogram of oriented gradients features and support vector machines (SVM) classifiers. It is conducive to improving the accuracy of vehicle identification.[5] Zhu and Guo proposed a feature-based vehicle identification method that selects geometric features as vehicle features, including vehicle length, vehicle height, and the ratio between several typical parts of the vehicle body, using radial basis function neural network pairs. The vehicle is identified by the vehicle.[6] Yang et al. used the pixel-weighted list to extract the vehicle foreground, and used the vehicle area size to form the space-time contour geometry image to obtain the vehicle model for vehicle type identification. This is also a vehicle-based identification method, but based on other methods. In terms of the method of vehicle feature recognition, since the method combines time and space, real-time is better in vehicle recognition.[7] Nazemi et al. studied the sparse feature coding method, which is to extract the characteristics of the vehicle by image, obtain the scale-invariant feature transform (SIFT) features of the vehicle, and then use the SVM classifier to classify the extracted features to realize the vehicle identification.[8] Qian et al. extracted pyramid histogram of oriented gradients and feature local binary pattern-equivalent operating hours features from vehicle images. In addition to extracting these two traditional features, the research method also extracted decibel relative to one milliwatt high-level features, and then merged the two types of features. The SVM classifier implements vehicle type recognition. In the field of vehicle identification research, this is a new model based on feature recognition.[9] Bochum et al. proposed a vehicle recognition method based on scene model and the image segmentation information obtained by clustering through the shadow of the vehicle and the geometric information of the vehicle, combined with the image segmentation information obtained by the clustering algorithm. The scene is modeled to complete vehicle target recognition. This method has achieved good recognition results in later experimental verification.[10] Hinz and Baumgartner used the relationship between vehicles and other objects (such as roads) and the direction of shadows of these objects to propose a vehicle model based on hierarchical models. The advantage of this method is that it is not too sensitive to the change of the attitude of the vehicle, and has less dependence on external information such as the scale map. It has a wider application in actual vehicle recognition, but if there is a difference between the vehicle target and the background color. When it is low, it is prone to false detection and missed detection.[11] On the basis of extracting the color characteristics and vehicle characteristics of the target vehicle, Jiayun et al.[12] calculated the Euclidean distance of these feature vectors and compared them with the database for vehicle identification. Xiaodong et al.[13] used multi-branch convolutional neural network to extract the feature of each segment of the car face image, and compared the similarity values of these features, and determined the vehicle model according to the comparison result. According to the scale space analysis of the generated image, Wang Zhengrong analyzes the SIFT feature matching and uses the BBF search method to quickly realize the search task of the deck car comparison.[14]

Through the review of historical documents and the analysis of the current research status, it is found that the following problems exist in the identification and tracking of intelligent vehicles:

1. Intelligent vehicles generally use sensors as cameras and the detection distance is relatively close, conditions that are easily affected by the surrounding environment, such as low light, rain, and snow, and the camera needs to consume a large amount of processor capacity when performing image recognition processing.
2. In the obstacle detection of intelligent vehicles, obstacles such as trees and buildings outside the road are also detected, which undoubtedly increases the workload of the processor. In addition, it is prone to false detections and missed inspections.
3. When performing target tracking, it is easy to be affected by external factors and cause deviation of the tracking trajectory. When performing multi-target tracking, when one of the targets changes, it often leads to the tracking failure of the smart vehicle.

Lidar is a combination of laser, atmospheric optics, target and environmental characteristics, radar, opto-mechatronics, and computer technology. Its core is laser emission system and laser receiving system. The laser emitting system emits a laser beam with a small divergence angle and

