Lecture Notes in Mechanical Engineering

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Human-Centered Technology for a Better Tomorrow

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This book is dedicated to the late Associate Professor Dr. Zakri Ghazalli.

Preface

Human and technology can never be separated. Humans can no longer exist without the help of technology. The influence of technology on human's daily lives is inevitable. Understanding the relation between humans and technology is key to responsible development and acceptance of future technologies in almost every application field, be it energy, mobility, health, work, living, learning or entertainment. We need to understand better how past technologies have fundamentally changed human existence, and how future technologies may impact human beings and their society. This reflection will help to design technologies with maximal value and minimal friction in a responsible way.

Universiti Malaysia Pahang (UMP) values technological advancement towards improving human lives. Therefore, UMP is planning on establishing a Centre of Excellence, whose research and development is focused on the application of technology for humans. There is a wide area of research in this field of human technology, such as biomechanics, medical technology, ergonomics and human safety, health and rehabilitation, sports technology, bio-inspired technology, among others.

This inaugural Human Enginering Symposium (HUMENS) 2021 is vital to put UMP on par with other universities that have already embarked on this field of research. Through a symposium like this, it is hoped that researchers from all over Malaysia and abroad can have a platform to discuss ideas and findings, in addition to fostering professional relationships for future collaborations among institutions.

This book gathers the papers submitted to HUMENS 2021, which was conducted online due to the COVID-19 pandemic that has affected the whole world. These papers were categorized into four parts: Artificial Intelligence and Biosimulation, Biomechanics, Safety and Sports, Design and Instrumentation, and Ergonomics. On behalf of the editors of this book, we believe that the papers will be of interest to researchers in fields related to human engineering and technology. Let technology enhances human's life, and not worsens it. Thank you.

Pekan, Malaysia

Mohd Hasnun Arif Hassan
Corresponding Editor

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Automatic Identification of Plastic Waste by HSV Colour

Irsyadi Yani, B. Firmansyah, Yulia Resti, Yenni Arnas, Rb. Budi Kartika, Todung Mulia Raja Nasution, W. Hendro, and Ika Endrawijaya

Abstract People don't enjoy living without plastic nowadays. It happens because, in almost every industry, plastic has become a commonly used material. However, at present, it causes the waste of plastic to increase. The process needs to be recycled to reduce the contamination of plastic waste. The manual recycling method has a high possibility of human error, therefore, this automatic system is designed to minimize human error. This research applies Artificial Neural Network (ANN) with three types of plastic to construct an automatic framework to classify and categorized plastic waste. This study also used HSV color space with six input characteristics (RHSV, GHSV, BHSV, mean2, entropy, and variance). The database analysis collected by the training and testing process focused on the implementation of an automatic identification and classification method for plastic bottles, and the rate of the percentage of progress achieved from the training process is 65.3%. The research process's percentage effectiveness is 57%.

Keywords Identification · Classification · Plastic Bottle · PET · HDPE · PP · HSV · Artificial neural networks

1 Introduction

Plastic becomes one of the favorite materials used for producing various items today. Plastic has advantageous bending, easy-to-form, translucent, heat-resistant, and light characteristics. People can discover many things in nearly every section of life that use plastics as the fundamental material. The increased use of plastic bottles begins to pile

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up waste. Efficient processing is therefore needed. In addition to landfill and incineration [1], a plastic recycling process is an alternative approach toward the disposal of solid waste in the form of plastic. The recycling method was chosen because of the long and stable plastic life cycle. For the sorting process to run securely, cleanly, and effectively, automating the sorting process is a positive step. Nevertheless, the automatic sorting system has some disadvantages in certain processes that make it difficult to develop and also has some image quality and lighting problems [2]. The method of burning and burial is inefficient, can cause environmental contamination, and has an impact on the lives of living beings that are biotic and abiotic. Based on its fundamental compounds, plastic waste is classified into seven types: polyethylene terephthalate (PET), high-density polyethylene or HDPE, polyvinyl chloride (PVC) or vinyl, low-density polyethylene or LDPE, polypropylene or PP, polystyrene (PS), etc. This study uses a color sensor to define and distinguish forms of plastic waste by analyzing digital images of plastic waste to obtain a simple and effective method for its processing.

