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Research on Chip Defect System based on Machine Vision

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Abstract

At present, machine vision based defect detection is a hot research channel to realize automatic defect detection technology. Based on the ultra thin Gigabyte single port network transformer chip product as the carrier, the paper puts forward a system research on the automatic defect detection technology based on machine vision to eliminate and sort the defective chip products in the manufacturing process. The research focuses on the development of a set of high efficiency, precision, stable ultra-thin single port network transformer chip automatic defect detection platform. The research content mainly focuses on the design of detection platform, vision system setting, image analysis and processing, and control system implementation. The results show that the accuracy of defect detection is 95%, and the detection efficiency is 38% higher than that of manual testing, which meets the research expectation.

Keywords

Machine Vision Defect Detection; Image Analysis and Processing; Control System Implementation.

1. Introduction

At this stage, the global electronic components manufacturing and technical level is constantly tending to chip, miniaturization, composite, high-performance and high-precision direction [1-2]. Among them, the network transformer as a representative of the surface mounted chip components are widely used in various industries of electronic and electrical equipment. In the new round of industrial restructuring, the market demand of ultra-thin Gigabit single port network transformer chip products with ultra-thin, micro, lightweight and high efficiency as the breakthrough point will continue to grow and be widely used [3-5].

The chip model of this study is 24atf02-5g, and its length and width are 16.5 mm × 7 mm, thickness is only 2. 5 mm, is a kind of ultra-thin Gigabit single port network transformer, surface mount type in equipment, mainly used for signal level coupling. As shown in Fig. 1.

(a) Top view of chip products (b) Side view of chip product

Fig. 1 Ultrathin gigabit single port network transformer chip

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Aiming at the low recognition rate of complex ceramic tile surface defects, Li Junhua [6] and others proposed a multi feature fusion algorithm based on the BOF framework to classify tile. Tang Wanyou [7] and others adopted a method based on blob analysis, through template matching, the defects in color and shape of printed products were visually identified. Aiming at the shape size and defect detection of sealing ring, lishaohui [8] and others proposed image processing algorithms for contour extraction and tracking, migration probability matrix and offset second-order moment extraction. The above algorithm can detect the multi feature defects of plane pictures of parts. However, under the actual production conditions, a part needs to identify more features, and a single detection algorithm can not meet the needs of all features [9]. Therefore, it is necessary to study a defect detection method which can automatically adjust the illumination, automatically realize multiple shooting and multiple judgments [10].

In this paper, the paper proposes "Research on defect detection system of network transformer chip based on machine vision", aiming to improve the efficiency of multi feature defect detection of small size parts. This paper takes ultra thin single port network transformer chip as the research object, uses machine vision technology, real-time acquisition of part image and extract its defect characteristics, and combines automatic control technology to develop equipment, and finally realizes automatic defect detection of chip products and rapid elimination of unqualified chip products [11].

2. Overall scheme design

Before designing the defect detection system, we need to define the detection index, that is, the evaluation index and detection requirements when relying on manual detection at first. Because the lower cover plate of the chip product belongs to the covering and laminating part, the key point is only to detect the defects of the upper cover plate. According to the technical requirements of defect detection and the actual situation of production detection, the following defect detection objectives and conditions are determined

(1) The manual inspection conditions require that the chip products are free of defects, such as the solder of the lower pins is free of adhesion, modification and other defects that affect the normal use of the equipment;

(2) The manual inspection condition requires that the upper cover plate of the chip should be parallel to the whole, and there should be no deflection, warpage and other shape and position defects. If the upper cover plate of the product is skewed, the upper row of pins will be exposed, and the maximum allowable length of the exposed area is 0.8 mm.

(3) The test condition of the chip product requires that the surface has no scratch, watermark and other surface quality defects. Among them, the length of a single scratch cannot exceed 2 mm, and the minimum radius of watermark cannot exceed 2 mm. And the same chip product can not have two surface appearance defects at the same time.

If there is no defect of any of the above characteristics, it will meet the chip product testing requirements and be regarded as qualified products, otherwise it will be regarded as defective products and will not be delivered out of the factory. As shown in Figure 2, examples of chip products with top cover skew, scratch and watermark defects and qualified products are listed respectively[12].