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concentrated energy; the laser receiving system detects and receives echo signals such as reflection and scattering that are irradiated onto the target.[15] The basic technology of laser radar is derived from microwave radar, and there is no essential difference between the two. Conventional radar is a radar with microwave and millimeter wave carrier. The laser radar uses laser as the carrier and its wavelength is much shorter than microwave and millimeter radar waves. With the continuous development and popularization of laser technology, the application field of laser radar is also increasing.[16] In terms of three-dimensional (3D) printing, where laser radar is also used, such as Printoptical3D printing technology is essentially a one-stop technology from computer-aided design to optical components, the printed optical components do not need to be polished, ground and coloring such post-processing. This technology is based on a mature wide-format industrial inkjet printing device that is sprayed out of ultraviolet (UV)-cured transparent polymer droplets and then cured by a strong UV lamp integrated into the printhead to form a wide variety of geometries. Lidar plays a role in measuring and monitoring.[17] In the game using augmented reality head display, the space-sensing positioning technology used will use lidar and many matching optical sensors, and accurately position itself in 3D space through simultaneous localization and mapping technology (instant positioning and map construction). Enhance the real experience in the game.[18] In recent years, environmental issues have received wide attention, and the protection of the marine environment has become a consensus. Marine laser radar has become the mainstream as an advanced means of ocean exploration and monitoring. The applications related to lidar and marine life are mainly reflected in fishery resources survey and marine ecological environment monitoring. The former often uses blue-green pulsed light as the excitation light source. The identification of the laser echo signal is used to obtain the fish population distribution area and density information. The polarization characteristic analysis can be used to identify the fish species. The latter often uses the marine laser fluorescence radar. By analyzing and analyzing the spectral signals such as fluorescence emitted by the laser-induced target, the species and concentration distribution information of marine plankton and chlorophyll are obtained.[19] In modern warfare, the detection and identification of targets play an important role in technologies such as precision guidance technology, anti-stealth technology, photoelectric countermeasure technology, and C5I (command, communication, computing, control, confrontation, and intelligence). Obtaining the right to battlefield information has become the key to mastering the initiative of war. Lidar and related technologies have become an important part of information command systems and weapon systems.[20] Lidar can detect, track, identify, and aim at targets around the clock. The reconnaissance satellite relies on laser multi-spectral imaging to obtain a large amount of information day and night; it can provide and identify accurate information of incoming missiles, and strive to intercept the warning time; it can also alert the incoming missile and the other source or threat, automatically issue a confrontation command, and initiate the initiative. Interfering devices for self-defense.[21]

The target detection method based on feature extraction is to use the original scanning points of the lidar to extract some features of the target, and to detect and judge the target through these features. As a new technology, laser radar has more space to expand in the future, and different scene requirements are different. Using the time of flight of the laser radar, i.e., according to the return time of the laser after encountering the obstacle, the relative distance between the target and himself can be calculated. The laser beam can accurately measure the relative distance between the contour edge of the object in the field of view and the device. These contour information form a so-called point cloud and draw a 3D environment map with an accuracy of up to centimeter level, thus improving measurement accuracy.[22] Therefore, lidar technology can be applied to the research of key technologies for intelligent vehicle target recognition and tracking. This paper mainly studies the intelligent vehicle identification and tracking technology based on laser radar-based vehicle target recognition and tracking and obstacle detection based on grid map. In vehicle identification, the lidar sensor acquires more information than other types of sensors, and can directly acquire the distance, angle, reflection intensity, speed, and other information of the target to generate a multi-dimensional image of the target. Compared with the traditional research methods, the method proposed in this paper obviously improves the recognition rate of the vehicle, thus ensuring the accuracy of the tracking trajectory and effectively detecting the obstacles in the tracking process.

2 Method

2.1 *Lidar Principle*

Regarding the working principle of the laser radar, simply speaking, when the radiation is irradiated to the target, the laser radar uses the echo radiation generated by the reflection, refraction, scattering, and transmission of the target to detect. The basic components of lidar include three parts: transmit, receive, and post-signal processing, as well as the mechanisms that coordinate these three parts.[23]

2.1.1 *Launch part*

The transmitting portion includes a laser emitter, a laser modulator, a beam controller, and an optical transmitting antenna. The laser emitter consists of a laser and a laser power supply, and can be equipped with laser modulation. The laser modulator modulates the emitted laser light into a desired waveform (continuous wave or pulse) and parameters (amplitude, frequency, phase, etc.). It can generally be achieved by controlling the laser power supply and the beam control mechanism. The beam controller controls the position, direction and beam width of the laser beam in space, and the matrix laser beam can also be obtained by a micro-optical systems, such as a matrix mirror, a matrix grating, or a matrix filter. The optical transmitting antenna, also called the transmitting telescope, shapes, and compresses the laser beam to become the required waveform and parameters, and shoots into the space to maximize the illumination energy obtained by the distant target. Traditional imaging lidars also require optomechanical scanning.[24] A pulse usually refers to a short-lived pulse-like electrical impulse (voltage or current) that is often used in electronic technology. The main characteristics are waveform, amplitude, width, and repetition rate.

