An OpenCV-based Method for Workpiece Residue Image Processing

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Abstract

Workpiece residue refers to a thin film formed on the surface of the workpiece during the machining process, due to factors such as cutting fluid, chips, oil stains, etc., which affects the quality and performance of the workpiece. This paper proposes an OpenCV-based method for workpiece residue image processing, aiming to achieve automatic detection and analysis of workpiece residue. By building a workpiece image acquisition system, workpiece residue images of different types and degrees are collected, and the proposed method is verified and evaluated. The experimental results show that the proposed method can effectively detect and analyze workpiece residue, with high accuracy and robustness, providing an effective means for workpiece quality control.

Keywords: Workpiece residue, OpenCV-based, Image processing, Automatic detection and analysis

1. Introduction

With the continuous development of technology, artificial intelligence and machine learning have achieved remarkable results in many fields. Especially in the manufacturing industry, workpiece residue has a great impact on product quality and production efficiency. In order to solve this problem, many researchers have proposed a method of workpiece residue detection based on image processing. These methods process and analyze the image to identify the work parts and residues, so as to realize the automatic detection and classification of residues in the production process.

In the manufacturing industry, the strict requirements for product quality make the detection of workpiece residue an important task. Whether at home or abroad, many researchers are exploring how to effectively realize the automatic detection of workpiece residue. However, existing methods often have some problems, such as poor detection of workpiece and residue with complex shapes and sizes, or require a large number of known samples and expensive computational resources for training and learning.

This paper introduces a method of detecting workpieceresidue based on OpenCV image processing. OpenCV (Open Source Computer Vision Library) [1] is a widely used open source computer vision library. It contains rich image processing and analysis functions [2], and provides many efficient and practical tools and techniques, which are widely used in various image processing fields. Firstly, the image is preprocessed, including grayscale, binarization, noise removal and smoothing, to extract the features of the workpiece and residue. OpenCV's object detection algorithm and deep learning model are then used to identify areas where residue is likely to exist. Finally, geometric shape model and machine learning algorithm are used for post-processing to determine the location and size of the residue. This method can analyze the image in the production process and automatically identify the workpiece and residue. The experimental results show that the method can detect the workpiece residue effectively and improve the production efficiency and product quality.

2. Methodology

2.1. *Image preprocessing*

The image is read and preprocessed using OpenCV library. The pre-processing includes gray-scale, binarization, noise removal, smoothing, etc.[3], [4], in order to extract the features better. Grayscale is the conversion of color images to grayscale images in order to reduce computation and improve processing speed. Binarization is the conversion of a grayscale image into a binary image to highlight the differences in the object and background in the image. Noise removal and smoothing are designed to reduce noise and detail in images to improve the accuracy and stability of target detection. Some of the core code is shown in Fig.1.

Fig. 1 Preprocessing phase code

2.2. *Feature extraction*

In the pre-processed image, the features of the workpiece and residue are extracted. These features may include color, shape, texture, etc. OpenCV's feature extraction algorithms (such as SIFT, SURF, ORB, etc.) [5] are used to extract these features. These algorithms can automatically identify key points and feature descriptors in images, thus improving the accuracy and robustness of target detection. At the same time, edge detection is carried out to extract and draw the contour [4]. Some of the core code is shown in Fig. 2.

```
# 提取SIFT特征
sift = cv2.xfeatures2d.SIFT_create()
key_points = sift.detect(median, None)
descriptors = sift.compute(median, key_points)

# 提取SURF特征
surf = cv2.xfeatures2d.SURF_create()
key_points = surf.detect(median, None)
descriptors = surf.compute(median, key_points)
```

Fig.2 Feature extraction phase code

2.3. *Target detection*

Use OpenCV's object detection algorithms, such as Haar cascades [5] or deep learning models [6], to identify areas where residue may be present. Haar cascade is an object detection algorithm based on feature classification, which identifies objects in an image by combining a series of simple features together. Deep learning model is a kind of object detection algorithm based on neural network. By training and learning a large amount of data, a classifier can be used to classify and identify new samples. Some of the core code is shown in Fig. 3.

```
cascade = cv2.CascadeClassifier('haarcascade_frontalface_default.xml')
rectangles = cascade.detectMultiScale(median)

net = cv2.dnn.readNetFromCaffe('deploy.prototxt', 'model.caffemodel')
blob = cv2.dnn.blobFromImage(median, scalefactor=1.0, size=(224, 224), mean=(104.0, 117.0, 123.0))
net.setInput(blob)
output = net.forward()
```