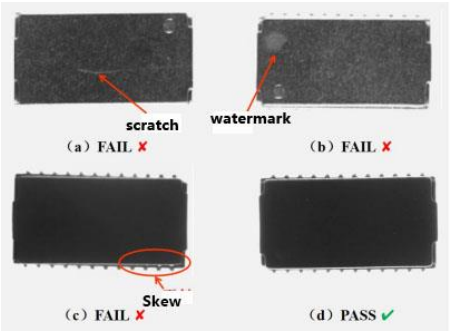

Fig. 2 Product Defect Characteristics

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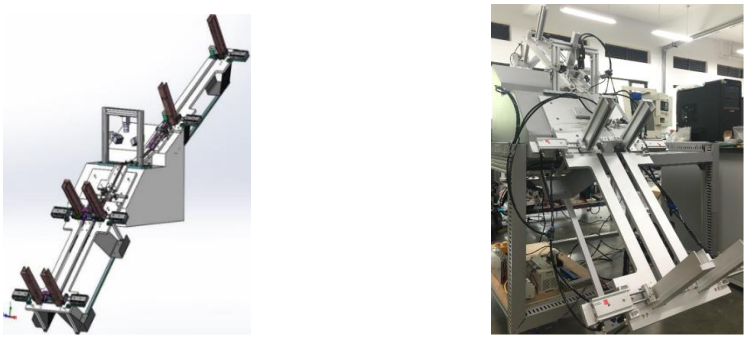
The detection and control platform studied in this paper mainly includes mechanical structure module, image processing module, software control module and electrical control module, involving mechanical structure design and assembly, chip product image acquisition and analysis and processing, hardware and software design and implementation The development of upper computer software control and programming, and the electrical control debugging of the detection platform to realize the automatic elimination and sorting of chip products [13].

2.1 Hardware platform construction

In order to avoid the failure of assembly caused by the separate design of parts, and improve the design efficiency, the system detection platform uses the first use to draw the three-dimensional diagram, and uses the Three-dimensional Modeling Software Solidworks for modeling. According to the function, quality, efficiency and design cost and other factors, the three-dimensional model detection platform as shown in Fig. 3 (a) is designed and constructed, with the length, width and height of 1850 mm × 470 mm × 1590 mm. The whole structure model is divided into three parts: upper part, middle part and lower part. Among them, the upper part and the lower part of the working device table are inclined 45 º, Part of the image defect detection area is designed horizontally. In addition to the cold-rolled carbon steel (SPCC) box, the non-standard design parts of the whole testing platform are 6061 aluminum plate, covering a total of 46 sets of 110 non-standard design parts. The hardware assembly of the platform is completed by a large number of fastening connectors. As shown in Fig. 3 (b), the physical construction of the detection platform.



(a) 3D model platform (b) Platform building object

Fig. 3 Platform model and construction

2.2 Machine vision system

The chip product defect detection and control system based on machine vision includes hardware system and software system. The hardware system includes machine vision hardware system and defect platform hardware control elimination mechanism, as shown in Fig. 4. It includes PC, digital controller, industrial camera group (camera and lens), light source, image acquisition card, input and output port, position sensor and other important parts [14].

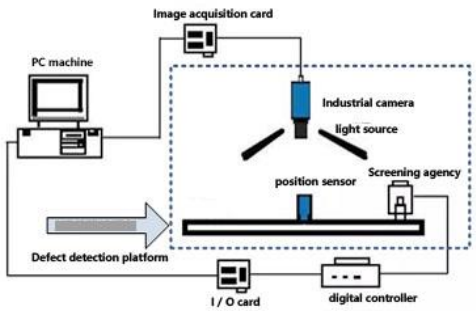


Fig. 4 Push PVC plastic pipe air cylinder

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2.3 Control system

In this chip product defect detection system, the visual system completes image acquisition and image processing, Halcon combined with visual studio programming control to get chip product defect characteristic parameters, the host computer converts the parameters into specific signals through communication protocol and transmits them to PLC, and then PLC control system controls the actuator to eliminate the defective chip products in real time. Fig. 5 is a schematic diagram of automatic defect detection and classification control for chip products [15].

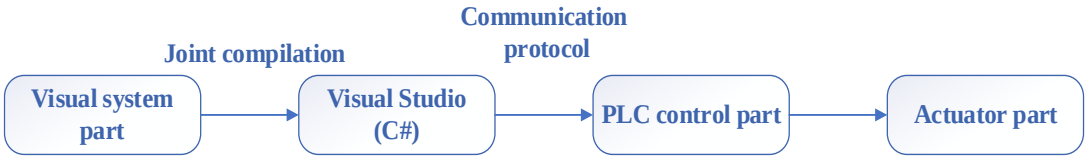

Fig. 5 Defect detection classification control diagram

As shown in the figure, the visual system is composed of image acquisition equipment and Halcon software, which is programmed with windows form framework under Visual Studio development environment based on C # language to exchange data and form a defect detection and control system; The PLC control part is composed of the controller and its accessories and GX works 2 software. It and the executive part of the automatic elimination mechanism of the defective chip products constitute the product elimination control system. Among them, Visual Studio (C #) and PLC are controlled by communication protocol. To sum up, defect detection control system and product elimination control system constitute the automatic defect detection system of ultra-thin Gigabit single port network transformer chip products.As shown in Fig. 6.

