A Computer Vision Based Detection System for Trash Bins Identification during Trash Classification

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Abstract — In this study, an image based detection system is designed and applied to identify different trash bins for classification. The CCD industrial camera is used to obtain the RGB format images on the trash disposal line in real time. In order to reduce the effect of environmental brightness, the obtained RGB format images are transformed into HSI color format. According to the calculated saturation and hue values, the threshold of saturation and hue values is set for the following image segmentation, respectively. Then, accurate position information of trash bin is obtained for the subsequent classification processing. This detection system could overcome environmental constraints and improve efficiency for trash classification.

1. INTRODUCTION

The categorized treatment of waste disposal is an important part of the sustainable development strategy of the city. Trash is a misplaced resource, and it is useful to recycle trash with different classification and characteristics [1-5]. Trash classification could not only improve the efficiency of trash recycling, but also beautify the city appearance, protect the environment, maximize resources and bring mutual profits to society, environment and economy. In recent years, trash classification has been widely concerned by the government. For example, Shanghai formally implemented “the regulations of Shanghai on the administration of domestic waste” in 2019, which is sought to force the management regulations of trash classification.

As the back-end link of classification system, trash classification is an extremely important link related to whether trash could be treated circularly and harmlessly. Due to the high-temperature and high-humidity work environment combined with the presence of toxic and smelly gases, the trash classification and treatment workshop is not suitable for long-time manual sorting [6, 7]. Therefore, the application of automation technology to each link of trash disposal could connect the independent mechanical equipment and reduce the human participation during the process of trash disposal. The automation technology could not only automate trash disposal and resource recycling, but also improve the efficiency of trash disposal and utilization [8]. During the procedure of trash classification, different color trash bins are employed to classify the trash, such as dry trash in black bins, wet trash in brown bins, recyclable trash in blue bins and hazardous trash in red bins. Therefore, the type of trash could be identified and determined by different colors and carry out the further disposal process. Currently, the machine vision technology has valuable applications in industrial production, object identification and positioning, medical diagnosis, automatic identification and sorting [9-14]. For example, L.D. Brian and his coworkers propose an effective approach for automated analysis and
classification of microstructural image data based on machine vision [9]. V. Chauhan and his colleagues designed a machine vision inspection system to detect and classify multiple faults by feature extraction from videos [10]. T. Panagiota et al. combined 2D vision system and data from computer-aided design files to identify 3D randomly placed objects [11]. K. He and his colleagues adopted a new network structure and obtain better image classification results by inputting image without fine adjustment [12]. Karen Simonyan and Andrew Zisserman contributed a very small convolution filter in order to increase the convolutional network depth, which could improve the accuracy of image identification [13]. Zhou et al. designed a structural similarity index to decrease the error between distorted and reference images calculated by traditional methods [14].

In this study, an image based detection system is designed and applied to identify different trash bins for classification. The CCD industrial camera is used to obtain the RGB format images on the trash disposal line in real time. In order to reduce the effect of environmental brightness, the obtained RGB format images are transformed into HSI color format. According to the calculated saturation and hue values, the threshold of saturation and hue values is set for the following image segmentation, respectively. Then, accurate position information of trash bin is obtained for the subsequent classification processing. This detection system could overcome environmental constraints and improve efficiency for trash classification.

2. EXPERIMENT SETUP

![Flow chart of the different trash bins identification process.](image)

Fig. 1 shows the flow chart of the trash bins identification process. According to Fig. 1, the images in RGB format of the trash bins are obtained firstly by using a CCD industrial color camera (2048×1536 pixels, 12 fps frame rate) on the trash disposal line in real time. Since the change of environment light would greatly affect the characteristic of the RGB format images, wrong results would be obtained during images recognition. In order to reduce the effect of environmental brightness, it is necessary to transform the obtained images from the CCD industrial camera based on RGB model into HSI color format. In the HSI color format, hue and saturation contain the color information, but intensity is independent of the color information. Therefore, HSI color format divides image intensity and color in
two parts and gray processing algorithms could be easily implemented in HSI space. According to the calculated hue and saturation values, the characteristic of different color trash bins could be determined. Then, the corresponding threshold of the hue and saturation for different trash bins is set, respectively. According to the threshold, the image segmentation from the hue and saturation diagram is carried out. Finally, the classification trash bins could be identified and determined. The identification results would provide accurate position information of trash bins, according to which the mechanical arm grabs the trash bins and put them into the right classification line for the following disposal. The RGB values of the obtained images are transformed into the HSI color format by the following equation [15, 16]:

\[ H = \begin{cases} \theta & B \leq G \\ 360 - \theta & B > G \end{cases} \]  

(1)

\[ \theta = \cos^{-1}\left(\frac{(R - G) + (R - B)}{2\sqrt{(R - G)^2 + (R - B)(G - B)}}\right) \]  

(2)

\[ S = 1 - \frac{\min(R, G, B)}{I} \]  

(3)

\[ I = \frac{R + G + B}{3} \]  

(4)

where R is the value of red, G is the value of green, B is the value of blue, H is the value of hue, S is the value of saturation, I is the value of Intensity.

3. RESULTS AND DISCUSSION

![Figure 2. The Images of different trash bins collected by the CCD industrial camera.](image)
Fig. 2 shows the images of different trash bins collected by the CCD industrial camera in RGB format. In practice, the color of the trash bin would be aged due to the long use time, or it would be changed due to the adhesion of soil or pollutants. In order to avoid the uncertainties mentioned above, a series of images should be collected in different area of each trash bin.

