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Machine Vision for Classification of Used Resistors

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Abstract: Resistor is one of the electronic components used in almost all the electronic circuits. Resistors are available in different size, shape, colour and texture. Classification Resistors are divided into different classes depending upon their functionalities and the material used for construction. From machine point of view resistors are divided into different groups according to their physical appearance. In this paper we have discussed the classification of different types of resistors based on their shape and size and material used for construction. Geometric features such as area, perimeter etc. Classification has been carried out by using SVM classifier and neural network. 96% accuracy has been achieved by both the classifiers.

Keywords: Classification, Machine Vision, Neural Network, Resistors, Reuse, Recycling

I. Introduction

Resistor is one of the electronic components used in almost all electronic circuits. Different types of resistors are used to limit the current in electronic circuits. Resistors are also used in amplifiers, filters, rectifiers, regulators and many circuits [1]. They are also used as temperature sensors, light sensors, current sensor etc. Various types of resistors are, fixed resistors potentiometer, trimmer, printed resistor, thermistor, varistor, LDR etc. Different materials such as metal alloys, carbon and graphite with binders are used for manufacturing these resistors.

A lot of research has been carried out for identification and classification of color coded resistors using machine vision. The resistors are located using Hough line detection method and lines are grouped in a set of lines parallel to axial resistor. Line detection method is followed by region of interest extraction method using horizontal and vertical pixel value analysis. ROI extraction is followed by color rings detection using edge detection technique and colors of these color rings are identified by comparing the color with reference color [2]. Histogram approach, for color band detection in [3]. Classification of resistors can be carried out in many different ways viz. classification based on function, classification by material used, classification by shape, classification based on tolerance etc. for use in electronic circuits [4]. Reuse of components is encouraged now days to reduce e waste and to minimize its hazardous effects on environment and human health [5]. To promote the reuse at component level we have designed machine vision system for classification of electronic components used in college laboratory. For reuse, classification should be done based on shape and size, while for recycling classification should be carried out based on the material used for fabrication.

In this paper we have discussed the classification of different types of resistors i.e. color coded and printed resistors. Classification of six different types of resistors viz., color coded, cermet power resistor, trimmer, preset, potentiometer and LDR as shown in figure has been carried out based on geometric features by using SVM classifier and neural network. Around 96% accuracy has been achieved by both the classifiers.

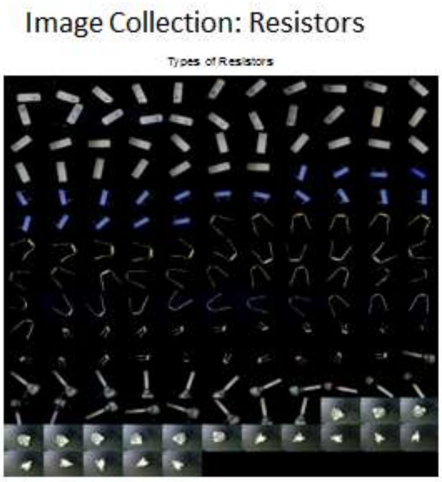

Figure 1. Images of Resistors

II. Related Work

Recycling of E waste is mainly focused on metal recovery from the PCB. Work on metal recovery at component level has not been reported so far [6]. Components from PCB are separated in two methods. First step involves removing solder joints between PCB and electronic components with the use of different processes such as grinding, dissolving in chemical reagents and by applying hot air ,fluids, paraffinic and silicon oil, infrared heaters, electronic heating tubes etc. Second step involves separation of electronic components from PCB by applying external force. Separated electronic components are classified into different groups such as resistors, capacitors, inductors, transistors, regulators, integrated circuits, sensors, connectors, etc. according to functionality and then tested according to the group they belong to. An electronic component is declared reusable if it passes the test. Reusable components are then sent to secondary market for sale to consumers. Electronic components which are not reusable are recycled separating the composition in them such as metal, plastic, semiconductor, ceramic, paper, etc. [6].Separating requires Image processing techniques to control the position of de soldering tool [7]. Image processing techniques can be used for classification of separated components by employing visual inspection method. Image processing techniques are already being used in component manufacturing Industries for quality inspection of painting of metal film resistors by acquisition of line pattern image of correctly painted resistor [8]. To detect incorrectly assembled components, the input image of the component is matched with standard images, using a template matching algorithm [9]. Color vision systems are used to verify correct electronic component or to select proper color for painting the surface of color rings of color coded discrete components. Combination of color location and grayscale pattern matching is used to search for template. Color information in the template is used to look for occurrences of the template in the image [10]. The gray scale pattern matching is then applied in a region around each of these occurrences to find the exact position of template in the image. [11]

III. RESISTOR CLASSIFICATION SYSTEM

1. System Overview

The system is divided into five steps viz., Image acquisition, Image processing, Image segmentation, feature extraction and Image classification.