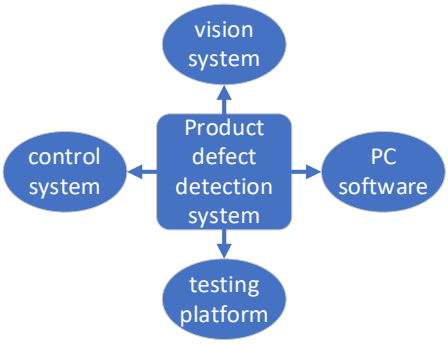

Fig. 6 Defect detection classification control diagram

3. Image processing

After obtaining the calibration parameters of the camera, the image of the chip products must be preprocessed to remove the image noise; Then, the global threshold segmentation is carried out to separate the chip products and the background; Then, the morphology of chip image is processed to remove the pixel clutter in the same connected domain, and to select and calculate the region features. Finally, the image judgment results are obtained, the classification and output are displayed, and the output is completed [16].

3.1 Image preprocessing of chip products

Because the collected image has different degrees of salt and pepper noise (as shown in Fig. 7), it is necessary to preprocess the image. In this study, median filter and histogram equalization algorithm are used to filter, denoise and strengthen the chip image.

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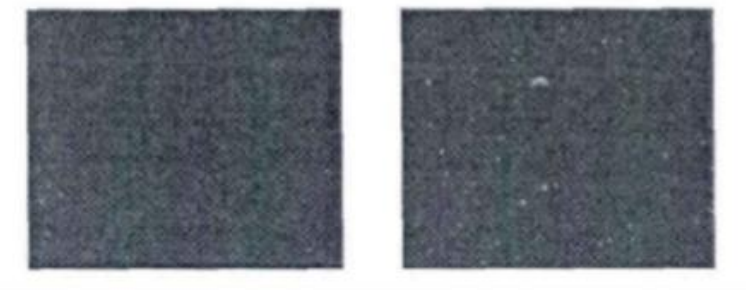

Fig. 7 Image noise of chip products

Through the above analysis, combined with the digital image theory of image filtering and noise reduction and enhancement processing methods, this study uses media_ Image () - median filter and emphasize () - image enhancement are used to preprocess the image. media_ Image () - median filter can not only effectively suppress and eliminate salt and pepper noise in the image, but also preserve the edge details of the image. It is a commonly used image denoising function in Halcon; Call emphasize () operator to enhance the image, so that the image edge and corner of the high-frequency area can be more clear, so as to reduce the difficulty of image processing.

This time we use media_ Image () - median filter. The operator variable format is median_ image (Image: Image-Median: MaskType, Radius, Margin:). Among them, the input / output parameters of image are image and imagemean respectively, while masktype, radius and margin are the input parameters of control variables. Masktype represents the type of noise control that needs to be masked. Its default value is' circle ', and' Square 'is optional; Radius represents the noise radius, the default value is 1, and 2, 3, 4, 5, 6, 7, 8, 9, 11, 15, 19, 25, 31, 39, 47, 59 are optional. The area type value is $1 \leq$ radius ≤ 4095; Margin represents the boundary processing parameter. The default value is' mirrored '. In addition,' cyclic ',' continued ', 0, 30, 60, 90, 120, 150, 180, 210, 240, 25 are optional. Fig. 8 shows the processing results of mean filtering and median filtering for the same chip product under the environment of other operators unchanged.

Emphasis () - image enhancement. The format of the operator variable is emphasize (image: imageemphasize: maskwidth, maskheight, factor:), where image and imageemphasize are the input and output parameters of the image, the control input variable parameters are maskwidth, maskheight and factor, and factor is the contrast enhancement coefficient[17].

(a) Median filtering (b) Image enhancement

Fig. 8 Image after chip preprocessing

3.2 Image segmentation

In Halcon, there are many image thresholding operators, among which threshold () - Global Fixed thresholding operator and binary are the most commonly used_ Threshold () - Automatic global threshold segmentation operator. In this study, binary method was used_ Threshold () - Automatic global threshold segmentation, as shown in Fig. 9, is the binary of the chip product after algorithm I_ Threshold () - Dev before and after automatic global threshold segmentation_ Display () compares the legend.