2.1.2 *Receiving part*

The receiving portion includes an optical receiving antenna and a photodetector. The optical receiving antenna, also called the receiving telescope, converges the energy of the reflected or scattered laser signal returned from the target, and corrects the wavefront so that the laser echo enters the photosensitive surface of the detector. The optical receiving antenna and the optical transmitting antenna can be either separated or combined. The photodetector directly converts the returned laser signal into an electrical signal, or mixes with the local oscillator light obtained by the splitter to obtain heterodyne reception and obtain an electrical signal. Array detectors can also be used to increase sensitivity or image detection.

2.1.3 *Signal processing and control section*

This part includes signal preprocessing, signal processors, servo systems, and communication systems. In the signal preprocessing part, the preamplifier first performs the matching filtering, denoising, signal-to-noise ratio enhancement, frequency, phase, and polarization preprocessing on the electrical signal output by the detector, and then amplifies to a certain power through the main amplifier. The signal processor processes various signal parameters into information containing distance, velocity, angle, and characteristics of the target image, and then converts it into a digital signal through an analog-to-digital converter, and sends it to a main processors, such as a computer or a microprocessor to become a main processor. Data and image information that can be analyzed and displayed and transmitted. It can be transmitted via a communication system, displayed on the screen via an image processing system, or sent to a servo system. The servo system controls the tracking frame of the lidar platform to track the captured target according to the angle and angular velocity information provided by the main processor. The communication system transmits the signal output by the main processor to the command and control center by wireless optical communication.[25]

According to the laser beam, laser radar can be divided into multi-point laser radar and single-line laser radar. Multi-point laser radar refers to the laser light emitted by multiple sources of laser radar, which is multi-wire bundle. Single-line laser radar is a single-wire harness from a laser source. The single-line laser radar has only one transmission and one reception, and the structure is relatively simple and the scanning speed is high. Single-line lasers are more advantageous than multi-line lidars in terms of pedestrian detection, obstacle detection (small target detection) and front obstacle detection, because single-line lidars have higher angular resolution than multi-line lidars and are more reliable. High, this is very useful in detecting small objects or pedestrians. The biggest advantage of multi-line radars over single-wire bundles is the ability to track the motion of multiple objects. Therefore, this paper chooses a single-line radar sensor for vehicle identification, and selects a four-wire radar sensor for target tracking experiments.

2.2 *Lidar Target Feature Extraction and Recognition*

Lidar target feature extraction is mainly divided into two steps: region segmentation and feature extraction. The segmentation phase mainly completes the classification and identification determination of the feature patterns, i.e., determines which types of modes the features belong to, such as lines, arcs, etc., and determines the laser data point sets in the regions and regions belonging to the feature mode. The feature extraction stage mainly completes the determination of various feature pattern parameters and the extraction of feature points.

For each frame of distance data, the laser scanning point is first divided into different blocks. If the distance between two consecutive scan points is less than a threshold, the two scan points belong to the same block. If the distance between two consecutive scan points is greater than a threshold, the data frame is split from this place. Finally, one frame of distance data is divided into several blocks. The divided blocks are denoted as R_i ($i = 1, \ldots, Q$, where Q is the number of divided blocks), and each block includes N_i points. Since the distribution of the scanning points is not uniform, in general, the density of scanning points near the sensor is larger, and the density of scanning points away from the sensor is smaller. Therefore, when performing distance data segmentation, an adaptive variable threshold segmentation method is applied. For example, when the distance of a certain scanning point from the center of the sensor is D, the dividing threshold is selected as d, and when the distance of the scanning point is 3D from the center of the sensor, the threshold is selected to be 3d. In addition, other linear or nonlinear functions can be used to define the adaptive segmentation threshold. In short, different segmentation thresholds are selected at different scanning points, so that the segmentation block of the distance data can be better consistent with the actual environment feature model. If the effective distance of the laser is k meters and the angular resolution is α deg, the distance between adjacent scanning points is at least: $2k\,\sin(\alpha/2)$. Based on this value, an appropriate separation threshold can be set.

