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Research on road condition environment and driving safety based on YoLo and thermal property information

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Abstract: The purpose of this paper is to explore the monitoring method of road condition environment and driving safety based on YOLO and thermal property information. By integrating visual and thermal imaging data, it can make up for the deficiency of a single sensing method, improve the detection accuracy and robustness of various targets in the road scene, and provide all-round and multi-level protection for driving safety. The research content covers the front information recognition, vehicle side safety recognition and driver status recognition based on YOLOv8 algorithm. The effectiveness and superiority of the thermophysical information compensation method in different scenarios are verified by experiments. The safe driving detection method provides theoretical basis and technical support.
Key words: driving safety; Driving monitoring and testing; Thermophysical image

I. Introduction

According to statistics, more than 1.3 million deaths are caused by traffic accidents worldwide every year, most of which are related to drivers' insufficient perception of the driving environment or delayed response [1]. Especially in complex traffic scenes, the emergency situation in front and side of the car, as well as the accurate detection of the status of the driver inside the car, is a key factor to improve driving safety. For example, emergency braking in front of the vehicle, lateral road emergencies or driver fatigue driving may cause serious traffic accidents. In this context, with the help of intelligent monitoring and early warning technology, accurate perception of the driving environment and real-time prevention and control of driving risks have become the core task of improving traffic operation efficiency and ensuring driving safety.

In recent years, computer vision technology has made remarkable progress in the field of transportation, providing a powerful tool for the perception and understanding of complex traffic environment. A single sensor or algorithm can give full play to its advantages of strong pertinence and low false detection rate in a single scene to achieve accurate perception and response. However, when dealing with complex scenes such as changeable weather and illumination, the phenomenon of recognition distortion will occur [2]. Therefore, the combination of target detection algorithm YOLO and thermal physical image provides a new way to solve the above problems. This study aims to explore detection methods of side and front information and driver status based on YOLOv8 and thermal physical information. By integrating visual and thermal imaging data, it can make up for the deficiency of a single sensing method, improve detection accuracy and recognition performance of various targets in road scenes, and provide all-round and multi-level guarantee for driving safety.

In the monitoring of driving environment, the detection of vehicle front information directly affects driving safety. Front-of-vehicle information (such as brake lights and turn signals) can provide drivers with important driving decision information. The accuracy of the traditional detection method based on visible light will decrease significantly under strong light, fog or rain and snow. Thermal imaging technology can detect the thermal radiation signal of taillights to make up for the shortcomings of visible light sensors and improve the reliability of detection [3]. YOLO technology can capture key information features of automotive taillights, quickly locate taillights through threshold segmentation, morphological processing and other methods, and combine deep learning algorithms to improve the recognition accuracy to more than 95% [4]. For example, in autonomous driving scenarios, thermal imaging data can help the system more accurately identify the taillight status of the vehicle in front, thereby optimizing the vehicle's driving strategy [5].However, how to effectively integrate thermal imaging data with visual data is still an urgent problem to be solved. The existing methods usually adopt the multi-mode fusion strategy, but the problem of feature alignment and weight allocation between different modes still needs further research [6].

Vehicle side environmental monitoring is also of great significance to ensure driving safety. When driving at night or on open roads, animals suddenly trespassing on the lane is one of the common emergencies. Traditional vision sensors are difficult to detect vehicle side information effectively under low light conditions, while thermal imaging technology can effectively capture animal thermal radiation signals [7]. Studies have shown that combining thermal imaging data with deep learning object detection algorithms can realize real-time detection of animals in complex environments, provide early warning information for drivers, and thus reduce the possibility of accidents [8]. For example, in an autonomous driving scenario, thermal imaging data can help the system more accurately identify the side animals, thereby optimizing the vehicle's driving strategy [9]. In response to this phenomenon, researchers have proposed a variety of solutions, such as multi-scale feature fusion, data enhancement and transfer learning, to improve the detection performance of models in complex environments.

