Research and development of intelligent safety sensor integration devices for autonomous driving

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Abstract—Grasping the status of vehicles timely and accurately is the key to avoid traffic accidents and collecting data from multi-sensors is significant for development of road-side intelligent sensor technology. In this paper, LiDAR (Light Detection and Ranging) and camera sensors are tested, and the sensor data can be processed and analyzed, and the display can be integrated. In this paper, a multi-sensor data acquisition integration device based on Raspberry Pi is proposed, which can realize the optimal processing of data and simultaneous acquisition display function. This method avoids the tedium of using an IPC and improves the efficiency of data acquisition and sensor integration.

1. INTRODUCTION

Traffic accidents and safety hazards are main problems for traffic workers all the time. The causes of them are multi-faceted, including road design issues, the fault of the vehicle itself, weather factors, drivers’ improper driving or the overlay of the above factors. With the continuous construction and development of transportation infrastructure, traffic conditions have been gradually improved, which will improve road traffic safety due to road factors to a certain extent. However, due to the increasing number of private vehicles, there are more and more new drivers. Traffic accidents caused by human factors are still serious, so we must take relevant measures to solve this kind of traffic safety problems, and the implementation of intelligent traffic is the only way. Road-side intelligent perception and road coordination are not only important components of intelligent traffic, but also the basis of intelligent traffic. With the gradual reduction of costs, LiDAR, mmWave radar and cameras have been widely used in the field of road traffic. Wu, J. et al. [1] proposed a network structure of on-board lidar, which is used to detect road roughness information. The results show that it can accurately identify road...
environment information. Kong Deming et al. [2] proposed a new road obstacle detection method based on grid clusterings using 16-wire LiDAR vehicle LiDAR. The results showed that the detection accuracy is 91%.

At the same time, cameras et al are widely used because of their high definition, wide detection range and low cost. Xu Yaohua et al [3] proposed to use the camera to collect road information, based on direct edge detection algorithm, tracking edge detection algorithm and cross edge detection algorithm to determine the road edge, effectively improve the real-time performance of the vehicle control system.

Chen Xiaoyu et al. [4] proposed a new method that integrates multi-sensors and collects data synchronously. This method mainly carries on the hardware circuit design to realize the the sensor integration device with FPGA as the main controller, through the selecting power supply module and master chip and integrating the camera, LiDAR and other sensors. The test results show that the circuit is highly efficient and can achieve multi-sensor data acquisition. In the process of collecting data, all kinds of sensors have advantages. All kinds of sensors are proposed to be integrated to improve the efficiency and performance of data acquisition.

However, previous research on sensor integration mainly focused on vehicles, and there was a lack of research on the integration of data collected by multi-sensors on the side of the road. Currently, the small Raspberry Pi industrial control machine made in Germany can help the charging station realize charge and discharge control [5].

With the development of technology of roadside intelligent sensing devices for smart highway, it is possible to display the data collected by multiple sensors in an integrated manner. This paper proposes a method for integrating multiple data using Raspberry Pi development board instead of the traditional industrial control machine. In this paper, the data is collected and processed by the Raspberry Pi connected lidar, camera and other sensors. The multi-sensor data can be displayed at the same time, solving the tedious problem of connecting each sensor to the industrial controller. In this paper test, lidar and camera are used, their data can be displayed simultaneously and the connection and installation of hardware equipment is directed, making road detection more efficient, concise and intelligent.

2.MATERIALS AND METHODS
In this paper, the Raspberry Pi board is used to process and integrate data from multiple sensors, so that lidar and camera data can be displayed simultaneously on the Raspberry Pi development boards. The development techniques used mainly include programming in Linux environment, point cloud filtering based on PCL open source point cloud database and the application of Opencv open source database. The whole project process is roughly divided into the following parts.

2.1.Device Selection

2.1.1.External Devices
Video are collected by high-definition surveillance cameras, and RS-LiDAR-16 was selected to collect point cloud data. RS-LiDAR-16 has 16 channels, measuring distance from 40cm to 150m. RS-LiDAR-16 speed is 300/600/1200rpm (5/10/20Hz) and laser wavelength is 905nm. It has a scanning accuracy of ±2cm where the horizontal view is 360°.
2.1.2. Main control equipment
The Raspberry Pi is a miniature computer, using an SD card as a memory drive. As a microcomputer based on Linux system, it is widely used in programming design and data processing because of its powerful computing power. The Raspberry Pi motherboard has four USB ports and a Gigabit Ethernet port. Besides, it also includes two HDMI video cable ports which are used to connect the display to display sensor data. As shown in Figure 2, in this test, the Raspberry Pi is installed with ubuntu 18.04.

