

Design of PCB Defect Detection System Based on PyQt

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Abstract: With the rapid development of electronic manufacturing industry, printed Circuit Board (PCB) is the core hub of electronic products, and its quality inspection plays a decisive role in ensuring the performance and reliability of products. In order to overcome the shortcomings of weak interactivity and low visualization of traditional PCB board defect detection methods, this study designed a highly interactive and intuitive PCB board defect detection system based on YOLOv5 with the help of PyQt toolkit. The system has a UI with complete functions and stable performance, which includes three functional modules: model selection, image input and detection result display. The system can not only accurately identify PCB short circuit, open circuit and other defects, but also accurately mark the location in a visual way on the inspection image, and enumerate the types of defects in detail, which greatly improves the readability and understandability of the inspection results. The UI designed in this study provides an intuitive and efficient operation platform for PCB board defect detection work, which is expected to promote the innovation and development of quality detection technology in the electronic manufacturing industry.

Keywords: PCB defect detection; PyQt; YOLOv5; UI.

1. Introduction

In today's era of soaring science and technology, the electronic industry is developing at an unprecedented speed and has been widely penetrated every corner of people's life and production. As the core component of electronic equipment, the quality assurance of printed Circuit Board (PCB) is directly related to the performance and reliability of electronic products, so the defect detection of PCB board is extremely important. Traditional PCB defect detection methods mainly rely on manual visual inspection and Automatic Optical Inspection (AOI) system based on machine vision. In the process of manual visual inspection, inspectors need to look at the lines and components on the PCB board for a long time, which greatly reduces the detection efficiency and accuracy. For AOI system based on machine vision, although it improves the detection speed to a certain extent, there are also many problems and shortcomings in practical applications. For example, for some special materials or under the interference of complex background, AOI system is often prone to miss detection or false detection, which cannot meet the quality requirements of PCB board defect detection.

In recent years, deep learning technology has made significant progress in the field of computer vision, providing a new solution for PCB defect detection. For example, Zhichao Sun [1] et al. proposed a PCB defect detection algorithm based on deformable residual convolution and telescopic feature pyramid, which improved the target feature acquisition ability, optimized the multi-scale recognition ability, and realized the PCB defect detection with high detection accuracy and speed. Guohua Fan [2] proposed a fast template matching method (BBM) based on color images, which can effectively resist the interference of outliers generated by background clutter and noise, and can complete the detection of various PCB defects at one time. Among them, YOLO series algorithms are widely used. For example, Kai Zeng [3] et al. proposed YOLOv3-spp target detection algorithm to construct welding defect detection model, realize the re-inspection of PCB welding defect images, and can quickly and accurately identify and locate welding defects.

Yan Zhao [4] et al. proposed a real-time circuit board fault detection algorithm based on Darknet network and YOLOv4, which can effectively identify the position of components in real time and intuitively identify the components with short-circuit faults.

All the above algorithms can detect the defects of PCB efficiently and accurately, but the presentation form of the detection results is lack of intuitiveness and interactivity. This design will give full play to the characteristics of GUI interface interaction, intuitive and easy to understand, and design a PCB defect detection system based on PyQt.

2. Basic Theoretical Knowledge

2.1. Introduction to YOLOv5 Model

YOLO (You Only Look Once) series is a very classic object detection algorithm, which can complete multi-scale and multi-object detection tasks, and is more efficient than two-stage detection methods. The characteristics of YOLOv5 are suitable for mobile deployment, small model and fast speed. There are four versions of YOLOv5s, YOLOv5m, YOLOv5l and YOLOv5x, and the difference between them is model depth and model width. YOLOv5s network is the network with the smallest depth and the smallest width of the feature map in the YOLOv5 series, and the other three are constantly deepened and widened on this basis. YOLOv5 is usually divided into four modules, including: input, baseline network, Neck network and Head output.

Input: refers to the input image. In this stage, the image is preprocessed, the input image is scaled to the input size required by the network, and operations such as normalization are performed. During network training, YOLOv5 uses Mosaic data enhancement to improve the training speed and network accuracy of the model. At the same time, adaptive anchor box calculation and adaptive image scaling methods are proposed.