The detection of in-car information is an important link to ensure driving safety. Taking the detection of driver status as an example, fatigue driving, distracted driving and other behaviors are one of the main causes of traffic accidents. The traditional driver status detection method based on visible light is not effective at night or under strong light conditions [10]. The infrared thermal physical property detection ADAPTS to various light source environments, solves the occlusion problem, and provides more comprehensive and accurate information, which can provide more clear feature points for the status recognition of drivers in the car.

Ⅱ. Technical path

In this project, YOLOv8 version is selected in the YOLO algorithm, which has significant advantages compared with the lower version, such as YOLOv5. YOLOv8 has a higher average accuracy (mAP) and improved reasoning speed compared to previous versions. Under the same hardware conditions, YOLOv8 can provide more accurate detection results in a shorter time. At the same time, YOLOv8 introduces the anchor-free detection method, which simplifies the model architecture and improves the detection performance of small targets, and has better adaptability to targets of different scales. On this basis, YOLOv8 also introduced Task-Aligned Assigner for positive and negative sample matching, combined with Distribution Focal Loss (DFL) to optimize the consistency of classification and positioning, and further improved the detection accuracy of the model. Compared with the higher version, YOLOv8 has a simpler architecture, lower development threshold and fully verified stability, which is easy to deploy and develop projects.

At the same time, this project carries on the image processing of the collected gray image and transforms it into false color image. This project mainly uses OpenCV (Open Source Computer Vision Library) for image processing. OpenCV is an open source computer vision library, which provides a series of powerful tools and functions in the process of computer vision and image processing. applyColorMap function is used for color mapping. When using this function, the gray histogram of the original image is calculated in advance and the cumulative distribution function of the gray histogram is calculated. According to the cumulative distribution function, the gray value of the original image is mapped to process the HSV value in line with the temperature field, and finally the equalized pseudo-color image is obtained. The following is the frame diagram of the project in this paper, as shown in Figure 2-1 and Figure 2-2.

