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Development of a Real-Time Driver Fatigue Warning System Using Edge Computing

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Abstract: Driver fatigue is a significant factor contributing to traffic accidents, necessitating the development of efficient detection systems. This study proposes a vehicle fatigue driving warning system leveraging edge computing to address latency and security challenges associated with traditional cloud-based approaches. The system utilizes the Ruixin RV1126 chip as its data processing core, enabling millisecond-level detection of fatigue through real-time processing at the edge. By analyzing facial features such as eye closure, mouth opening, and head sway captured via onboard cameras, the system identifies fatigue states and issues immediate warnings to drivers. Key advantages of this approach include low cost, high recognition speed, and robust accuracy, demonstrating substantial practical value in enhancing driving safety.

Keywords: Edge Computing; RV1126; Fatigue Driving; Image Processing.

1. Introduction

To accurately determine the driver fatigue status, it is necessary to process huge amount of data. cloud computing, as a computing model extended by parallel computing and grid computing, which stores data in the cloud and processes huge data through cloud servers provide users with convenient and reliable services. However, due to the limitation of the distance between the cloud server and the device terminal, there are problems such as delay and security of data transmission in the cloud, so this paper intends to use edge computing to reduce the data transmission delay and provide real-time and reliable services for customers.

In addition, drivers cannot accurately judge their own fatigue status during driving, so this paper makes a comprehensive judgment of the driver's eye closure degree, mouth opening status and head sway, and designs a vehicle fatigue driving warning system based on edge computing.

2. Overall System Design

The system uses Rockchip Micro RV1126 as the core board, with an external camera, speaker and LCD display. Through the image information captured by the camera, complete the image information processing work; calculate the eye PERCLOS parameters [1], PMOT parameters of the mouth [2] and head shaking degree to determine the driver's fatigue status and drive the voice warning system to issue real-time warnings. The system includes image information acquisition system, comprehensive information processing system and voice warning system, and the system structure framework is shown in Figure 1.

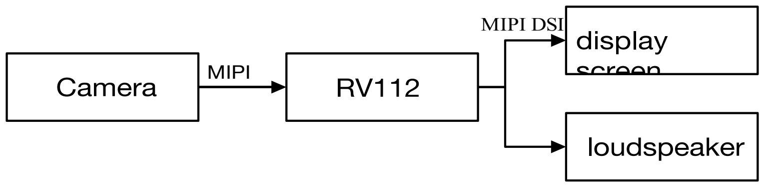

Figure 1. System architecture framework

3. System Hardware Design

3.1 RV1126 Main Control Board

The main control chip contains quad-core Arm Cortex-A7 32-bit cores with main frequency up to 1.5GHz, integrated NPU and VPU, supporting 4K video encoding and decoding; equipped with Rockchip's self-developed ISP2.0 technology, supporting multi-level noise reduction, 3-frame HDR, Smart AE intelligent auto-exposure, AWB white balance and distortion correction, etc., supporting ISP processing of up to 14M pixels It can realize up to four-way Sensor time-sharing multiplexing, with strong image processing capability.

3.2 Camera Information Acquisition

The camera module adopts CMOS camera with mipi CSI-2 transmission interface[3]. This interface has strong anti-interference capability and fast transmission speed, and the total time delay from acquisition to output display is less than 100ms, which meets the real-time requirements of the image acquisition system and reduces the monitoring time of the whole system. This paper adopts 60FPS, 500W pixel ATK-MCIMX335 HD camera, which has built-in timing adjustment and serial communication circuit, supports CSI-2 serial data output, supports multiple exposure HDR, digital overlay HDR, and has variable speed shutter function.

3.3 Voice Alert System

When the system detects that the driver is in a fatigue state, the voice reminder system will issue a fatigue warning to serve as a wake-up call.The RV1126 core board's power management chip RK809 has an integrated audio codec, so the system does not need an additional audio codec chip.

3.4 Display Module

The display screen is mainly used for system program development and debugging and system test result display. The RV1126 video output supports MIPI DSI interface, which has the advantages of lower power consumption, higher data transmission rate and smaller PCB occupied space, so the 720P screen with MIPI interface is selected for this system.

4. System Software Design

4.1 Overall System Software Design

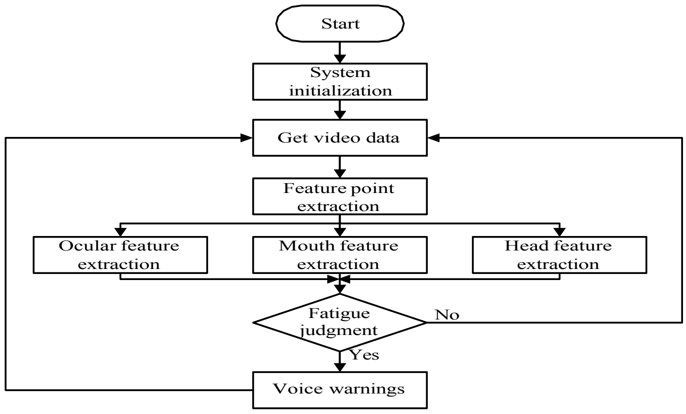

Figure 2. System operation flow

Based on the superiority of edge algorithm and the powerful processing capability of RV1126, more efficient fatigue state detection can be achieved. The system analyzes the driver's eye, mouth and head status through the face features obtained by PCA analysis, and determines whether the driver is in a fatigue state, and issues voice warning if he is in a fatigue state.The system operation flow is shown in Figure 2.