![Raspberry Pi physical image](image)

Figure 2. Raspberry Pi physical image

The parameters are shown in the following table.

| Spec              | Raspberry Pi 4B                     |
|-------------------|-------------------------------------|
| CPU               | 1.5GHz, Quad-Core Broadcom BCM2711B0(Cortex A-72) |
| GPU               | 500 MHz VideoCore VI                |
| Video Out         | Dual micro HDMI ports               |
| Max resolution    | 4K 60 Hz + 1080p                    |
| USB Ports         | 2×USB 3.0 / 2×USB 2.0               |
| Power Requirement | 3A,5V                               |
| RAM               | 1-8GB DDR4                          |
| Wired Networking  | Gigabit Ethernet                   |

2.2. Method

2.2.1. Equipment Installation
Crossroad with moderate pedestrian and vehicle number is selected to conduct a experiment. LiDAR and HD camera are installed to the appropriate position, as shown in Figure 3. Since the Raspberry Pi has only one mesh, a mesh divider is connected. LiDAR and camera are connected to the Raspberry Pi.com via a network cable, and the network between LiDAR and Raspberry Pi is configured.

Considering the parameters of LiDAR and camera, LiDAR is installed 2.4m away from the vertical ground to achieve better data acquisition results. The camera is installed directly above the LiDAR, 0.7m away from it.

![Field test environment](image)

Figure 3. Field test environment
2.2.2. Data acquisition and processing
The data is collected when LiDAR and camera drive are installed successfully. Images and point cloud data are displayed and saved in real time by drive, which is realized in ROS robot system. The technology adopted is based on the classic open source visual database OpenCV and the UVC camera function package in the software library. Pre-set the LiDAR driver to make point cloud data display in the Raspberry Pi with node commands. The image is played through the OpenCV database. Finally, the point cloud data and image data can be displayed at the same time. Data display steps are as follows:

- from cv2 import cv2 as cv2
- //Opencv database is used to open the camera and obtain pictures.
- def_init (self, ser_adr ← ('192.168.1.102',8888));
- socket.socket(socket.AF_INET,socket.SOCK_DGRAM);
- def send_frame (self, frame, adr ← ());
- save_video_start_flag←false;// Save video by default
- save_video_end_flag←false;

The above is the specific steps of collecting LiDAR data and camera data, which can be stored in the form of . bag and .avi respectively. At the same time, the locally saved data can be played back by establishing workspace and function package and compiling with code. The specific display steps are as follows.

- Create a file in the. CPP format in the new workspace, and write and call the local video code in it.
- VideoCapture cap;
- Cap.open(“Path to save data”);
- Ensure that the data saving path in the code should be filled in correctly.
- Compile the program Catkin_make.
- Run a node file named baocun_bdshipin.
- Create a new terminal, start and display local video.

The overall flowchart is shown in Figure 5.
After completing the data acquisition, the data needs to be further processed because of the noise of the point cloud data will affect point cloud feature extraction. Downsampling of LiDAR point cloud data based on PCL point cloud database can further improve the computational speed of Raspberry Pi. Point cloud data in spatial 3D coordinates [6] are filtered and rasterized in mini-cubes and differentiated by pre-set thresholds. The coordinates of the background points are stored in the 3D array. Details of the use of 3D-DSF can be found in Wu et al.'s study [7].

3. DISCUSSION AND RESULTS
As shown in Figure 6, the lower left corner is the video image data collected by the camera, while the right corner is the point cloud data collected by the lidar. Therefore, raspberry Pi can realize the integrated display of sensor data. Not only can moving pedestrians be scanned, but stationary vehicles and buildings can also be displayed in the point cloud data.

![Integrated display of sensor data](image)

In the test of this paper, data collection of lidar and camera is carried out at intersections with large human flow, and the collected point cloud data can be processed by down-sampling filtering through PCL in raspberry Pi to reduce the amount of point cloud data and effectively improve the computing speed of raspberry Pi main control board. It shows the data processing power of the Raspberry Pi. As shown in the figure, Figure 7 is the point cloud data before filtering, and Figure 8 is the point cloud data after filtering. The comparison effect is obvious, and the basic information can be retained after filtering.
Although the integrated display of LiDAR and camera sensor data was realized, and point cloud data were processed, it has not been installed in the highway test section for field testing due to the limitation of the test environment. Further optimization of equipment performance is required. At the same time, point cloud data will be further processed, including MEC processing of camera data.

4. CONCLUSION
In this paper, a method of using Raspberry Pi to collect LiDAR point cloud data and camera image data instead of traditional industrial computer was proposed. The focus of the research was to collect and process the sensor data, realize the simultaneous display of multi-sensor data, and realize the data preservation and call playback. The construction of the integrated system is of great significance to the detection and evaluation of the safe operation status of the vehicle and to the performance of the platform operation and service. The results showed that Raspberry Pi can be used to display multi-sensor data and process the collected data. Through this study, it effectively solved the complicated problem that all roadside devices must be connected to the industrial computer, and realized the process of data collection, processing and display by connecting a variety of roadside devices to a Raspberry Pi at the same time. This paper still has some limitations. Raspberry Pi integrated equipment needs to be tested on the highway site. In future research, more sensors should be integrated for data acquisition, and multiple sensor data should be optimized for synchronization.

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