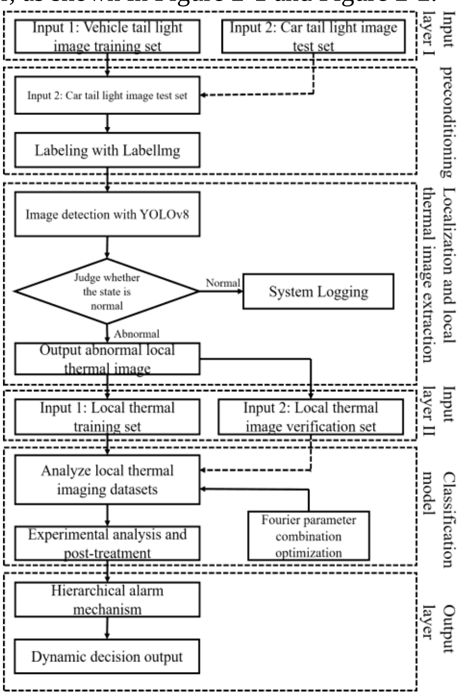

Figure 2-1 Technology architecture of vehicle front information identification

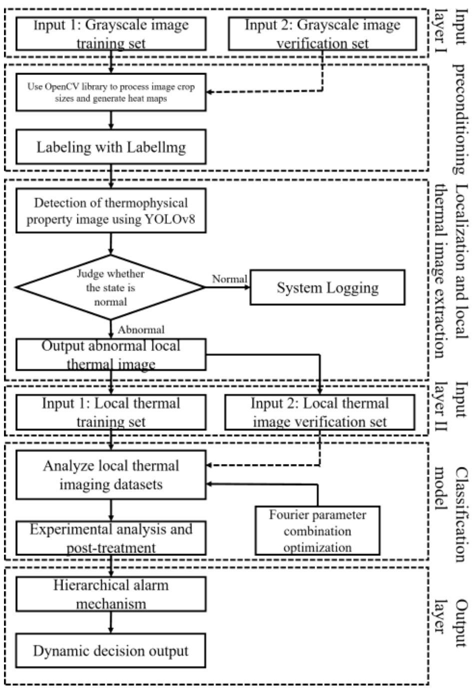

Figure 2-2 Thermal physical property image recognition technology architecture

Ⅲ. Research on vehicle front information recognition based on YOLOv8 algorithm

In the short and medium distance scene, the characteristics of the working state of the car taillight are obvious, and YOLO technology can capture the key information characteristics of the car taillight. In order to improve the efficiency of computing resources and the responsiveness of the model, a single image can be used to optimize the recognition model.

In this project, road driving photos collected by tachograph were used to cover the data under different lighting conditions.According to the characteristics of headlights, each picture is marked with headlights, and the headlights in the far area are manually screened out and the examples of headlights information completion are manually screened out. The YOLO algorithm segmentation images according to the pre-marked frame and import them into the convolutional neural network, thus completing the recognition of headlights.

The main parameters of this project are shown in Table 3-1.

Table 3-1 Training parameters of YOLOv8 taillight recognition

Parameter Name	Numeric
Epoch	2000
Patience	300
Batch	64
Imgsz	640

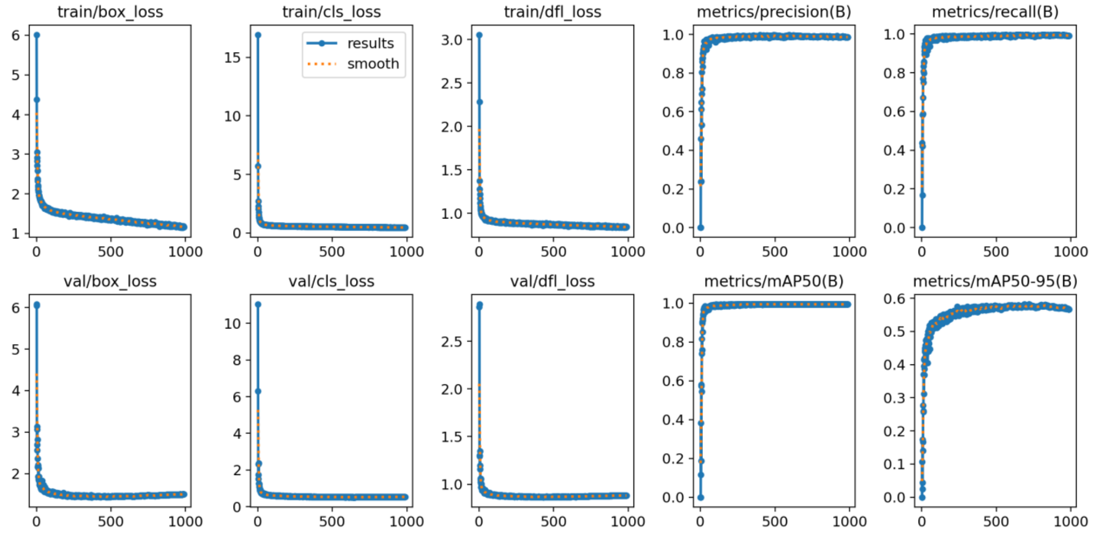

Figure 3-2 Training data of taillight recognition model

When epoch=933 is used in model training, it is verified that the loss does not decrease significantly in 300 consecutive epochs and Overfitting occurs. The early stop mechanism is triggered to stop the training, and the model is returned to the epoch=633 model and output to prevent overfitting. As shown in Figure 3-2, loss decreased significantly during model training. The recognition threshold of headlights is set at 70%, and the overall recognition accuracy is 91%.

Figure 3-3 Original image of lamp identification

Figure 3-4 Results of identifying headlights

The model recognition effect is shown in Figure 3-3 and Figure 3-4. It takes 38.2ms to accurately identify the car headlight in the left front of the car in the scene of low light, and it is less affected by the environmental point light source, thus verifying that YOLO has a certain efficiency and accuracy in headlight recognition.

