Identification and plastic type and classification of PET, HDPE, and PP using RGB method

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Abstract. Plastic is one of the most commonly used materials in daily life. The characteristics of the material that is light, durable, waterproof, and cheap become the main reason why plastic is chosen in the manufacture of ready to use goods. However, due to the increasing use of plastic materials, the amount of waste produced is significant, and tends to increase over time. Therefore, an effective process and recycling of plastic waste are needed. This paper will discuss a method of identifying and classifying plastic waste by type, that use three types of plastic, there are PET, HDPE and PP. The method used in this study is the RGB method, that based on the color value of the plastic.

Keywords: RGB, RGB method, identification, classification, plastic, PET, HDPE, PP

1. Introduction

Plastic is the material that we can easily find at our daily life because of its characteristics. In some uses, plastic is only used at once, such as plastic bottles. Moreover, the most used plastic bottles are PET (Polyethylene terephthalate) types [1]. The continued use is increasing that make the amount of plastic waste continue to increase over time. Plastics require at least decades, even some types of plastic need hundreds of years to decompose.

The accumulation of plastic waste that occurs continuously, if it is not balanced with proper processing will cause pollution. This pollution will be very detrimental because it can affect every aspect of living thing. Moreover, it can contaminate the soil, water, and other elements of life.

Recycling is an effective way to process plastic waste into something kind of useful. Plastic mixes are one of the materials that are difficult to recycle due to their complex characteristics [Wang, 2015]. Until now, there are at least two methods in sorting, namely the manual method and the automatic sorting method. Sorting plastic waste is based on the type of resin forming it. It is essential because the sorting process must be obtained by pure resin from each type of plastic.

The types of plastics consist of 7 types; there are polyethylene terephthalate (PET), high-density polyethylene (HDPE), polyvinyl chloride (PVC), low-density polyethylene (LDPE), polypropylene (PP) and polystyrene (PS), marked with numbers 1 to 6 in each type. Also, there is one additional type of resin to indicate plastic other than the previous six, marked with code seven called "other" [2]. If two or several types of plastic resin are mixed, it will cause a negative impact that can harm the environment, as if PVC and PET are mixed up, it will produce hydrochloric gas [3, 4].

Plastic waste is classified based on the resin or its constituent material. However, nowadays, the manual system is barely used and start to change to the automatic systems that are more efficient and
In general, computer vision aims to take pictures, standard lighting systems, and as software for image processing and analysis using digital cameras [5]. Some studies that use computer vision as a technology for assessing the quality of a product, such as Benalia et al. [6]; Jackman et al. [7]; Ercisli et al. [8]. These studies show that computer vision is an accurate technology, not damaging, consistent, easy to use, cheap, and efficient.

2. Methodology

In 2019, Bektı Khona’ah et. all. have researched the identification and classification of plastic types using the RGB method. However, in her research only two types of plastics were used, there are PET and HDPE [9]. While in this study uses three types of plastic so that the results of this research can be more accurate. The first thing to do is take the image of plastic using a 720 mega pixel webcam. The webcam is installed at a distance of 600 mm from the plastic. The image was taken through a 640 x 480 pixels webcam because it is considered to be most suitable for the needs in terms of image color retrieval. The plastic image that has been detected by the webcam will be directly sent to the PC that is connected to the webcam. The format used to store images of plastic is jpg or jpeg format. This format is chosen because jpg or jpeg is a bitmap file compression scheme, that can compress large sized images into smaller sized images. It is advantageous because it can compress extensive data in rather small storage media.

After the required image of plastic is complete, it can be used to create a database. The making process of the database is based on the color image using the RGB method, that was previously carried out by the characteristic feature extraction process from the plastic. RGB is a method consisting of three primary colors or basic colors, namely red (R), green (G) and blue (B). The color value of each primary color in this RGB method is 0 to 225, so the number of colors obtained is 256 x 256 x 256 or about 16.7 million types of colors. RGB is illustrated using a three-dimensional cube based on the Cartesian coordinate system, as shown in Figure 1. Where specific colors will be obtained if we combine the primary colors that exist (fig 2) [9]. Processing of the RGB method is complete when we already obtain the values from the three primary colors that are conditioned in a specific pixel.

![Figure 1. RGB illustrated based on Cartesian coordinate](image1.png)

![Figure 2. Colors input in RGB method](image2.png)
Preparation process of the database is based on the characteristics of the primary colors red, green, and blue in the form of universal values are of each color in each plastic image. The average of each color red, green, and blue can be obtained by the average formula, for red is the total of all red values is divided by the amount of data available, as well as the green color and the blue color.

The first step in making a data base is to set the template using the `imcrop` command with settings `[280 180 33 33]`, and the image of plastic will be the size of 5x 5 pixels, and we get what we want. Image feature extraction is a fundamental process in image identification and classification. Only certain features needed are maintained for the recognition process so that classifications can be implemented under the conditions required. Feature extraction is a way to simplify the for and make it easier for the system to learn the target concept, and get a simpler hypothesis. The choice of feature extraction method is the essential factor in carrying out a pattern recognition system.

Several factors, such as lighting, camera position, treatment (contrast and brightness), camera height above the object, will affect the quality and sharpness of the final image we obtained, so that configuration is needed in such a way as to get the best results.

After the process of the main database, making has been completed; the plastic identification testing process is carried out by taking a webcam image. The results of the identification are in the form of graphs of red, green, and blue values, that will be processed for the classification process of the type of plastic.

