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Accurate spray paint design of reciprocating machine based on YOLOv5

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Abstract
The precision painting system of the reciprocating machine is an important component of the automated painting system. Traditional reciprocating machine painting systems have many issues in positioning and spray quality control, severely impacting the quality of painting and production efficiency. Relying on mechanical structures to determine positions makes it difficult to achieve high-precision positioning, and variations in ambient lighting conditions further increase positional errors in the positioning system. Over long-term operation, difficulties in correcting mechanical structural errors can lead to increasingly severe positional deviations. It also cannot achieve three-dimensional adaptive painting on complex product surfaces, making it challenging to ensure uniformity and consistency in painting on upper and lower surfaces. Manual adjustments to positioning are hard to achieve, leading to new errors and making it difficult to precisely control the painting quality.In this study, a precision painting system based on YOLOv5 for the reciprocating machine was designed using computer vision and Opencv deep recognition technology. This system can detect the position and shape of workpieces in real time, automatically adjust painting parameters, and achieve efficient and precise painting effects.

Keywords
computer vision, YOLOv5, Opencv, reciprocating machine

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I. Introduction

The precision painting design based on YOLOv5 for the reciprocating machine utilizes convolutional neural networks and algorithm control through Opencv.The main purpose is to improve the efficiency of the reciprocating machine painting, save paint usage to some extent, and enhance the energy-saving process in the painting industry. The precision painting design based on YOLOv5 for the reciprocating machine, starting from practical needs, achieves greater accuracy and speed in painting positioning through the introduction of new network structures, loss functions, and optimization strategies. Computer vision, as an interdisciplinary field, utilizes computers to analyze and understand digital images or video sequences, and is widely applied in various fields such as autonomous driving, medical image analysis, and facial recognition [1]. With the widespread application of deep learning in computer vision, computer vision technology has experienced significant advancements.As computer vision technology rapidly advances, there is a need for an open-source and powerful computer vision library to support algorithm development and applications. OpenCV meets this need as an open-source computer vision library, containing a plethora of mature computer vision algorithms and function interfaces, implementing various fundamental algorithms such as image processing, feature extraction and matching, object detection, and recognition [2].

II. Research Status and Significance of Accurate Paint Spraying Design for Reciprocating Machine Based onYOLOv5

Currently, the existing painting reciprocating machines in factories waste a significant amount of paint during operation. This not only increases the factory's expenses but also hinders theimprovement of production efficiency and product quality, while also impacting the environment to some extent. Moreover, the technology used in these painting reciprocating machines is relatively outdated. Compared to other advanced painting equipment, their operational efficiency and paint utilization rates are notably low.Therefore, developing a paint-saving painting reciprocating machine is crucial for factories to save a substantial amount of paint and increase profitability. In today's rapidly advancing computer technology landscape, the trend towards intelligent equipment in factories is unstoppable. As institutions of higher education focusing on knowledge innovation, it is essential to address practical issues with advanced technologies, adapt to modern needs, and promote the scientific and standardized production processes.Ultimately, we aim to achieve the following goals through this system: improve the painting efficiency of the painting reciprocating machine without compromising efficiency while saving paint usage. Address the harm caused by paint pollution to air quality. Reduce paint consumption, develop a sustainable lifestyle, achieve cost savings, and enhance the working environment for employees.

III. System introduction

3.1requirement analysis

With the rapid development of the information age, the demand of various electronic components is increasing day by day, and the production efficiency of factories is also in urgent need of improvement. The traditional paint reciprocating machine has a high paint loss rate during operation, and the need for a paint reciprocating machine that saves paint usage is indispensable. If the paint reciprocator in the factory was upgraded to our computer vision-powered reciprocator, its productivity and paint savings would be significantly higher, and its economic benefits would be significantly higher.Because the color and shape of the sprayed objects are not fixed, it is difficult to identify objects with different shapes and colors. The precision spray painting technology is inseparable from the depth vision technology. In this project, Intel advanced binocular camera D435i is used to upgrade and optimize the traditional painting reciprocator. his project aims to upgrade traditional painting reciprocating machines using the YOLOv5 algorithm and leveraging the OpenCV open-source computer vision library for algorithmic support.

3.2 system working principle

Before the system starts working, sufficient preparation is needed, including collecting training data, collecting validation data, and annotating their coordinates, as shown in Figure 1 and Figure 2. Figure 1 is the image data of the training set, and Figure 2 displays the corresponding coordinate data of theimage. Subsequently, the model will be trained using the official YOLOv5s.pt weightfile.