Ⅳ. Research on vehicle side safety recognition based on thermal physical property image and YOLOv8 algorithm

The image data set adopted in this paper is grayscale map, which is processed by OpenCV library function applyColorMap, and a relatively typical animal is taken as the research, and YOLO selects the key point as the head,as shown in Figure 4-1, continuous video frames are extracted and recognized, and the recognition results are finally fed back to the overall recognition of the image object.

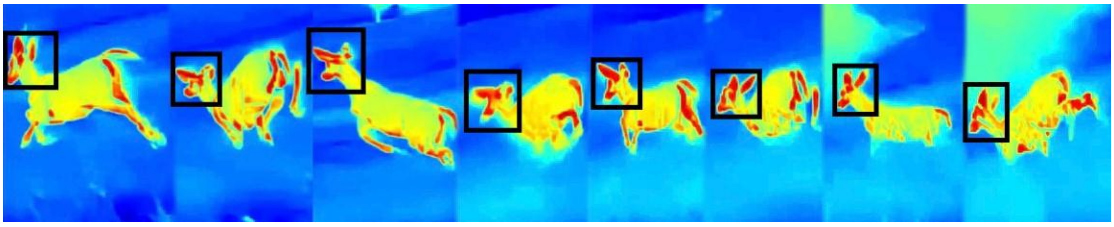

Figure 4-1 YOLO identification diagram

Table 4-2 Training parameters of YOLOv8 animal recognition

Parameter Name	Numeric
Epoch	2000
Patience	300
Batch	16
Imgsz	1280

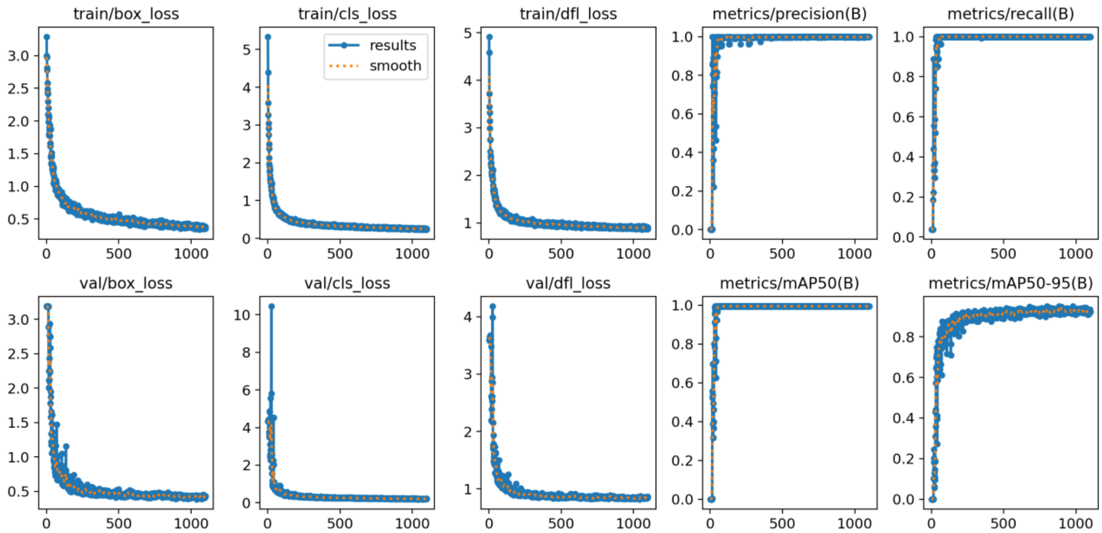

Figure 4-3 Training data of animal recognition model

The training parameters are shown in Table 4-2. During model training, when epoch=1033, the early retreat mechanism is triggered, the training is terminated, and the model is returned to the model when epoch=733. As shown in Figure 4-3, the loss decreases significantly during model training, the recognition threshold is set at 70%, the recognition accuracy rate is 89%, and the recognition time is 30.6ms.The identification effect diagram is shown in FIG. 4-4-1, FIG. 4-4-2 and FIG. 4-4-3. According to the identification information provided by YOLO and the data in the database, the image is a deer.