In the data of lidar scanning, there are several important features: tear point, corner point, straight line, and arc. The fold line can also be regarded as a feature, which can be understood as the characteristic of straight line plus corner points.[26] In the previous segmentation, the tear points in the data have actually been found. Considering that the target of the detection is a vehicle, and the target of the vehicle scanned by the lidar is generally a straight line or a line close to the L-shape, the straight line as a key feature is the key to extraction, and the fold line is also ubiquitous, then the corner point The detection is also an unavoidable problem. Therefore, first extract the corner points and break all the broken lines into straight lines and corner points. Assuming that there is a polyline with only a single corner, then the multi-deformation fit can be used to determine the position of the corner. First, fit the points in the area into a straight line, and then find the point farthest from the line. If the distance is greater than a certain threshold, it can be regarded as a broken line, and the point is the dividing point of the broken line, otherwise it is a straight line. When an area contains multiple corner points, iterative or recursive method is needed, and the corner points are continuously searched, split into two parts, and looped until there is no corner point in each area. If there is no corner point in a certain area, and the point data are relatively large, then it is generally a straight line. The principle of straight line fitting can use the least-square method, or the weighted least-square method can be used to improve the accuracy of the fitting. The weighted least-squares method fits the line. The measurement data in the target recognition process is converted into the minimum enveloping rectangular area, and then

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compared with the external dimensions of each vehicle in the database, the best identification of the target identity can be achieved.

2.3 *Multi-Target Tracking*

When the lidar is used for target tracking, the road scene faced by the intelligent vehicle has multiple targets for most of the time, accompanied by the disappearance or sudden appearance of the target. In addition to these further processing, there are some undesired components, including trees, buildings, or some traffic signs often treat these undesired components as clutter and filter them out. After the feature information of the target is acquired, the distance, speed, and angle information about the target are obtained at this time. The following data need to be processed to get the target's motion status, etc., including where the current target will be at the next time, and what kind of motion exists. The motion estimation method for the next moment of the target is usually linear or extended Kalman filtering, and other tracking filters include multi-hypothesis tracking, fixed-gain Kalman filtering, and $\alpha - \beta$ filtering. A major part of the lidar tracking process is the association of data, and often requires the management of the trajectory, the need to develop rules, including when to create a new trajectory, when to delete the wrong trajectory. Kalman filtering is an algorithm that uses the linear system state equation to optimally estimate the system state through the system input and output observation data.

Generally, before data association, some pre-processing of the data containing the target is needed, and the undesired data are removed to reduce the influence of the undesired target in the environment. The culling method can usually be judged by the speed of the target, and other pre-processing includes the limitation of the distance and the limitation of the range of angles, and only the effective area is processed. To obtain information about the relative speed and angle of the target, when the vehicle equipped with the laser radar is in motion, factors such as the traveling speed and curvature of the vehicle should also be considered when processing the data. After the pre-processing of the data, the next step is to process the target after the undesired target, including other vehicles, pedestrians, and other targets. The pedestrians and the moving vehicles mentioned above are not completely point-like in the distance and speed upwards. Therefore, multiple target data belonging to the same real target are required to be clustered, and the clustering can establish the corresponding distance and speed. Judging with the angle gate, the targets falling within the same specific area can be regarded as the same target.

The method used for data association is the Hungarian algorithm, which solves the problem of optimal staffing. The same idea can be used in radar tracking processing. Use this method to get the target position and estimate the best match, the match refers to the trajectory between the currently active trajectory and the currently detected target. After the association, the trajectory and state need to be updated and managed, and then the Kalman filter can be used for tracking processing. When using the Hungarian algorithm for matching, this article uses cascading matching. Because in the target tracking process, if a track is occluded for a long period of time, then the probability of dispersion in the continuous prediction of the Kalman filter. Assuming that the two trajectories generated by the Kalman filter compete for the same detection target, then the long occlusion time is often smaller than the Mahalanobis distance, so that the target tends to be assigned to the trajectory with a longer loss time, but intuitively, the target should be assigned to the most recent trajectory in time. The cause of this phenomenon is precisely the probability dispersion caused by the continuous prediction of the Kalman filter that cannot be updated. Therefore, the strategy of cascading matching is introduced in this paper, so that each time the allocation is considered, the trajectory with the same occlusion time is considered.