2 Literature Review

The picture is an object's reflection, resemblance, or imitation, produced from the capture of reflected light. In the kind of video signals such as television images or digital images that can directly be processed on media storage [3], image as the output of an optical data recording device is equivalent. The image is split into three groups, which are; RGB image, grayscale image, and binary image, based on the combined pixel colors. Image value can adjust from its physical properties to a scalar view, including the brightness of the monochromatic image, vectors, and matrices. Two forms, analog and digital divide the picture. For example, television screen images, X-ray images, photos, drawings, CT scans, and images on cassette tapes are a type of image that is continuous.

Digital images are arrays that are spelled out in a particular sequence of bits, containing complex and real values. Next, the analog image is transferred to digital format so that a computer program can be used to process it. The numbers stored are numbers that indicate in pixels the sum of pressure. Computer processing of digital images in the form of numerical data [3], In 2012, Hamed Masoumi carried out a separation of plastic resins based on Near Infrared (NIR) reflectance spectroscopy. With this method, the researchers were able to distinguish the types of plastic resins between polyethylene terephthalate (PET), high-density polyethylene (HDPE), polyvinyl chloride (PVC), polypropylene (PP), and polystyrene (PS). Researchers state that the NIR method is an accurate method of analysis and separation but is not suitable for dark-colored plastics. In 2015, Biswajit Ruj et al. conducted a sorting analysis using a variety of plastic sorting methods. From the results of the analysis and observations of these researchers, it is stated that a good sorting technique is sensitive to small differences in gravity and commercial without high investment.

Image processing is also called an activity that seeks to enhance the quality of an image or image. Besides, it is usually divided into different categories, including image quality improvements, image segmentation, image extraction, and image restoration. Picture segmentation is an aspect of computer vision that separates digital images into segments to facilitate and alter the current image so that it can be analyzed more easily. Picture segmentation, including the use of pixel similarity and pixel discontinuity, can be achieved in two ways. Pixels of similarity are pixels that have the same intensity of the gray level, and pixel discontinuities are boundary pixels that have the community pixels' unequal gray intensity levels. It is easy to group photos using details on borders, colors, and backgrounds [4].

Colour is a set of many values present in a light wave that are spectral. The wavelength of light determines a color's identity. From the object, the capturing effect of the light intensity is mirrored. Each color is shown in a spectrum of critical components in the RGB model that are red, green, and blue. The Cartesian system of coordinates is the basis of this model.

The colors are projected on a cube, the main colors are occupied by three corners of the cube, and the secondary colors are cyan, magenta, and yellow at three more angles. Also, black and white are on the edges. In capturing color, the HSV or Hue, Saturation, Value color space is a reflection of the RGB color space that is adapted to the human sense of sight. Using the HSV color system [5], RGB colors can be translated to HSV colors. In Fig. 1, the HSV color space representation is shown.

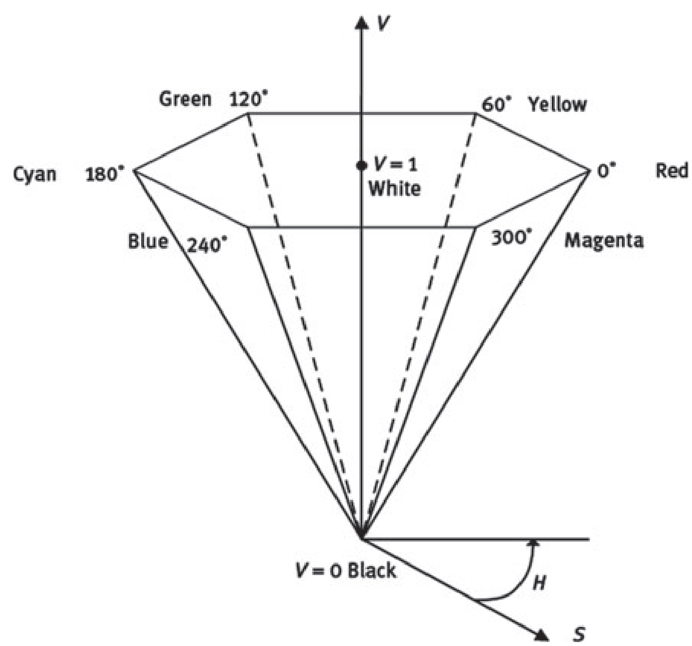


Fig. 1 Representation of HSV color space [3]