Baseline Network: Derived from some of the best performing classifier networks, this module is mainly used to extract general feature representations. In YOLOv5, not only the CSPDarknet53 structure is adopted, but also the Focus structure is used as the baseline network.

Neck network: Usually between the baseline network and the Head network, it can further enhance the diversity and robustness of features.

Head output: It is responsible for completing the output of target detection results. According to different detection algorithms, the number of branches at the output is different, generally including a classification branch and a regression branch.

2.2. Introduction to PyQt

PyQt combined with the improved YOLOv5 model was used to make the visual interface, and the UI program was written to display the results, which completed the interactivity of PCB defect detection.

PyQt [5] is a GUI (Graphical User Interface) framework for the Python programming language. It provides a wealth of tools and features for creating interactive applications. It combines Python with the Qt library, a cross-platform C++ application framework. It is known for its powerful GUI development capabilities and cross-platform features. PyQt brings the power of Qt into the Python environment, allowing developers to leverage the simplicity and flexibility of Python to create various types of desktop applications, including window applications, dialog boxes, menus, toolbars, and

more. The main feature is the cross-platform feature based on Qt, which provides many predefined components, such as buttons, text boxes, labels, etc., covering almost all common GUI elements. The signal and slot mechanism makes event handling very intuitive and flexible, and facilitates developers to implement various interactive logic. A variety of layout managers are provided, such as horizontal layout, vertical layout, grid layout, etc., to ensure that the interface can maintain good appearance and readability under different window sizes and screen resolutions.

3. System Frame Design

The system framework of this study is shown in Fig. 1, which is mainly divided into two parts: training model and UI. In the environment that Python depends on, the first part of model training is performed, that is, the training model of YOLOv5 is used to train the PCB board data set to obtain the pt model. Then, the second part of UI is carried out, in which the model is selected as the pt model obtained in the first part, and a PCB picture to be detected is uploaded to start the detection. If the model and picture are uploaded successfully, the detection result is obtained, and if the upload fails, the upload is returned.

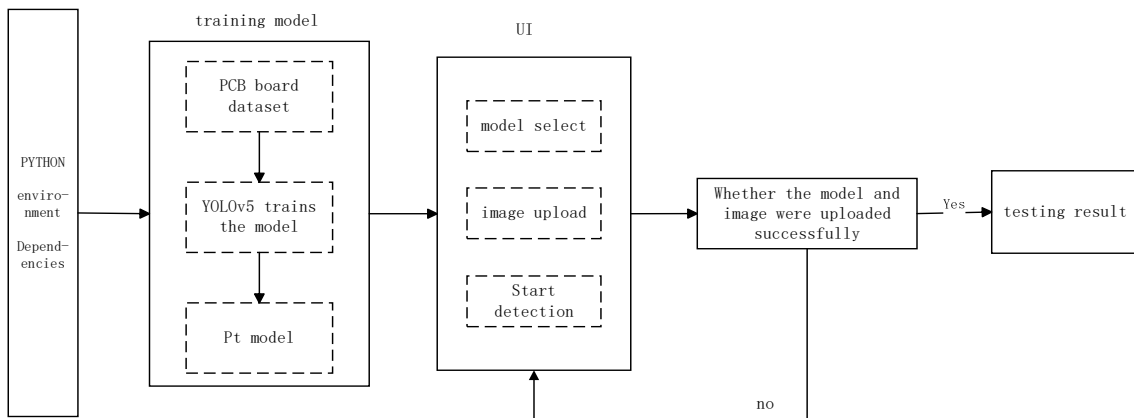


Figure 1. System framework

4. Design and Analysis of PCB Defect Detection System Based on PyQt

4.1. Interfacial Design

The interface design of PCB defect detection consists of three parts: selecting model, uploading pictures and starting detection. Through the GUI interface written by Python PyQt library [6], the intuitive and interactive presentation of PCB defect detection results is realized, and the final detection results are automatically displayed.

The system interface, as shown in Fig 2, is designed by multiple buttons "PushButton", "Lable" and text editing "textEdit" and other controls. When clicking the function buttons of "select model", "upload picture" and "start detection", the detection results will be automatically displayed in the display bar such as "prediction results".