2.4 *Grid Map Creation*

In this paper, a grid map is constructed by laser radar for the detection of obstacles. When using a lidar to construct a grid map, there is a problem that the distance between the detected vehicle and the obstacle may be different at two adjacent moments. When the values of the two distances are small, they mark both locations as obstacles, which is the noise problem of the sensor. To solve this problem, this article introduces the concept of occupying a grid map.

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In a typical scale map, for a point, it is either occupied (represented by 1), that is, there is an obstacle; or it is idle (represented by 0), that is, there is no obstacle. Therefore, for occupying a point in the raster map, $p(s=1)$ can be used to indicate the probability that it is idle, and $p(s=0)$ is used to indicate the probability that it is occupied. The sum of the two is 1. There are too many values, and this article introduces the ratio of the two as the state of the point:

$$\mathrm{Odd}(s)=\frac{p(s=1)}{p(s=0)}. \tag{1}$$

For a point, a new measured value $z=\{0,1\}$ is generated, after which it needs to be updated. Assuming that the measured value comes before, the state of the point is $\mathrm{Odd}(s)$, to update it to

$$\mathrm{Odd}(s|z)=\frac{p(s=1|z)}{p(s=0|z)}. \tag{2}$$

According to the Bayesian formula,

$$p(s=1|z)=\frac{p(z|s=1)p(s=1)}{p(z)}, \tag{3}$$

$$\mathrm{p}(s=0|z)=\frac{p(z|s=0)p(s=0)}{p(z)}. \tag{4}$$

Bring the ratio of the two and the new measured value to the Bayesian formula and take the logarithm to obtain the measured value model (denoted as lomeas):

$$\log\,\mathrm{Odd}(s|z)=\log\frac{p(s=1|z)}{p(s=0|z)}+\log\,\mathrm{Odd}(s). \tag{5}$$

After the measurement model is established, the point status idle in the raster map can be expressed as log free $=\log\frac{p(z=0|s=1)}{p(z=0|s=0)}$, occupancy can be expressed as looccu $=\log\frac{p(z=1|s=1)}{p(z=1|s=0)}$, and both are fixed values.

After building the measured value model, you can write a function to build a raster map with the following functions:

function myMap = occGridMapping (ranges, scan Angles, pose, param).

Among them, scanAngles is an $N\times 1$ array, indicating the N laser emission direction of the lidar sensor (the angle with the vehicle orientation, fixed value); ranges is a $K\times N$ array, indicating the N time sampling point laser sensor reading (distance from the obstacle); pose is a $3\times N$ array, indicating the position and orientation information of the N time sampling point robot (the first two dimensions are the position and the third dimension is the orientation angle); param is some incoming. The parameter, param.origin is the starting point of the vehicle, param.lo_occ and param.lo_free are the looccu and lofree in the second section, respectively, param.max and param.min indicate the threshold of the position state (more than the threshold boundary). Param.resol represents the resolution of the map, that is, the number of grid points represented by 1 m in the actual map, and param.size indicates the size of the map.

When constructing a raster map, first convert the coordinates in the real world into coordinates in the raster map. In the case of one dimension, use x to represent the coordinates in the real world, and i is the coordinates in the discretized raster map. The length of a cell is represented as r, $1/r$ is the resolution, obviously $i=\mathrm{ceil}(x/r)$, the same reason, in two dimensions: $(i,j)=[\mathrm{ceil}(x/r),\mathrm{ceil}(y/r)]$, and in 3D state $(i,j,z)=[\mathrm{ceil}(x/r),\mathrm{ceil}(y/r),\mathrm{ceil}(z/r)]$; second, calculate the detection of each laser and the location of obstacles and non-obstacles in the grid map. Finally, the state of the grid is continuously updated using the measured value model.