Figure 4-4-1 Gray scale of animals

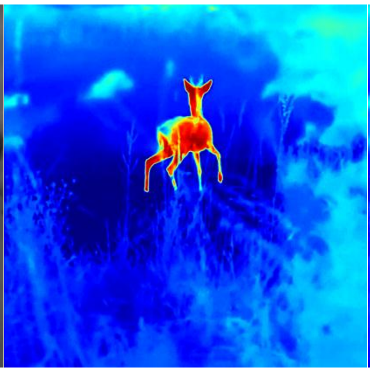

Figure 4-4-2 Thermal physical properties

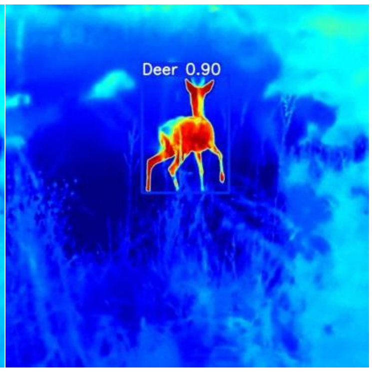

Figure 4-4-3 Test results

V. Research on in-car driver status recognition based on thermal physical property images and YOLOv8 algorithm

The image data set used in this paper is gray level image, which is also processed by applyColorMap, an OpenCV library function, to transform gray level image into false color image, perform YOLO recognition and detection of face, record the location and size information of detection frame, and represent forehead. By judging the forehead temperature, the result indirectly reflects the driving state of the driver.

Under the condition that the driver is wearing sunglasses, the outline of the red region near the border of the upper image is traversed, and the outer envelope contour is taken according to the recognition contour for secondary calibration. At the same time, according to the HSV distribution value in the detection frame for recognizing faces, 15% of the area of the detection frame is selected as the high temperature area, that is, the area in the 15% rectangular frame is characterized as the brightest area. If the IOU value of the bright area and the forehead calibration area exceeds 0.5, Y is output as the forehead high temperature area; otherwise, N is output as the non-high temperature area.

In the case that the driver is not wearing sunglasses, the whole face recognition box is processed, the y value of the detection box is multiplied by a certain proportion to cut, and the length close to the upper boundary is retained, so that the boundary is retained as the forehead calibration area. At the same time, according to the HSV distribution value in the detection box of the whole face, the box selects 15% of the area of the detection box as the high temperature area, that is, the area in the 15% rectangular box is the brightest area. Output Y/N represents the high temperature region.

Table 5-1 below shows the training parameters of pre-processing face recognition detection:

