AUTOMATED WIRE CUTTING AND CRIMPING MACHINE WITH WIRE COLOR DETECTION SYSTEM USING IMAGE PROCESSING AND DATA SEQUENCING

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Abstract—this paper produces design of an embedded system for color detection of insulated electrical wire, which is to be cut, stripped and crimped by an automatic WCCM (wire cutting and crimping) machine. These wire segments would be used in the assembly of Wire Harness. It describes the subsystems which together will compose the required application. Design of the system is performed using Image Processing, Embedded Software, Microcontroller Programming, and hardware design. Each subsystem is shown and key design features are discussed with supporting rational for their implementation.

Keywords—CAW-600II, BOM (Bill Of Material), Harness detection, Image recognition, Color space models, Template matching.

I. INTRODUCTION

The proposed is an embedded system. The design of the system utilizes three subsystems (Embedded System + S/W program + Hardware Design) which together compose the application. Design of the Project is performed using Image Processing, Embedded Software, Microcontroller Programming, and hardware design (somewhere might be PLC programming, etc.).

This system will incorporate all the additional features to the existing system. In present Industrial scenarios, the wire cutting and crimping machine (CAW 600II) is operated manually. The system consists of touch screen display on which input is fed for the wire to be cut and crimped according to a database of BOM (Bill Of Material). BOM consist of the item code, color of wire, length of wire and size of strands i.e. their diameter. Operator only enters the quantity and length of wire. After which, he feeds the wire manually to machine. Machine starts to cut the wire and crimp it accordingly.

Different colors of the wire signify its different functionalities. A wire harness is a collection of several numbers of wires of distinct colors and features. Hence for mistake proofing Image Processing technique is used which will capture the wire image and will detect the color of wire so that the wire which is not mentioned and required in the database will not be accepted by the machine.

The design prepared for existing system will make the process simpler, faster and error proof.

II. PROPOSED SYSTEM

The proposed system consists of all the additional features to the existing system. The database of BILL OF MATERIAL is created which has specifications of wires required in the harness. It also includes the sequence according to which the wires should be cut and crimped.

Proposed system consists of a system which generates daily report of work done on the machine. All the records related to wire cutting machine i.e. wire_id, types and quantity of wires cut and crimped will be updated.

![Fig. Block diagram of the proposed system](image-url)
Automated Wire Cutting And Crimping Machine With Wire Color Detection System Using Image Processing And Data Sequencing

3. **WCC-CAW-600II:**
   It is the main automatic machine that performs all the wire cutting and crimping operations.

4. **Main circuit:**
   Main circuit consists of the PIC microcontroller and its interface with stepper motors of the CAW-600II machine.

5. **Computer:**
   A computer is connected to the machine via RS232 port. It consists of the main software and the Database.

6. **ERP:**
   ERP is the company’s resource planning software form where the Bill Of Material are made and stored to the database in this proposed system.

7. **Output Area:**
   Here we will get the wires that are cut and crimped according to the database.

III. **IMAGE FILTERING AND DENOISING ALGORITHM**

Detection of the wire location is an important part of the image acquisition and processing module. Firstly use of image denoising and edge detection for capturing exact required image and then template matching, color recognition to improve accuracy. Any one of the unprocessed image will inevitably be a variety of noise sources and effects during the generation and transmission. Noise worsens the image quality, uniform and continuous change gray become abruptly or decrease, the formation of a number of false edges or contours of objects, resulting in image blur and difficult to analysis.

Therefore, image processing is very necessary. Suppress or eliminate the image noise to improve image quality is called as image smoothing or filtering. Image smoothing serves two purposes: to improve the image quality and characteristics of the object image extraction. Frequency domain processing is to time-frequency transform the image, in the frequency domain to make consequential amendments to the coefficient, then the image obtained by inverse transform. This indirect method of smoothing has good image smoothing effect, but the drawback is computationally intensive, and not intuitive. The image in this issue is simple; From industrial applications it’s unnecessary to use frequency-domain method to eliminate the noise, so a spatial filter for image processing is used. Spatial filter using the template of the image to do neighborhood operations in the image space, the output value of each pixel of the image are based on the template, calculated by the input pixel values of neighboring pixels.

Median filter is one of the most common non-linear filter, its principle is to move a window W contained an odd number of pixels (typically 3 x 3) in the image, sorted the gray value of the pixels in every location within the window from small to large, and then gray value which is the middle is as the output value of the center of the window pixel, just like:

\[ f(x,y) = \text{mid}\{f(1,1), f(1,2), f(n,n)\} n \in [1,N] \]

Median filter is actually one of a percentage filter. Percentage filter sorted pixel gray values corresponding to the template first, and then select the corresponding pixels of the gray sequence according to the percentage as the center of the pixel gray value of the corresponding pixels. If you take the percentage of 50%, then the percentage filter is median filter; if you take the largest percentage, the percentage filter is the maximum filter. If you take the minimum, then that is the minimum filter. As long as using the appropriate filter transfer function, it can compress the image gray level range, but also allows gray-scale of the interested image to extend, so that the image is clear.
IV. IMAGE EXTRACTION

Threshold segmentation method is a region-based image segmentation method, the basic principle is: dividing the image pixel into a number of categories, by setting different characteristic threshold value. Common features include: directly from the original image grayscale or color features, features transferred from the original grayscale or color value. Extraction of the differences of the gray in the target and its background, to select a suitable illustrates value to determine each pixel's region of the image, if higher than the threshold point belong to the object region, if below illustrates value point belongs to a background area, thus generating a corresponding two value image.