To clearly represent all the information around the intelligent vehicle, in the obstacle detection, it is necessary to establish two kinds of grid maps at the same time: a partial grid map and a global grid map. In some cases, a partial map needs to be projected onto the global map and

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merged with the existing global map to form a new global map. In this paper, Bayesian filtering fusion method is used for map fusion. It is worth noting that when merging maps, only the range that the current local map can see can be merged, and the unknown range cannot be merged into the global map, otherwise, it will be wrong.

3 Experiment

3.1 *Data Source*

The experiment is divided into three parts, namely, vehicle identification experiment, pedestrian detection experiment, and vehicle tracking experiment. Among them, vehicle identification uses single-line laser radar, pedestrian detection, and vehicle tracking to select multi-line laser radar. Vehicle identification experiments and vehicle tracking experiments were conducted on urban roads, and pedestrian detection experiments were conducted near intersections with more pedestrians. The specific performance parameters of IBEO LUX are shown in Table 1.

3.2 *Experimental Design*

In the vehicle identification experiment loop, set up a control experiment that compares the recognition results of the proposed method with the traditional method and the time of use; in the pedestrian detection experiment, select two different scenes, and move obstacles, static obstacles, and pedestrians They are marked with red, black, and green rectangles, respectively; in the vehicle tracking experiment, two different scenarios of experiments are designed, which are target reduction, i.e., two vehicle targets are tracked at the beginning, and one target is driven out during the tracking process. The detection range of the lidar; the target is increased, i.e., one vehicle target is tracked at the beginning, another vehicle target is driven into the detection range of the laser radar during the tracking process, and the tracking process is photographed by the camera to evaluate the tracking situation. Through experiments, the calibration results of the IBEO four-line lidar can be obtained as shown in Table 2.

Table 1 The specific performance parameters of IBEO LUX.

Characteristic	Data
Laser class and wavelength	Level 1 905 nm
Operating voltage	9-27 VDC
Measuring range	0.4 to 200 m
Size ($W \times H \times D$)	$164.3 \times 93.1 \times 87$ mm
Weather performance	All weather

Table 2 The calibration results of the IBEO four-line lidar can be obtained through experiments.

Common point	Vehicle coordinate system	Radar coordinate system	Error RMS
1	(0,10)	(0.71, 10.27)	0.053
2	(0,15)	(0.72, 15.24)	0.060
3	(0,-5)	(0.76, 5.26)	3.578
4	(3,5)	(3.52, 5.12)	0.151
5	(−3,5)	(−2.19, 5.27)	0.140

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Table 3 The calibration results of UXM-30LX single-line lidar.

Common point	Vehicle coordinate system	Radar coordinate system	Error RMS
1	(−6000,0)	(1745,5218)	20.411
2	(−6000,6000)	(7766,4823)	100.318
3	(−6000, −6000)	(−4257,5305)	108.483
4	(−6000, 10000)	(11623, 4743)	96.174
5	(−6000, −10000)	(−7986, 5492)	125.717

3.3 *Experimental Evaluation*

According to the different characteristics of the three experiments, the following three evaluation criteria are proposed:

1. For vehicle identification experiments, the accuracy of identification and the time of identification are used as evaluation criteria;
2. For the pedestrian detection experiment, the detection of the missed detection rate and the false detection rate as the evaluation criteria; and
3. For the vehicle tracking experiment, the degree of coincidence between the laser radar tracking process and the actual process of the camera shooting is taken as the evaluation standard. Through experiments, the calibration results of UXM-30LX single-line lidar are shown in Table 3.

4 Results and Discussion

4.1 *Vehicle Identification Results*

The target vehicle recognition result is shown in Fig. 1. Figure 1(a) shows the recognition result of the set threshold method studied in this paper, and Fig. 1(b) shows the recognition result of the traditional method. The circle in the figure is clustered. Identifying the vehicle target is shown by rectangular box consisting of the starting and ending point. Figure 2 shows a comparison of the time taken by the two methods to identify the same number of target vehicles.