**TABLE I. THE FEATURED INTERVALS OF HUE AND SATURATION VALUES FOR DIFFERENT TRASH BINS.**

| Trash Bin      | Saturation | Hue      |
|----------------|------------|----------|
| Red trash bin  | 80-90      | 0-10     |
| Green trash bin| 78-95      | 130-150  |
| Gray trash bin | 25-35      | 210-220  |
| Blue trash bin | 88-95      | 225-235  |

Fig. 3 exhibits the calculated characteristic hue and saturation values of different trash bins. It is found that the characteristic hue and saturation values of different trash bins distributed in different areas, which is suitable for the set of segment threshold. Table 1 analyses the featured intervals of hue and saturation values for different trash bins. It is observed that the saturation of red trash bin is from 80 to 90 and hue from 0 to 10; the saturation of green trash bin is from 78 to 95 and hue from 130 to 150; the saturation of gray trash bin is from 25 to 35 and hue from 210 to 220; the saturation of blue trash bin is from 88 to 95 and hue from 225 to 235. According to the featured intervals of hue and saturation values, the appropriate threshold could be set for different trash bins, which provides the key parameter for image segmentation.

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**Figure 3.** The calculated saturation and hue values of different trash bins, respectively.
Fig. 4 distributes the identification process of different trash bins. Fig. 4(a) shows four trash bins located in different places. After image processing, the result of segmentation is obtained in Fig. 4(b), where different color of trash bins is identified by matching threshold information and randomly assigned different colors. In order to clearly distinguish different trash bins, the images after segmentation are stitched to the original image, as shown in Fig. 4(b). Through image processing, different trash bins could be accurately identified and the extract location information could be obtained. This would provide accurate parameters for the mechanical arm to grab trash and put them into the right classification line for the following disposal. This machine vision based system could greatly enhance the automation of the trash classification and treatment workshop, which is not suitable for long-time manual sorting.

4. CONCLUSION
In conclusion, we design an image based detection system to identify different trash bins for classification. The obtained images from the CCD industrial camera based on RGB model are converted into HSI color format to avoid the effect of environmental brightness. Then, the corresponding threshold of the hue and saturation for different trash bins is set, respectively. According to the threshold, the image segmentation from the hue and saturation diagram is carried out. Finally, the classification trash bins could be identified and determined, which would provide accurate position information of trash bins for the following disposal. This automatic computer vision system would provide a convenient, efficient and accurate approach for trash classification.

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REFERENCES
[1] D. Zhang, S.K. Tan, and R.M. Gersberg, “Municipal solid waste management in China: status, problems and challenges”, J. Environ. Manage., vol. 91, pp. 1623-1633, 2010.
[2] R. Linzner, and S. Salhofer, “Municipal solid waste recycling and the significance of informal sector in urban China”, Waste Manage. Res., vol. 32, pp. 896-907, 2014.
[3] Y. Chen, “Trash to treasure: using recyclables in physical activity settings”, J. Phys. Edu., vol. 87, pp. 45-51, 2016.
[4] A. Wang, L. Zhang, Y. Shi, S. Rozelle, A. Osborn, and M. Yang, “Rural solid waste management in China: status, problems and challenges”, Sustainability, vol. 9, pp. 1-18, 2017.
[5] A. Kumar, and S.R. Samadder, “A review on technological options of waste to energy for effective management of municipal solid waste”, Waste Manage., vol. 69, pp. 407-422, 2017.
[6] J.C. Solartetoro, J.M. Romerogarcia, J.C. Martinezpatino, E. Ruizrmos, E. Castrogaliano, and C.A. Cardonaalzate, “Acid pretreatment of lignocellulosic biomass for energy vectors
production: A review focused on operational conditions and techno-economic assessment for bioethanol production”, Renew. Sustainable Energy Rev., vol. 107, pp. 587-601, 2019.

[7] G. Chen, X. Wang, J. Li, B. Yan, Y. Wang, X. Wu, R. Velichkova, Z. Cheng, and W. Ma, “Environmental, energy, and economic analysis of integrated treatment of municipal solid waste and sewage sludge: A case study in China”, Sci. Total Environ., vol. 647, pp. 1433-1443, 2019.

[8] S. Bansal, S. Patel, I. Shah, A. Patel, J. Makwana, and R. Thakker, “AGDC: Automatic Garbage Detection and Collection”, Robotics, 2019.

[9] B.L. Decost, and E.A. Holm, "A computer vision approach for automated analysis and classification of microstructural image data", Comp. Mater. Sci., vol. 110, pp. 126-133, 2015.

[10] C. Vedang, and B. Surgenor, "Fault detection and classification in automated assembly machines using machine vision", Int. J. Adv. Manuf. Tech., vol. 90, pp. 2491-2512, 2017.

[11] P. Tsarouchi, S. Matthaiakis, G. Michalos, S. Makris, and G. Chryssolouris, “A method for detection of randomly placed objects for robotic handling”, CIRP J. Manuf. Sci. Tech., VOL. 14, PP. 20-27, 2016.

[12] K. He, X. Zhang, S. Ren, and J. Sun, “Spatial pyramid pooling in deep convolutional networks for visual recognition”, IEEE T. Pattern Anal., vol. 37, pp. 1904-1916, 2015.

[13] K. Simonyan, and Z. Andrew. "Very deep convolutional networks for large-scale image recognition", Compu. Vis. Pattern Recogn., 2014.

[14] Z. Wang, A.C. Bovik, H.R. Sheikh, and E.P. Simoncelli, “Image quality assessment: from error visibility to structural similarity”, IEEE T. Image Process., vol. 13, pp. 600-612, 2004.

[15] K. Muhammad, J. Ahmad, H. Farman, and M. Zubair, “A novel image steganographic approach for hiding text in color images using HSI color model”, Multimedia, 2015.

[16] S. Chen, R. Feng, Y. Zhang, and C. Zhang, “Aerial image matching method based on HSI hash learning”, Pattern Recogn. Lett., vol 117, pp. 131-139, 2019.