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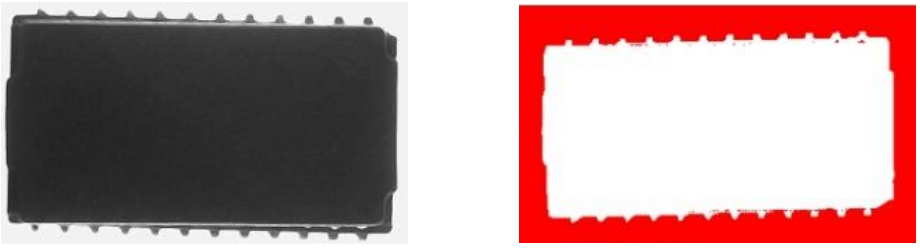

(a) Before threshold segmentation (b) After threshold segmentation

Fig. 9 comparison before and after image threshold segmentation

3.3 Morphological treatment

Morphological processing is carried out around the target after image segmentation. Morphology is one of the most widely used methods in image processing. In this morphological study, there are a variety of image processing algorithms combined by different forms, as shown in Fig. 10, which is the processing results obtained from the regional connectivity processing and the target subtraction set after the operation of circular structural elements. The algorithm can extract a defect feature.

```
binary_threshold (Image, Region1, 'max_separability', 'light', UsedThreshold)
threshold (Image, Region, 220, 255)
opening_circle (Region, RegionOpening, 1)
connection (Region, ConnectedRegions)
difference (Image, ConnectedRegions, RegionDifference)
select_shape (ConnectedRegions, SelectedRegions2, 'height', 'and', 4, 10)
area_center (SelectedRegions2, Area1, Row1, Column1)
```

Fig. 10 Difference operator window

As shown in Fig. 11, on the basis of the above morphological processing method, a fill is performed on the target image after the difference () subtraction set_ Up () is used to fill in, and the processed region fill up is used to calculate the difference set again, thus the algorithm obtains three defect features. Therefore, after a large number of operator combinations and image parameters debugging, the image algorithm in the chip product defect detection system is established.

```
binary_threshold (Image, Region1, 'max_separability', 'light', UsedThreshold)
threshold (Image, Region, 220, 255)
opening_circle (Region, RegionOpening, 2)
connection (RegionOpening, ConnectedRegions)
difference (Image, ConnectedRegions, RegionDifference)
fill_up (RegionDifference, RegionFillUp)
difference (RegionFillUp, RegionDifference, RegionDifference1)
*select_shape (ConnectedRegions, SelectedRegions2, 'area', 'and', 1, 50)
area_center (RegionDifference1, Area1, Row1, Column1)
```

Fig. 11 Difference operator window

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3.4 Chip product shape feature extraction

Using Select_ Shape () operator is used to filter the region; Call area_ The center () operator measures the area and center position of the defect feature, and finally obtains the defect feature of the chip product. Among them, the chip product shape and position defect feature (algorithm I) is mainly the area feature of the top cover skew leakage pin part, and the main implementation operator is select_ Shape () - select region and area with shape feature_ Center () - the area and center of the measurement area.

The following is the morphological processing programming code of the unqualified chip products detected in the shape and position defect feature algorithm (algorithm I) for the first image acquisition and detection:

```
select_shape (ConnectedRegions, SelectedRegions2, 'height', 'and', 4, 10)
  area_center (SelectedRegions2, Area1, Row1, Column1)
  Number:=Area1
  if(Number>0)
      gen_rectangle1 (Rectangle, Row1-20, Column1-20, Row1+20, Column1+20)
      *reduce_domain (Image, Rectangle, ImageReduced)
      *sub_image (Image, ImageReduced, ImageSub, 1, 128)
      boundary (Rectangle, RegionBorder, 'inner')
      dev_display (Image)
      dev_display (SelectedRegions2)
      dev_display (RegionBorder)
      disp_message (WindowHandle,' unqualified ', 'window', 100, 100, 'black', 'true')
      disp_message (WindowHandle,' Features: the upper cover is askew ', 'window', 100+25, 100,
'black', 'true')
       *sub_image (Image, ImageMedian, ImageSub, 1, 128)
  else
      disp_message (WindowHandle,'qualified', 'window', 100, 100, 'black', 'true')
  endif
  close_framegrabber (AcqHandle)
```

As shown in Fig. 12, the image processing results of the feature of shape and position defects (algorithm I) are shown.