As can be seen from Fig. 1(a), the method of setting the threshold can accurately identify the target vehicle of various external dimensions, including target 9 and target 10 which are far away. In Fig. 1(b), from the start and end points of the cluster, target 7 and target 8 are identified as one target, and target 10 is identified as two clusters, so for all three targets, it is the wrong

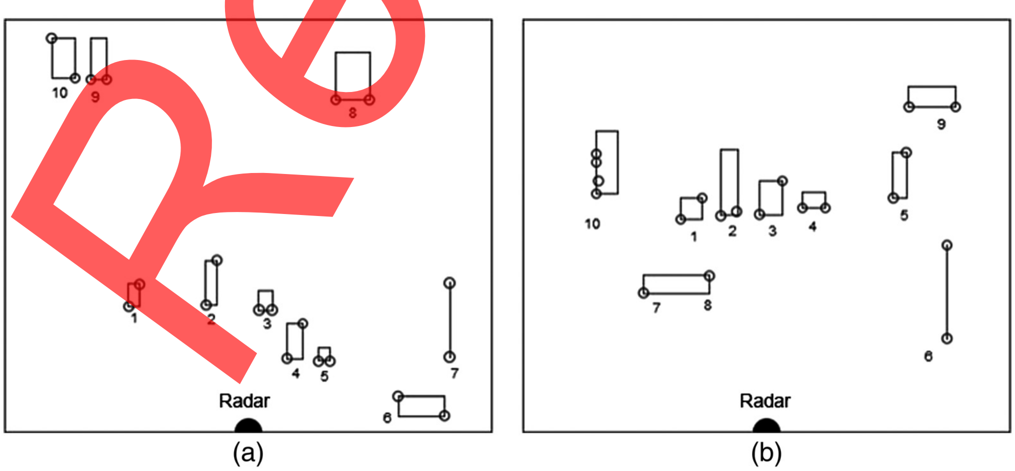

Fig. 1 Comparison of vehicle identification results.

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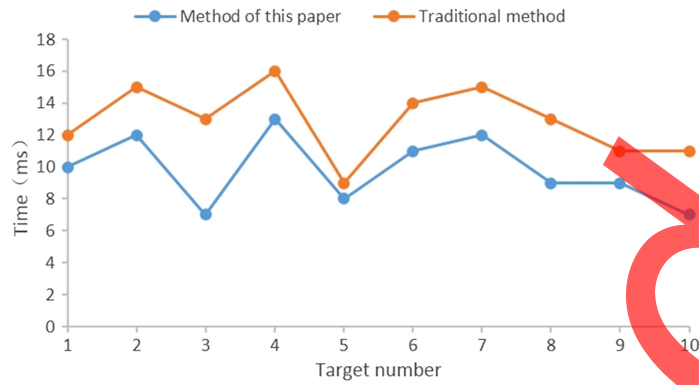

Fig. 2 Identification time of the two methods.

Table 4 The UXM-BR rear right single-line lidar calibration.

Common point	Vehicle coordinate system	Radar coordinate system	Error RMS
1	(0, −15,000)	(7199,6890)	14.984
2	(0, −20,000)	(10,706, 10,667)	75.177
3	(1490, −24,200)	(12,784, 14,962)	154.203
4	(−1245, −24,200)	(14,604,13,141)	143.556
5	(−4120, −24,200)	(10,712, 16,907)	2315.332

identification. In Fig. 2, 10 frames of images are randomly selected and the time taken to identify the target vehicle is counted. It can be seen that the research method proposed in this paper uses less time for identifying the target vehicle in the 10 frames than the traditional method. Identification time. In the 10 frames of images, the average time taken for the recognition of one frame of image is 9.8 ms, while the traditional method is 12.9 ms. For target recognition of a moving smart vehicle, the identification time of the target vehicle is critical to pedestrian safety and vehicle safety. The UXM-BR rear right single-line lidar calibration is shown in Table 4.

4.2 *Pedestrian Test Results*

Figures 3 and 4 show the pedestrians in the vicinity of the same intersection at two different time periods. It can be seen from the test results that the moving vehicle (which can be regarded as a moving obstacle target in pedestrian detection) and the stationary vehicle (can be regarded as a stationary obstacle target) and pedestrians in walking are accurately detected, with no missed detection and false detection, which means that the grid map constructed based on the lidar sensor can not only detect pedestrian targets, but also have good detection rates for stationary and moving pedestrians.