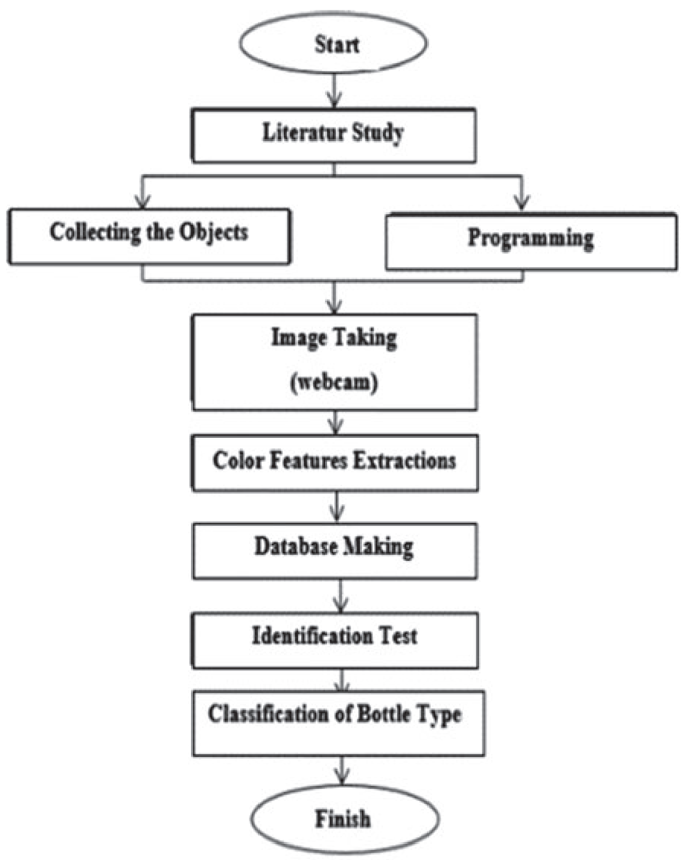
3 Methodology

This research was carried out based on the steps of the flow diagram, as shown in Fig. 2.

This work starts with an attempt to find research that supports, opposes, or similar paper, in order to find any similar studies that have been conducted over the past five years. Afterward that, to support the automatic framework, the items that are needed later should be collected and the software rendered. The three kinds of plastic bottles that need PET (polyethylene terephthalate), HDPE (high-density polyethylene), and PPP are (polypropylene). In this word those samples is chosen because easy to find out everywhere, any products in this world is producting with those plastic. For example is soft drink, many kind of soft drink is producting with PET (polyethylene terephthalate), HDPE (high-density polyethylene), and PP plastic are (polypropylene). This research used transparant bottles because it easier to identifty colored plastics by RGB method.

Taking photographs of things is the next step. This work uses a C270 webcam with a 720p/30fps resolution specification, a 60° view field, and a standard focused lens fixed to take the object's images. Set the image template to a resolution of 640 × 480 pixels and 24-bit colors, then store the image in jpg format. For the best output, high-quality images are necessary. From this process, the system will get a high-quality

Fig. 2 Study flow chart



picture with low noise. The next step is extracting color features after the process of taking pictures. Extraction features needed to obtain the plastic characteristics are used to detail the plastic form. The template is set to 280 180 33 33 cropping so that a 5 × 5-pixel resolution image is the output of the image cropping. The red variable, green variable, and blue variable color values are the products of this process.

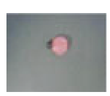
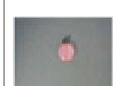
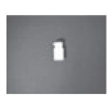
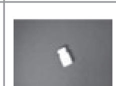
After that, all the pictures have been collected to create the database. In this study, the objective of the database is to collect information based on the extraction of color characteristics. This system uses some new photos in the identification test in the programming process that have been taken randomly from the data test before. At random, but still, on the webcam focal area, the location of objects is put on the table. The data test consists of 90 images of the three types of randomly selected plastics. Finally, plastics will be automatically categorized into each category.

4 Result Dan Discussion

Wearing a webcam, collecting the images of plastic bottles, and then following the recognition and classification method using an automatic computer system. The key components of this study system are the webcam and the automated computer system. The value effects of a webcam capture of a plastic bottle image are in the form of HSV color space.