4.2 Image Processing

The image processing process of this system can be divided into the following steps: input image, image pre-processing, feature extraction, face matching, fatigue judgment and output recognition results. Among them, image pre-processing uses Gabor filtering [3] The face features are extracted using PCA analysis based on wavelet transform, and 68 feature points are extracted to prepare for the extraction of key points of eye, mouth shape and head posture next. After face localization, we will face the problem of distinguishing the eye and mouth. In this paper, we divide the image according to the "three chambers and five eyes" face structure, and use the integral projection method to distinguish the eye and mouth area.

4.2.1 Eye Fatigue Determination based on PERCLOS

Studies related to fatigue driving have found a strong correlation between the degree of eye closure and fatigue, and it is considered to be the most reliable and accurate indicator. p80: indicates that the eyes are considered to be in a closed state when more than 80% of the pupil area is covered by the eyelids. After a large number of experiments, it has been shown that p80 is a more accurate detection compared to other parameters. PERCLOS parameter indicates the percentage of eye closure duration per unit time compared to the total duration, which in this paper is the ratio of the total number of frames of eye closure per unit time to the number of image frames per unit time, calculated as shown in Equation (1).

$$P_{perclos} = \frac{\sum_i^N P_{80}}{N} \times 100\% \tag{1}$$

4.2.2 Fatigue Judgment based on PMOT Index

The PMOT parameter is defined as the ratio of mouth opening time to total time per unit time and is calculated as shown in Equation (2).

$$P_{pmot} = \frac{\sum_i^N P_i}{N} \times 100\% \tag{2}$$

4.2.3 Fatigue Determination based on Head Sway

The performance of drowsiness in the head region mainly includes head tilt, low head and head tilt postures, so this system selects low head posture as one of the fatigue judgment criteria, and takes the duration of low head as the fatigue judgment criterion. Firstly, by matching the head model with 68 facial features, the head posture pitch angle pitch is derived; secondly, the pitch angle threshold th is set, and the head state is judged according to the size of the pitch angle and the threshold th; to avoid misjudgment of low head, the system makes the following provisions: if the low head state appears in three consecutive frames, the head is considered to be low once; if the head is low 10 times in a row, the head is considered to be drowsy low once, at which time the system will The system will issue a voice warning. The flow of head posture determination is shown in Figure 3.

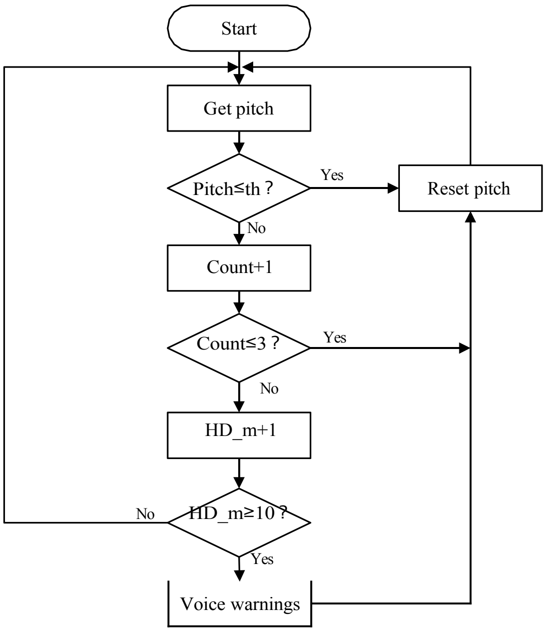

Figure 3. Head posture determination process

5. System Commissioning

The program developed on the PC side was ported to the system to measure the accuracy of monitoring under different environments. The test results are shown in Figure 4. The system test results show that the system can accurately identify the driver's fatigue state by the comprehensive judgment of three parameters.

Figure 4. Graph of test results

6. Conclusion

The development of vehicle fatigue driving warning system based on edge computing is mainly based on Ruixin RV1126 chip as the data processing center. Through the data collected by the camera, face features are extracted, and the eyes and mouth areas are divided according to the facial features. By extracting the fatigue features of the driver's eyes, mouth and head, the fatigue driving state of the driver is comprehensively analyzed, and the fatigue state of the driver is given real-time warning. The system uses edge detection and RV1126 to realize millisecond level fatigue detection, and has the characteristics of low cost, fast recognition speed and high recognition rate, so it has certain practical value.

References

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