4.3 *Vehicle Tracking Results*

Figure 5 shows that only the target 1 is started. After tracking the target 1 for a period of time, the target 0 enters the scanning range of the lidar. When the target 0 enters, the smart vehicle equipped with the lidar can simultaneously perform the two target vehicles. Tracking map. Figure 6 shows that both the target 1 and the target 0 are within the scanning range of the lidar, which is to increase the target vehicle tracking and reduce the target vehicle tracking. After tracking the two targets for a period of time, the target 0 travels right in front of the target 1, which is equivalent to the target 0 leaving the scanning range of the lidar, at which point

Fig. 3 Pedestrian detection (1).

Fig. 4 Pedestrian detection (2).

Fig. 5 Target increase tracking.

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Fig. 6 Reduce target tracking.

Table 5 The statistical results of only considering the movement characteristics of the target.

Identifier	Only consider movement characteristics (%)	Also consider the target category (%)
Object	66	88
Pedestrian	67	89
Vehicle	65	93

Table 6 The statistical results of the target's motion characteristics and category attributes.

Identifier	Only consider movement characteristics (%)	Also consider the target category (%)
Vehicle 1	50	90
Vehicle 2	53	91
Pedestrian 1	40	92
Pedestrian 2	46	95

the smart vehicle can continue to track the target 1. The captured video of the target vehicle during the tracking process is viewed and compared with the driving route of the intelligent vehicle. It is found that the driving route of the intelligent vehicle in the captured video matches the driving route of the target vehicle in the captured video completely in the case of the target increase and the target reduction.

To show the role of target category attributes in target association, sub-Monte Carlo simulations were carried out for different scenarios. The statistical results of only considering the movement characteristics of the target are shown in Table 5.

At the same time, the statistical results of the target's motion characteristics and category attributes are shown in Table 6.

5 Conclusion

Recognizing the spectrum dynamic characteristics of wireless networks increases the requirements on network protocols. The protocol is required to support asynchronous and real-time

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characteristics, and must be able to adapt to changes in network topology and network topology due to changes in the communication environment or changes in mobile terminals. Therefore, the design of the protocol stack should fully consider the reconfiguration and dynamic spectrum characteristics of the cognitive wireless network. The cross-layer design can coordinate and merge the characteristic parameters scattered in each protocol layer, thereby, optimizing the overall performance of the cognitive wireless network. On the other hand, cognitive wireless networks can usually maintain a set of end-to-end goals (such as end-to-end trust management, end-to-end routing, etc.) to achieve a compromise between multiple goals, which requires the entire network and protocol stack to have ability to run a complete cognitive loop is achieved through cross-layer design. With the progress of the times, China's automobile manufacturing industry and road traffic have made great progress. While bringing convenience to people's lives, it has also brought pressure to urban traffic and various frequent traffic accidents. In recent years, the continuous development of various technologies has brought about tremendous changes in our daily life. The widespread application of big data technology and artificial intelligence technology has made our life more convenient and faster, and based on this, we have created an intelligent transportation system. It can effectively solve the current traffic congestion problem in China. Intelligent vehicles are a key part of intelligent transportation systems. This paper studies the target recognition and tracking of intelligent vehicles based on lidar. Compared with other types of vehicle driving sensors, lidar detects farther distances and has higher precision. Since the laser radar is an active beam, it is less susceptible to the surrounding light environment, and the 3D map information generated by the laser radar is more easily analyzed by the computer. In this paper, the effects of laser radar on target vehicle identification, pedestrian detection, and target vehicle tracking are verified by experiments. It is found that laser radar can effectively improve the accuracy of vehicle perception of the surrounding environment. It is hoped that later researchers can further study the application of laser radar on smart vehicles, so that intelligent vehicles can promote the standardized development of China's transportation field and improve the management efficiency of transportation. For the conclusion part of the article, we made a further outlook: because the lidar itself has certain errors, and the distances from the selected markers to the center of the radar coordinate system and the vehicle coordinate system are measured manually, there will be certain measurement errors. Geometric target feature extraction methods can be further studied to maximize the accuracy of detection results.

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