An Extended Smart Recycling Bins Using Deep Learning Networks

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ABSTRACT

The main purpose of this paper is to develop a smart recycling bin to replace the manual sorting of waste. This paper extends the previous work by 1) adding an ultrasonic module to assess the amount of waste in the recycling bin, 2) distinguishing one more class, i.e. the glass bottles, in addition to metal cans, plastic bottles, and Tetra Pak cartons, and 3) developing a mobile App to real-time monitor the status of recycling bins. Experimental results show that the developed system has the over 96% mean average precision (mAP) for the Tetra Pak cartons and plastic bottles.

INTRODUCTION

The developed smart recycling bin would classify metal cans, plastic bottles, glass bottles, and Tetra Pak cartons. With the purpose of achieving the capability to collect and reuse wastes effectively, this work extended our previous work [1] which utilized the single-shot detection (SSD) and MobileNet-SSD model under a PyTorch artificial intelligence framework. Moreover, a depthwise separable convolution-based lightweight approach is also employed so as to apply to service performed by edge mobile phones [2]. This paper extends the previous work [1] by

1) adding ultrasonic modules to assess the amount of waste in the recycling bins,
2) distinguishing one more class, i.e. the glass bottles, and
3) developing a mobile App to real-time monitor the status of recycling bins.

SYSTEM REALIZATION

Fig. 1 shows the developed smart recycling bin with the internal and structural representation. In addition to our previous design, which includes a camera, a push board, three opening gates, and four servo motors, one more opening gate and servo motor are newly provided for the glass bottle recycling. Fig. 2 shows the improved smart recycling bin, which supports four waste types, those are metal cans, plastic bottles, glass bottles, and Tetra Pak cartons. Furthermore, four ultrasonic modules are added to assess the amount of each type in the recycling bins. Moreover, a mobile App is developed to real-time monitor the status of recycling bins, as shown in Fig. 3.

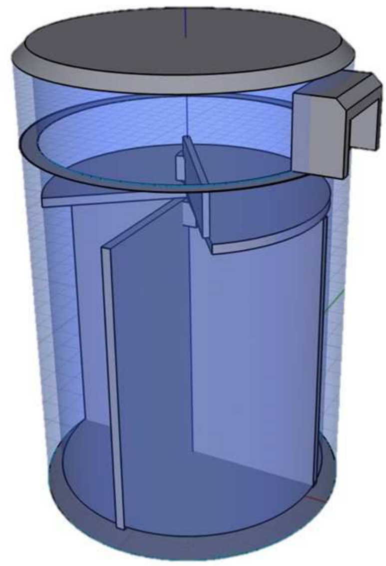


Fig. 1. Internal structure of the designed recycling bin.

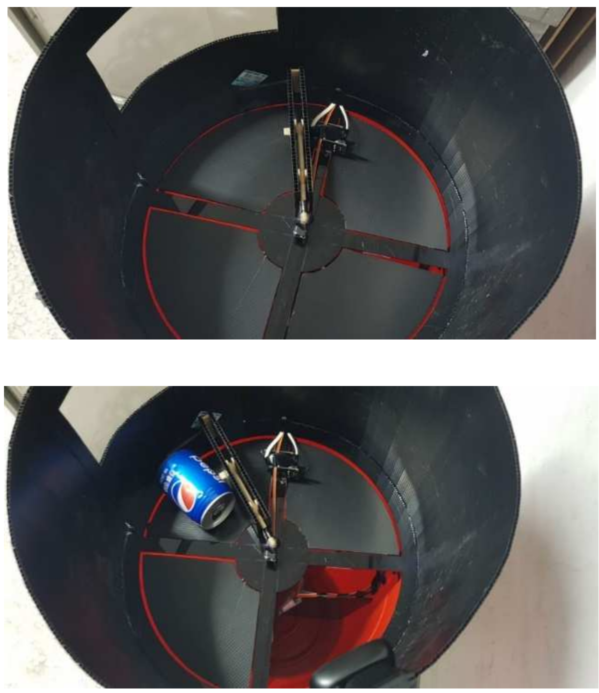
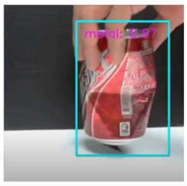


Fig. 2. Four positions to collect four waste types.

Table I
EXPERIMENTAL RESULTS

Types	Tetra Pak Cartons	Plastic Bottles	Metal Cans	Glass Bottles
Object recognition				
mAP	240/250(96%)	99/100(99%)	58/74(78.38%)	31/37(83.78%)

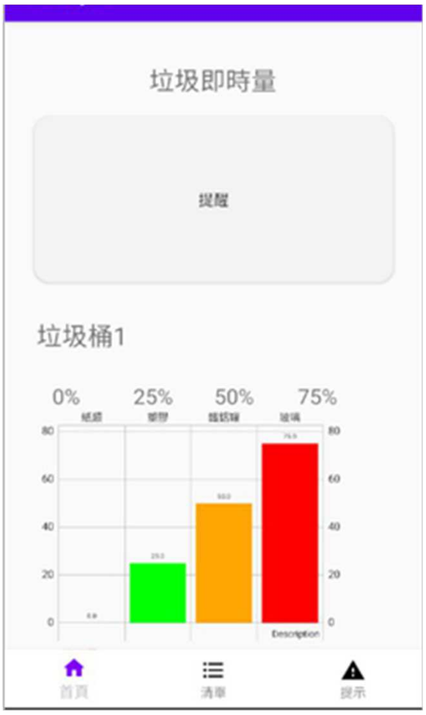


Fig. 3. Use mobile App to show real-time status.

EXPERIMENTAL RESULTS

The empirical results are shown in Table I. Obviously, the mean average precision (mAP) for the Tetra Pak cartons and plastic bottles reaches above 96%. In addition, the recognition precision for the metal cans is around 78.38%, which could be improved and enhanced in the future.

CONCLUSIONS

On the basis of our previous work [1], an extended smart recycling bin has been implemented using lightweight deep learning models in this paper. The recycling bin could classify four waste types by means of deep learning networks and push them into the corresponding storage space. In addition, four ultrasonic modules are added to monitor the amounts of four types of waste. A mobile App is developed to access the amounts in real time. Moreover, a MobileNet-SSD neural network is used to detect the class of each waste. Experimental findings display the practicability of the developed system, where the mAP accuracy reaches more than 96% for the Tetra Pak cartons and plastic bottles.

Future work includes enhancing the detection accuracy. Furthermore, providing the recycling bins with energy-harvesting functions [3]-[4] or transmission power control are also research directions.

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