2. Image acquisition

The proposed system consists of Image acquisition device i.e. USB interface web camera RoboK20, appropriate lighting system and a computer as shown in figure 2. The camera is mounted about 9 cm over a conveyor belt. LED lights are used for uniform lighting. Black color belt has been used to avoid shadow and to simplify image segmentation. Twenty images of each component were captured by RoboK20 and transferred to PC via USB interface and were stored in image database using RGB color space. Total of one hundred forty images were captured for seven types of resistors.

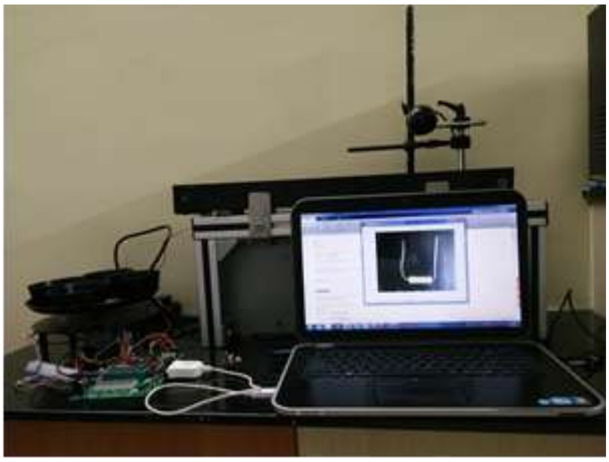

Figure 2. Experimental Setup

3. Preprocessing

A 640 X 480 RGB image was converted to gray scale image using formula

$Gr= 0.21R + 0.71G + 0.07B$

Where Gr is corresponding pixel gray value, R is red color component value, G is green color component value and B is blue color component value. The gray scale image was converted into binary image by using thresholding [12]. Region of interest was extracted from the image for extraction of geometric features of the resistors.

4. Feature Extraction

Resistors are of different size, shape, color and texture depending upon their functionalities and material used for construction. From machine vision point of view resistors have been divide into six groups viz., power resistors with leads, power resistor with broken leads, half watt color coded resistor, trimmer resistor, potentiometer, preset and LDR. Feature extraction method is based on geometric shape description. Geometric shape descriptors have been divided into two groups viz., basic shape descriptors and derived shape descriptors [13].

A. Basic shape descriptors

1. Area

Number of pixels in the region of interest

2. Perimeter

Total number of pixels around the boundary of ROI

3. Major Axis Length

The length (in pixel) of major axis of the ellipse that has the same normalized second central moments as the ROI.

4. Minor Axis Length

The length (in pixels) of the minor axis of the ellipse that has the same normalized second central moments as the ROI.

5. Diameter

The diameter of a circle with the same area as the region of ROI

6. Width

Total number of columns in the image of ROI

7. Height

Total number of rows in the Image of ROI

8. Total Area

Total area is product of width and height of ROI

9. Total Perimeter

B. Derived Shape descriptors

1. **Area Ratio**
2. **Perimeter Ratio**
3. **Form Factor**
4. **Rectangularity**
5. **Perimeter Length Ratio**
6. **Narrow Factor**
7. **Perimeter Diameter Ratio**
8. **Compactness**
9. **Roundness**
10. **Elongation**
11. **Solidity**
12. **Circularity**
13. **Eccentricity**

IV. Classification

Different classification techniques can be used for classification of used electronic components [14]. Some of the classifiers that have been used to classify used resistors are linear discriminant classifier, SVM classifier, K nearest neighbor classifier, Ensemble classifier and neural network, Geometric features extracted from training Images are used to train SVM classifier and K nearest neighbor classifier to discriminate between seven different classes of resistors. Classification is also carried out based on materials used for construction of different types of resistors.

V. Result and Discussion

Web camera RoboK20 was used to acquire the images of different types of Resistors. An Intel core 7, 2.10 GHz CPU was used to run this program for classification. Program code was developed using computer vision toolbox of MATLAB. MATLAB R2017b version was used to obtain the results of classification using neural network and all other classifiers. Size and shape based classification of seven different types of resistors has been carried out based on their functionalities and material used for construction. Nine basic and thirteen derived features have been extracted from each image. Due to addition of derived features accuracy of the classification has been increased. The accuracy rate of classification about 96% has been achieved. Size and shape based classification provides the facility of visual testing for reuse while material based classification provides the facility to sort the resistors for recycling.