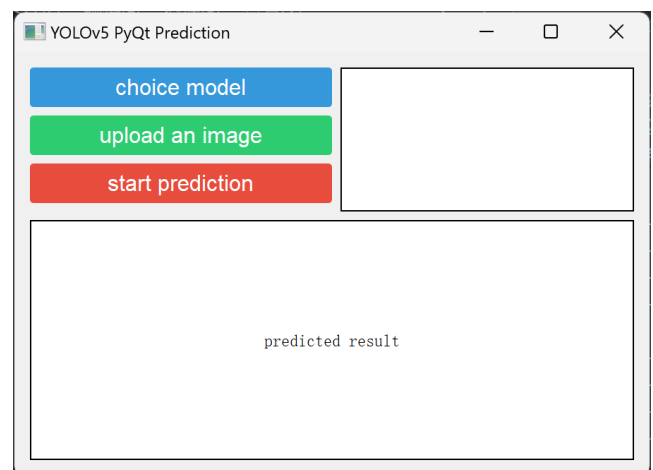


Figure 2. System interface

The interface design of PCB defect detection consists of three parts: selecting model, uploading pictures and starting detection. Through the GUI interface written by Python PyQt library [6], the intuitive and interactive presentation of PCB defect detection results is realized, and the final detection results are automatically displayed.

4.2. Function Introduction and Analysis

In this study, a public dataset of PCB board defects was used, which contains a variety of types of PCB images, totaling 693 images. It covers various common defect types of PCB boards, such as short circuit, broken circuit, mouse cavities, leakage holes, burrs, and virtual copper. The pt model is obtained after training the dataset using the basic model of YOLOv5.

1) Model selection

After clicking the button of "choice model", the windows system will pop up the file selection dialog box as shown in Fig 3. Select the "pt Model" that has been trained, namely the best.pt file in Fig 3, and the right display bar will display "Model loaded successfully!" That is, the selection is successful, as shown in Fig 4.

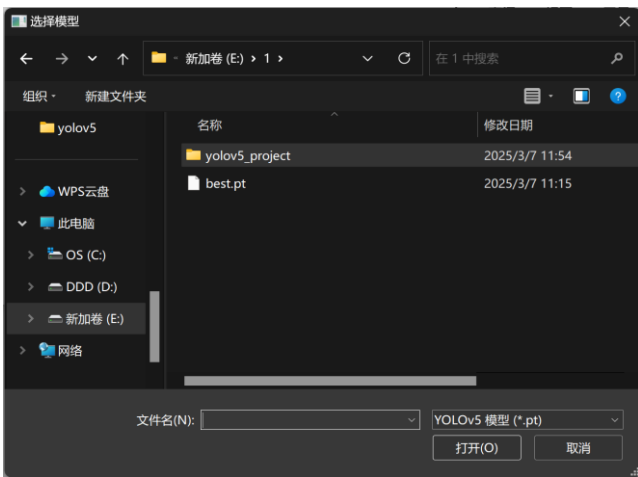


Figure 3. File selection dialog box

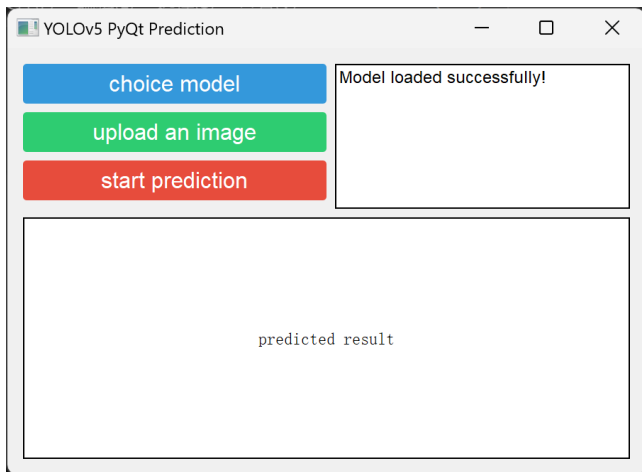


Figure 4. Successful model selection

2) Upload images

After clicking the "upload an image" button, select the image to be detected in the file selection dialog box that pops up, and "Image uploaded successfully!" will be displayed in the right display bar. As shown in Fig. 5, the uploaded picture is displayed in the "predicted result" display bar.