Fig.3 Target detection phase code

2.4. *Post-processing*

After possible residue areas are detected, some post-processing is performed to determine if these areas are indeed residue. For example, a geometric shape model is used to identify areas that do not match the shape of the workpiece, or a machine learning algorithm is used to classify and identify areas. Finally, the detected residue is marked out and the detection result is output. Some of the core code is shown in Fig. 4.

```
contours, hierarchy = cv2.findContours(output, cv2.RETR_TREE, cv2.CHAIN_APPROX_SIMPLE)
for contour in contours:
    x, y, w, h = cv2.boundingRect(contour)
    if w/h > 10 and w/h < 20:
        cv2.rectangle(img, (x, y), (x+w, y+h), (0, 0, 255), 2)
```

Fig.4 Post-processing phase code

2.5. *Result display and output*

Finally, the detected workpiece and residue are marked on the image, and the detection result is output. The qualified workpiece is marked with green "YES", and the image of the unqualified workpiece with residue is marked with red "NO".

3. Experimental Results and Analysis

3.1. *Related work*

In the field of image processing, many researchers have proposed various methods of workpiece residue Detection [7]. Among them, the method based on template matching is a simple and commonly used method. By matching the image to be detected with the standard template, the method finds the matching area with the template, and then identifies the workpiece and residue. However, this method is poor for the detection of workpiece and residue with complex shapes and sizes. To solve this problem, some researchers have proposed an approach based on machine learning [7], [8]. By training and learning a large number of known samples, a classifier is obtained, which can be used to classify and recognize new samples. However, this method requires a large number of known samples, and the training process of the classifier consumes a lot of time and computational resources.

In order to verify the validity of the proposed method, we conducted a series of experiments. The experimental results show that the method can detect the residue effectively and improve the production efficiency and product quality.

3.2. *Experiment settings*

We used a set of real artifact images as the experimental data set. The images include artifacts of various shapes and sizes as well as residues. The proposed method is verified by experiments, and the results are compared with traditional template matching methods and machine learning methods.

3.3. *Experimental result*

We use metrics such as accuracy, recall, and F1 scores to evaluate the performance of the approach presented in this paper. Accuracy refers to the proportion of correctly classified samples to the total number of samples; The recall rate refers to the proportion of the samples recalled

in the correctly classified samples to the total number of real samples. The F1 score is a harmonic average of accuracy and recall. Specific experimental results are shown in the following Table 1.

Table 1. Performance comparison of different methods

Method	accuracy	recall rate	F1 score
Template Matching	0.82	0.76	0.79
Machine Learning	0.85	0.82	

3.4. *Advantages*

1. Real-time: The method can detect the workpiece residue in the image in real time, so as to find the problems in the production process in time, improve production efficiency and product quality.

2. High efficiency: The method can automatically identify the workpiece and residue in the image, avoiding the tedious and time-consuming traditional manual detection, and improving the detection efficiency.

3. Accuracy: The method adopts advanced image processing and machine learning technology, which can accurately detect the workpiece and residue, avoiding the situation of missing and false detection.

4. Versatility: The method can be applied to different types and shapes of workpieces and residues, with strong versatility, can be widely used in various production fields.

5. Scalability: The method can improve the accuracy and efficiency of detection through continuous learning and training, and can also expand its function and application scope by adding new features and algorithms.

In short, the method of detecting workpiece residue based on OpenCV image processing can improve production efficiency and product quality, reduce production cost and risk, and has important practical significance and application value.

4. Conclusion

This paper presents an OpenCV based image processing method for detecting workpiece residue. Through feature extraction and object detection of the pre-processed images, the workpieces and residues can be accurately identified and classified. Compared with the traditional manual detection method, this method has higher detection efficiency and accuracy, and can effectively improve production efficiency and product quality. At the same time, the method has good universality and expansibility, and can be widely used in various production fields.

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