Result of classification using KNN classifier is shown in figure 3 where different colors of clusters corresponding to different types of resistors are shown.

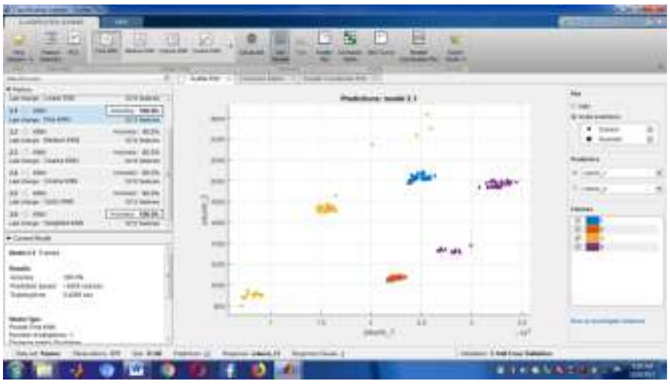

Figure 3 Scatter plot for Classification using SVM classifier

Confusion matrix in figure 4 shows the type based classification of resistors. True positive and false positive members of each class are shown by green color square and pink color square respectively.

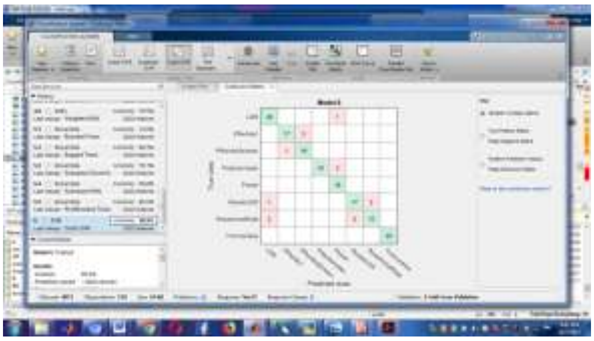

Figure 4. Confusion matrix for type based classification

For proposed system, the best validation performance is At epoch 24. On the training state plot the neural network halt at epoch 24 to provide best performance

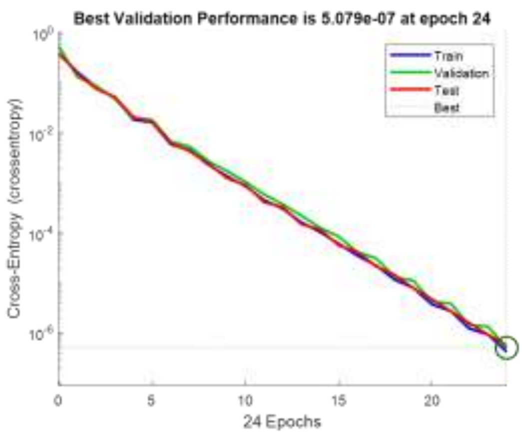

Figure 5 Best validation performance Cross Entropy vs. Epoch

For the proposed system a set of twenty samples is used for each class of resistor and total of 140 X 22 feature matrix is used for training, testing and validating artificial neural network. Comparison of accuracy obtained in type based and material based classification using fine tree, ,medium tree ,coarse tree, linear discriminant, ,linear SVM, quadratic SVM, cubic SVM ,fine Gaussian, medium Gaussian, coarse Gaussian, fine KNN, medium KNN, coarse KNN, cubic KNN ,weight KNN and neural network is shown in table 1

CLASSIFIER	SHAPE BASED ACCURACY	MATERIAL BASED ACCURACY
FINE TREE	91.8	93.7
MEDIUM TREE	91.8	93.7
COARSE TREE	71.9	78.6
LINEAR DISCRIMINANT	92.4	96.9
LINEAR SVM	90.5	95.0
QUADRATIC SVM	90.5	95.6
CUBIC SVM	92.4	95
FINE GUASSIAN	82.9	86.2
MEDIAN GUASSIAN	82.9	86.2
COARSE GAUSSIAN	81.0	89.9
FINE KNN	91.8	95
MEDIUM KNN	78.5	85.5
COARSE KNN	25.3	49.1
CUBIC KNN	73.4	83.6
WEIGHT KNN	88.6	93.6
NEURAL NETWORK	97.87	100

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