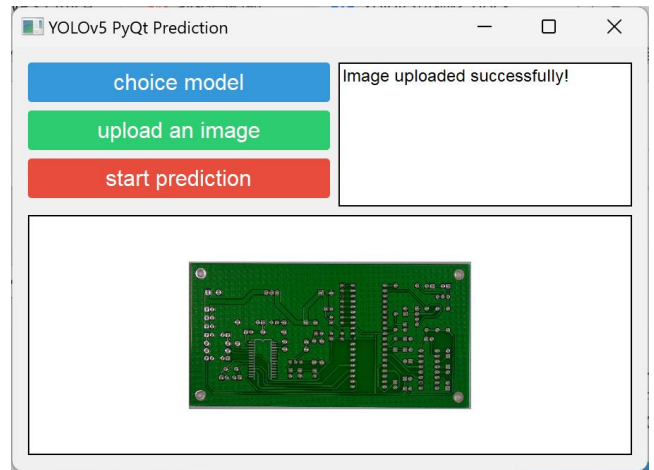


Figure 5. Image uploaded successfully

3) Display of results

After clicking the button of "start Prediction", the detection results are shown in Fig 6. There are defects in the PCB board at three places, all of which are missing holes.

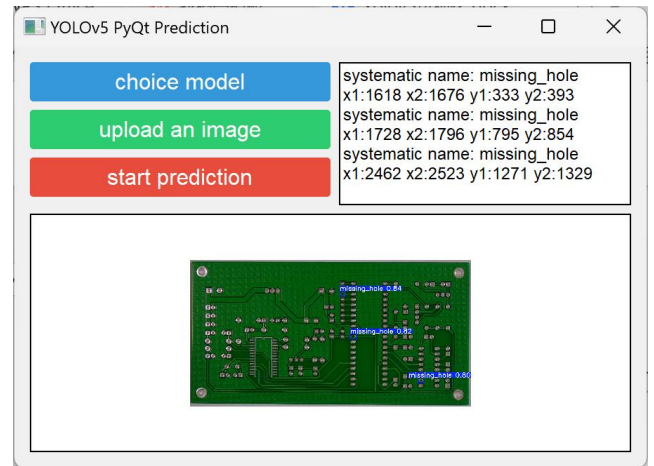


Figure 6. Detection result

4) Error alerts

If the model and images are not uploaded successfully, there is a warning as shown in Fig 7, "Please load the model and upload the images first!".

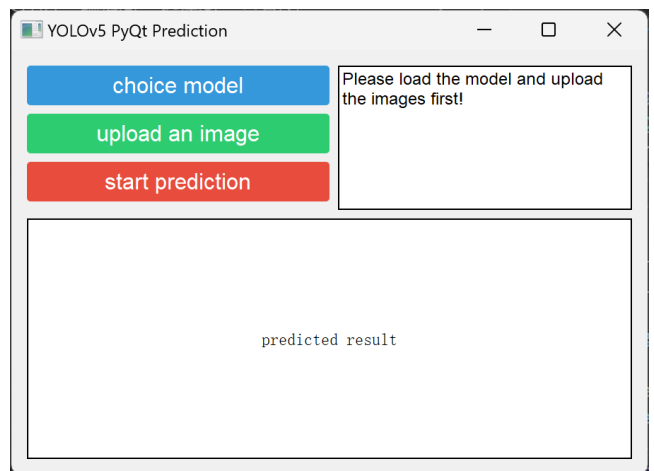


Figure 7. Upload failure warning

5. Peroration

In this study, a PCB board defect detection system is designed and constructed based on PyQt toolkit. The system interface designed in this paper integrates key functions such

as model selection, image input and test result display. With its simple and easy-to-use operation mode, powerful interactive performance and intuitive and clear presentation effect, it brings users a high-quality experience, and effectively solves the problems of complex operation and low visualization in the traditional PCB defect detection process. This research has important theoretical significance and application value, and its results are expected to be widely used in the electronic manufacturing industry, helping enterprises to improve the efficiency and accuracy of PCB board quality detection, reduce production costs, and promote the technological upgrading and innovative development of the whole industry. At the same time, it also provides practical experience for subsequent related research, and further expands the application boundary of PyQt toolkit in the field of industrial detection.

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