The first step in the image processing phase is capturing the image of plastic bottles. The image quality previously obtained may affect the quality of the raw data and may also affect the impact of the image results on the functioning of a complete system of identification and classification. The used webcam has an image sensor device that can generate images of high quality but has low noise. For this purpose, in this image processing stage analysis, a webcam has been selected as an image capturing system or can be referred to as an image sensing tool on Table 1.

Table 1 Digital image example of PET type

No	Plastic bottle image	Vertical	Horizontal	Diagonal
1	PET 1			
2	PET 2			
3	PET 3			

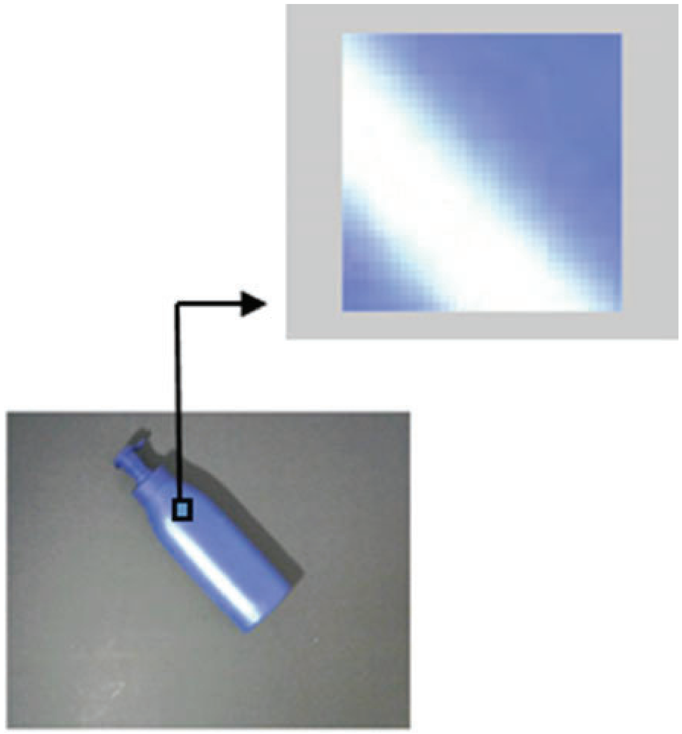


Fig. 3 Image cropping illustration

The image is converted into digital format 'jpg' after capturing the 738 samples, Those photos are collected according to their kinds, PET (polyethylene terephthalate), HDPE (high-density polyethylene), and PPP (polypropylene). To extract image features and find the characteristics of each bottle type, the images collected are needed. Picture capture to obtain the color characteristics of each stored image from each plastic bottle used as a test object. Figure 3. The picture cropping diagram is displayed.

The aim of building a database is to save the results obtained after the process of taking images and extracting image features is carried out. In several levels, digital forms from a database are carried out, such as image processing, image retrieval, identification, and classification. The information that has been compiled is processed and categorized by its sort.

As reference data applied in the identification and classification of plastic bottles, the HSV value of each plastic bottle is stored in the database. Figure 4 shows the RHSV, GHSV, and BHSV values for each type of plastic container. And the average value for RHSV, GHSV, and BHSV is shown in Fig. 5.

The training data total of 738 images; 258 PET images, 243 HDPE images, and 237 PP image samples. In this instruction, detection and classification systems are applied, where the system is attached to a computer system with a webcam as an image sensor interface. Result of the training is indicated to be effective outcomes. Based on the samples from the 738 plastic bottle picture. The results for each method of correct presentation of the plastic bottle identification and classification system are shown in Table 2.