Table 5-1 Face recognition detection training parameters

Parameter Name	Numeric
Epoch	2000
Patience	300
Batch	16
Imgsz	640

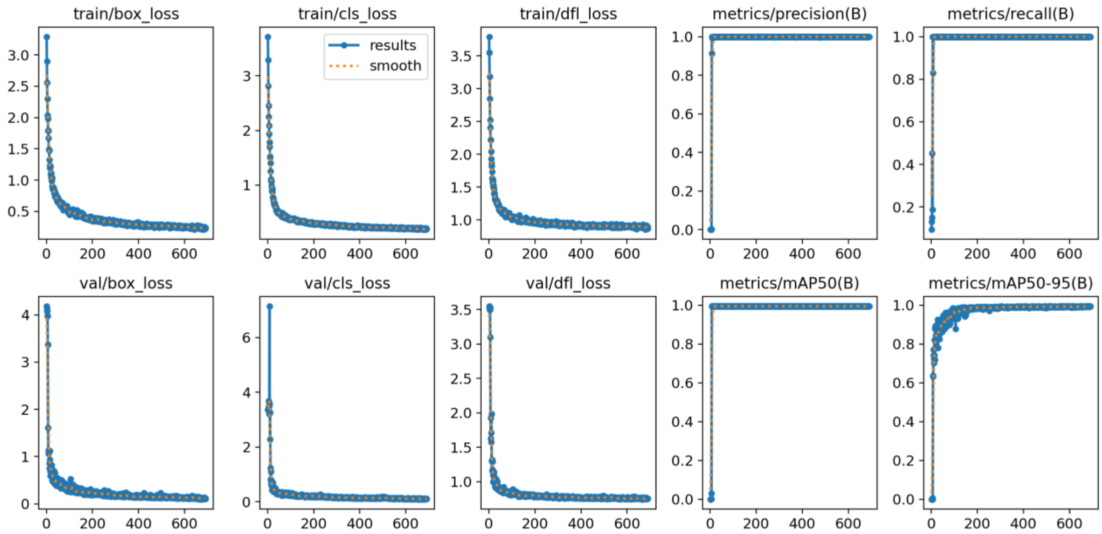

Figure 5-2 Model data diagram of face recognition based on thermophysical image

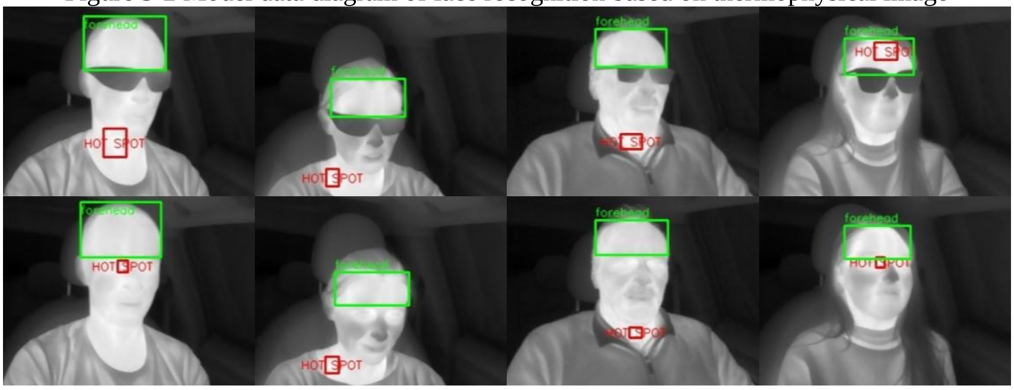

Figure 5-3 Output graph

Table 5-4 High temperature zone judgment results

Number	1	2	3	4	5	6	7	8
Result	N	N	N	Y	N	N	N	N

During model training, when epoch=690, the early retirement mechanism is triggered, the training is terminated, and the model is returned to the model when epoch=390. As shown in Figure 4-2, loss decreases significantly during model training, and the recognition threshold is set at 70%. Through the above detection methods, the effect picture is shown in Figure 5-3. The red box is the hot area, and the green box is the forehead area. Except that the recognition result of the first row and the fourth column is Y, and the forehead is judged to be a high temperature region, the IOU value of the other recognition results is less than 0.5, and the output result is N, that is, the forehead is a non-high temperature region. The recognition effect is good, and it can be used for reference.

Ⅵ Conclusion

In summary, the YOLO recognition algorithm based on thermal physical property images has important application value and positive research conclusions in object detection. Through the acquisition of thermal physical property images and the research and construction of YOLO recognition algorithm, the efficiency and accuracy of object detection can be effectively improved, especially in the recognition, positioning and classification of objects in complex scenes. In the future research on driving safety, it is necessary to further strengthen the research of thermal physical property images in the YOLO recognition algorithm, constantly explore more efficient and accurate detection methods, optimize the detection structure, establish a complete detection and processing system of vehicle circumference information, and improve driving safety and driving quality.

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