Figure 1

```
0 0.724609 0.296528 0.202344 0.229167
1 0.584766 0.310417 0.038281 0.159722
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Figure 2

After training the model for 200 epochs, the detection algorithm can display the detection results, as shown in Figure 3. In this well-trained model, it is now possible to clearly identify the coordinates of the target object to be sprayed. Subsequently, the same training process can be applied to the laser beacon markers.

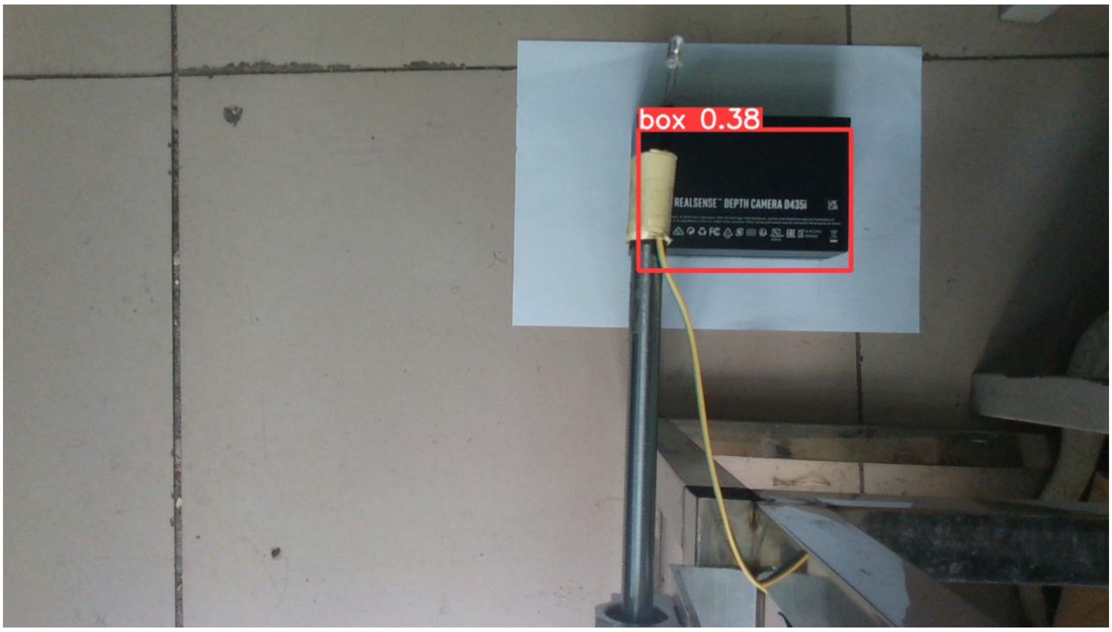

Figure 3

Afterwards, the system can start working. We import relevant computer vision libraries such as the RealSense camera, OpenCV library, and pyautogui library, laying the foundation for the algorithm. The system uses the pyrealsense2 library to initialize the RealSense device and accurately configures the parameters of the depth and RGB data streams to ensure high-quality image input. After obtaining the image sources, precise alignment of the depth and RGB images is performed. Color restoration is applied to the depth image, providing convenience for subsequent visual extraction. The RGB image undergoes format conversion and other preprocessing to meet the requirements of subsequent algorithms. This system utilizes an Intel RealSense D435i camera to capture video data, obtaining high-quality depth and RGB images, as well as inertial measurement unit (IMU) data. The images are then preprocessed through simple adjustments such as resizing and normalization to make them compatible with the yolov5 model. The depth images and IMU data are used for further feature extraction or enhancing object recognition performance. The pretrained YOLOv5 model is then loaded to identify the processed images. Subsequently, the results output by YOLOv5 undergo post-processing, including non-maximum suppression to remove overlapping bounding boxes. Additionally, a predefined threshold is applied to filter out bounding boxes with low confidence while retaining those with high confidence. When the algorithm detects that the object overlaps with the coordinates of the laser beacon marker, the laser beacon will emit light.

IV. System test

The precision painting design of reciprocating machine based on YOLOv5 is tested by actual operation. Through the problems occurred in the process of the reciprocating machine, the algorithm parameters are adjusted, and the precision painting process is also completely realized.

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