Fig. 12 Image processing results

4. Upper computer compilation and experimental verification

4.1 Upper computer compilation

The upper computer software system mainly includes graphics processing; Serial communication; PLC control program. The host computer software human-computer interaction of the chip product defect detection system is the front-end development tool of visual studio 2015 platform. Net

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architecture based on C # language. According to the actual testing requirements of chip products, the UI human-computer interaction interface information is deeply developed and designed. As shown in Fig. 13, the interface contains a total of 12 items of information. It contains five image processing information, including judgment result, defect type, defect size, detection count and display image. It also contains seven button information, such as run and stop cycle detection. The whole UI interface meets all the requirements of product feature detection, and the second integration will be carried out in the later stage, which is easy to put into production.

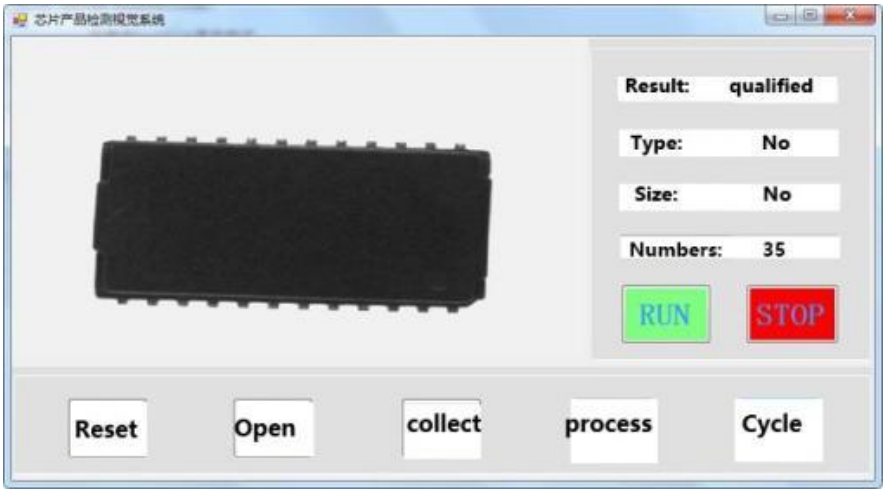

Fig. 13 Host computer interface development

4.2 Experimental verification of defect detection system

After the completion of defect detection control system and product elimination control system, the research work of automatic defect detection system of ultra-thin Gigabit single port network transformer chip based on machine vision tends to be completed. As shown in Fig. 14, the debugging site of the system upper computer, software and detection platform is shown.

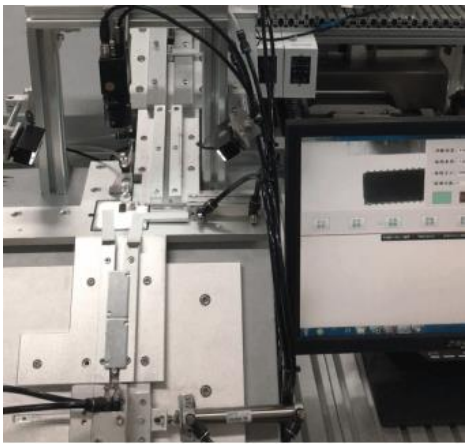

Fig. 14 Experimental debugging site

5. Summary

In this paper, ultra-thin, micro, lightweight and efficient as the breakthrough of innovation, ultra-thin Gigabit single port network transformer chip products as the carrier, research and design a device inspection platform that can automatically detect and eliminate the chip products with appearance defects. The purpose of this paper is to improve the manual operation efficiency of multi feature defect detection of chip products, and solve the prominent problems of automation transformation

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faced by small and medium-sized electronic manufacturing enterprises in industrial structure adjustment and transformation and upgrading.

After experimental verification, the lowest accuracy of repeated experiments is 99%, which shows that the system has high reliability and can guide the actual production. The detection rate of the image processing algorithm for the two unqualified features of qualified chip products, cover skew and warpage is 100%; The detection rate of watermark is 95% (accurate 1 percentage point); The detection rate of scratch was 91% (accurate 1 percentage point). After analysis, in the process of scratch detection, chip products have surface positioning marks, which will produce the same gray features as surface scratch when processing and extracting image features, thus affecting the judgment results. After the improvement of the algorithm, the location features are excluded before the judgment, and then the judgment is made, and the judgment result is accurate. At the same time, the detection time of single image is 131 MS, which is far faster than the manual detection rate.

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