3. **Result and Discussion**

3.1. **System Description**

The system of classification and identification of automatic plastic sorting systems consists of three main components; there are a computer system, a webcam, and an integrated automatic system. The description of the system is a description of the design that has been integrated with the automatic identification and classification system into mechanical systems. The webcam is used in the process of taking images from the objects in the form of several types of plastic; then the image will be processed into digital format. Digital images that have been obtained from the image retrieval process will be processed by a computer system that aims to obtain data similarity values with the database that has been made before. The next process is the automatic identification and classification of computer systems according to the type of plastic based on color images.

3.2. **Data Base**

Database making is one of the most important processes because it will be used as a basic framework in developing automatic sorting systems. The first step is to create an object database. In making a data base, the process that must be done consists of image pre-processing, feature extraction, and classification of color images in the image of plastic that has been obtained before. Image pre-processing consists of image capture and image acquisition processes, and feature extraction consists of cropping and extraction of images, and the trimming process consists of matching templates. The extraction process includes the edge extraction process and the color extraction process. The results of several classifications show the harmony between features and values in the data base.

3.3. **Data Pre-Processing**

The first step is the process of image taking. The quality of the image affects the quality of raw data, and if raw data has good quality, it will automatically affect the overall system performance. Image capture uses a digital webcam as a sensing device, where the digital webcam can produce images with high quality and low noise.

The image is adjusted to 24-bit color, and 640 x 480 resolution obtained using a webcam, then stored in the jpg format. After the image is obtained through the image retrieval process, the quality of the image is examined, whether it is good enough or not. If the image quality is not good enough, the image cannot be processed. As a result, the existing data base is only filled with templates with good quality, and the accuracy of the system will also be better. All images that used are good quality images so they can be processed entirely. It is because at the time of the image taking process, the researchers positioned the plastic to a predetermined position.
3.4. Image Extraction

Image extraction is included trimming parameters and pruning solutions needed in the image composition calculation process. Image solution space still has many parts that must be eliminated because it includes some part of its background that can be identified and decreasing the accuracy of image values. Removal of unnecessary parts of the image will simplify the identification process because it does not require the calculation of the composition features, and the image area exception feature only needs to be counted once for images. The research template settings that used is im crop [280 180 33 33] so that the final size of the image becomes 5 x 5 pixel. Examples of images after the extraction process can be seen in the picture.

3.5 RGB Value

After the identification process is obtained, the values of each color are red, green, and blue for each type of plastic. Moreover, it can be seen in the following pictures (figures 5, 6, and 7).
Based on the profile on Fig. 5-7 above, PET type plastic has a maximum red color value of 253.2042 and minimum value of red 145.39, while the maximum color value for green is 254.9602 and the minimum color value for green is 151.7621, then for maximum color value blue is 252.4066 and the minimum color value for blue is 160.128. Moreover, for HDPE type plastic has a maximum color value for red ranging from 255 and a minimum color value of red 132.8685, for maximum green 255 color value and minimum green color value 140.109, and the maximum blue color value is 254.7362, and minimum color value for blue is 144.1185. The maximum value of red for PP type is 254.1367 and the minimum value is 85.9974, the maximum for green is 254.8088 and for the minimum is 149.3564, moreover for the blue value the maximum value is 236.3651 and for the minimum value of blue is 107.455.

It can be seen that the comparison of the value of red, green, and blue of PET, HDPE and PP seems quite clear, plastic with HDPE type has a value of red, green, and blue that is larger than the type of PET and PP. Based on the results obtained, the difference in the value of three types is significant; the possibility to distinguish each type of plastic will be more significant and more accurate.

The average color value of the PET type is as follows, for the average red value of 173.758, the average green value is 182.247, and the average color value for blue is 191.612. Meanwhile for HDPE type plastic, the average color value for red is equal to 232.44, the average color value for green is 236., and the average color value for blue is 233.45. And the average color of PP type is 172.39 for red, 197.28 for green and 185.418 for blue.

PET type plastic, HDPE type plastic and PP type plastic have a different average value for each color. Comparison of the average value of PET and HDPE is 58,682 for red, 53,853 for green and 41,838 for blue. Comparison of the average PET and PP 1,368 for red, 15,034 for and 6,192 for blue. Comparison of the average value of HDPE and PP is 60,01 for red, 38,82 for green, and 48,032 for blue. Based on the comparison of the three types of plastic, it can be seen that there are significant differences between the average color values of three of it.

4. Conclusion

The type of plastic used in this study includes three types of plastic, the type of PET, HDPE and PP. The study was conducted to present the process of identifying and classifying three types of plastic. Identification and classification are carried out using the RGB method with a data base obtained from image pre-processing, feature extraction, and color image classification in the image of plastic. Set the template by using the im crop command with settings [280 180 33 33], until having the plastic image with the size of 5 x 5 pixel according to what you want. Red, green, and blue values have comparisons that appear to be quite clear between three types of plastic. Plastic with HDPE type has a value of red, green, and blue, that are bigger than the PET and PP type. Comparison of the average value of PET and HDPE is 58,682 for red, 53,853 for green and 41,838 for blue. Comparison of the average PET and PP 1,368 for red, 15,034 for and 6,192 for blue. Comparison of the average value of HDPE and PP is 60,01 for red, 38,82 for green, and 48,032 for blue. Based on the comparison of the three types of plastic, it can be seen that there are significant differences between the average color values of three of it.
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