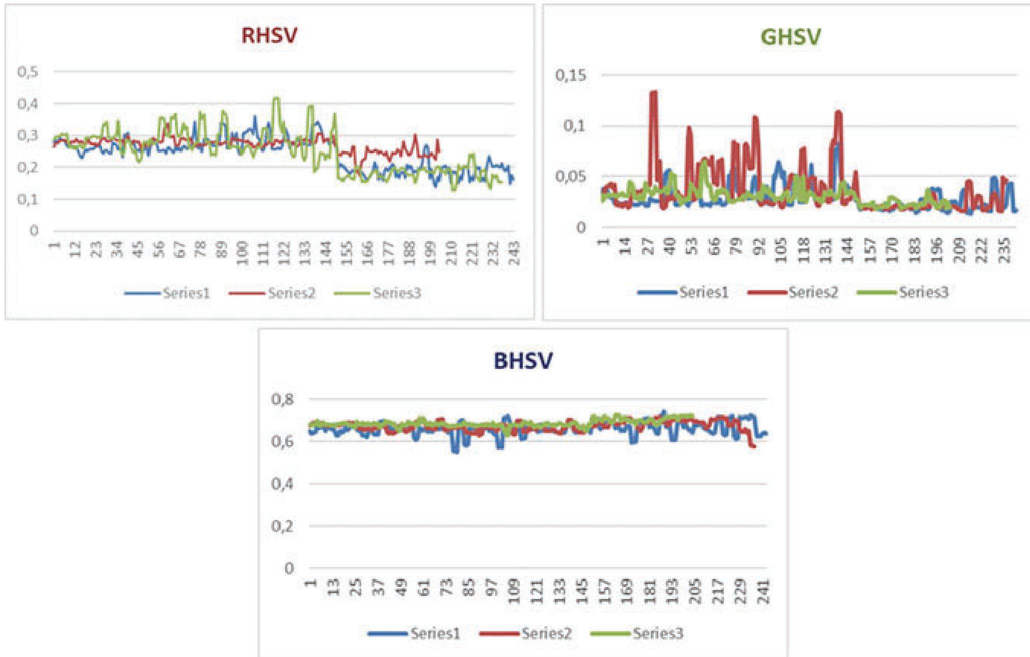


Fig. 4 HSV value of PET type (series 1), PP type (series 2), and PP type (series 3)

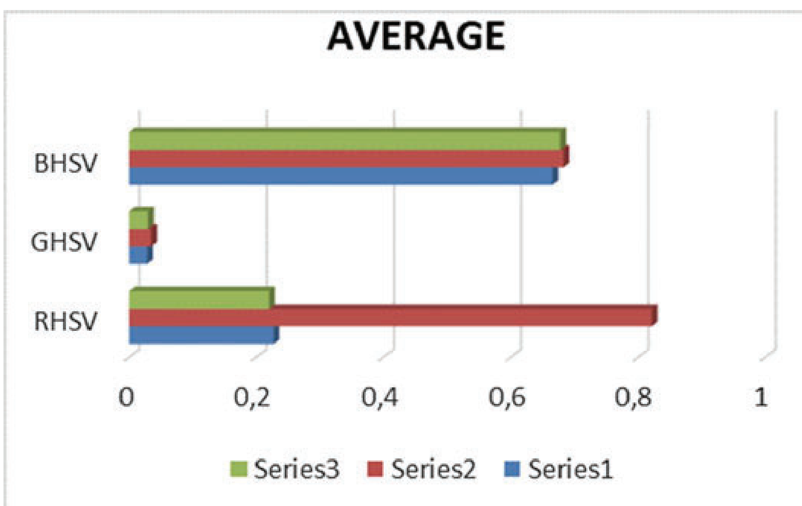


Fig. 5 The average value of RHSV, GHSV and BHSV

Table 2 Accurate presentation of data training

No	Plastic bottle image	Total image	Succeed	Accuracy presentation (%)
1	PET	258	202	78.68
2	HDPE	243	128	52.67
3	PP	237	178	75.10
Total		738	508	68.81

New samples are selected randomly for the testing process. With the central point yet in the image capture range, the bottle position in the image used as test data placed randomly. Test results amounted to 90 samples taken at random from three kinds of plastics. The method from this study is 57.8 percent accurate. 52 were successful in the testing process, 38 were unsuccessful.

The outcome of testing is 8% lower than the training process. Any factor can be triggered, and the bottle location in the picture used in the testing process is not precisely at the focus point of the crop, and the lighting variations between capturing a database image and the image for the testing process.

5 Conclusion

The purpose of this works is: First, a system has been built to simplify the automatic sorting process that can minimize the human error of the manual sorting process. Second, the automatic identification and classification of plastic bottle waste have been developed to facilitate the sorting process. Third, 68.81% of the successful identification and classification system training using HSV color characteristics is accurate. Besides, the accurate percentage of testing for plastic bottle data is 57.8%.

There are the followings suggestion that based on this work: For further it's recommended to use numerous size cropping to get the best template for identification and classification of plastic bottles, increase the number of plastic bottle samples as database as of the accuracy value obtained are getting better, try to use the other color variations of the lamp to maximize the intensity of the color space and it is also recommended to add more features besides R, G, and B in the HSV color space so that the results will be more accurate.

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