The Otsu method, the principle is “Use the threshold to divide the original image into foreground and background. Foreground: use n1, csum, ml to express points of threshold in current foreground, mass moment, average gray. The background use n2, sum-csum, n2 to express points of threshold in current foreground, mass moment, average gray.

When the optimal threshold, background and prospects should be and maximum difference, the key is how to select the standard of measuring difference. The standard of measuring difference in this Otsu algorithm is maximum variance between two 2398 classes. Variance between two classes is very sensitive of noise and target size, it only has better segmentation effect as the single peak image. When the size of the target and background is quite different, variance function may be rendered into double or multiple peaks. This effect is not good, but the between class variance costs least time. The traditional edge detection is based on the original image, study gray-scale step change of a field in each pixel of the image, use changes of the edge of the adjacent first or second order directional derivative to detect edge. Commonly used edge detection methods are: Laplacian detection operator, Roberts detection operator, Sobel detection operator, etc.

V. WIRE COLOR MATCHING ALGORITHM

After harness location determined, we can use the color space model and its corresponding color formulas and color matching algorithm to compare and match the image of the wiring harness, resulting whether the wire color is qualified.

VI. COLOR SPACE MODELS AND COLOR FORMULAE

1) RGB Color Space:

The wiring harness color images collected by the graphics card are represented by the RGB color space. In RGB mode, the red, green, blue overlay can produce other colors; each color can change the brightness from 0 to 255. In this color space, all color values with RGB three-channel, Such as red is (255, 0, 0), green is (0, 255, 0).

RGB color space representation has some drawbacks:
Non-intuitive, difficult to see the cognitive properties of the color represented by the RGB values; Uneven, the distance between two color points is not equal to two a color difference between the perceptions, dependence on hardware. Therefore, RGB color space is a device-dependent color description not intuitive space.

2) HIS Color Space:

Since RGB is device-dependent and incompatible with the intuitive understanding of color. So, it presents a more intuitive color space model HSI, the three components of it represent hue, saturation and intensity. HSI color space has two important features. First, the luminance component and chrominance components are separated, I components has nothing to do with image color information. H and S component and color the way people feel are closely linked. These features make the HSI color space is ideal for processing and analysis of the characteristics of image processing algorithms based on color perception of human. The ability to describe color of H component is relatively ability closest to human visual, the ability of distinguish is strong. HSI color space and RGB color space conversion by a certain algorithm, you can use the following equation, RGB to HSI space model conversion formula is as follows:

Intensity = max(r, g, b)
Saturation = 1-min(r, g, b)/intensity

The standard color difference formula is defined as:

5+b', if r = max(r, g, b) and g=min(r, g, b)
1-g', if r = max(r, g, b) and g!=min(r, g, b)
Hue = 1+r', if g = max(r, g, b) and b = min(r, g, b)

3-b', if g = max(r, g, b) and b! = min(r, g, b)
3+g', if b = max(r, g, b) and r = min(r, g, b)
5-r', otherwise

Among,
r' = (i-r)/(i-min(r, g, b))
g' = (i-g)/(i-min(r, g, b))
b' = (i-b)/(i-min(r, g, b))
The distance between two image points can be expressed as:

\[
\text{Distance} = [(H_1 - H_2)^2 + (S_1 - S_2)^2 + (I_1 - I_2)^2]^{1/2}
\]

In this formula, \(H\), \(S\), \(I\) three-component independent of each other, we combine these three components, the color is expressed as:

\[
(S \cdot I \cdot \cos H, S \cdot I \cdot \sin H, I)
\]

Then the distance of color can be defined as:

\[
d_{ij} = [(i_j - i_h)^2 + (s_j - s_h)^2 + (s_j - s_h)^2]^{1/2}
\]

The smaller the distance is, the degree of match between two images is higher. The model based on HSI color has high recognition accuracy, and easy to compute, so HIS color model is used to identify wire color.

**VII. IMAGE COMPARISON ALGORITHM OF TEMPLATE MATCHING**

1) **Sample Color Recognition**

Step1: Calculating the average of the surface hue of all colors in harness wires sample.
Step2: Statistical the distribution range of hue average of the sample color category.

2) **Color Identification of Test Harness**

Step 1: calculate the average hue of all the pixel in the surface of the test harness.
Step 2: analysis the average hue present in which of the discrimination range in sample color recognition.
Step 3: determine the color.

3) **Template Matching**

Step 1: compare extracted harness with the template.
Step 2: Analysis their eligibility.

**CONCLUSION**

The system obtains information from developed database storage software, color identification by image processing technology in order to determine the wire is qualified or not as input to the WCC machine. The detection of wire input location is an important part of the image acquisition and processing module. First, use image denoising and edge detection to improve accuracy of color recognition. After harness location determined, we can use the color space model and its corresponding color formulas and color matching algorithm to compare and match the image of the wire, resulting whether the wire is qualified to be cut and crimped.

Experimental results show that the detection system has convenient control, simple operation, accurate data, and high stability. Improves the detection processing speed, accuracy and reliability, save manpower, reduce costs.

**REFERENCES**

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