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A Garbage Identification and Its Processing Fee Calculation System Based on Deep Learning and Carbon Emission

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Abstract. With the rapid development of urbanization, the identification of garbage becomes more and more important for reducing the environment pollution, using the renewable resources, and saving urban land resource. To address this problem, this paper introduces the deep learning model for garbage identification and the carbon emission for garbage processing fee calculation. Specifically, the deep learning model is first used to identify the garbage from an image. After that, an intelligent charging method based on carbon emission, garbage collecting and processing is presented. With the trained model, this system is able to significantly shorten the time of garbage classification and improve the efficiency of garbage recycling management. In addition, this provide a solution for calculating the garbage processing fee based on the carbon emission. Finally, we develop a garbage fee software with user friendly interface for garbage processing and garbage processing fee systems.

Keywords: Garbage identification, Garbage processing fee calculation, Deep learning, Carbon emission

1. Introduction

Under the background of carbon neutral, the status quo of the city household waste has caused much attention and thinking. The 2020 city household waste in China has reached 235 million tons, an increase of 49% compared to a decade ago[1]. The high-speed economic development has caused the problem of garbage-surrounded city, making it a priority task for the decrease and the recycling and the detoxification of household garbage.

In addition, the city household waste processing unit is an important emission of greenhouse gas[2]. With the increase of carbon emission pressure and the great economic spending of garbage processing all over the world, paying the garbage fees are gradually becoming a good way to encourage the garbage sorting, which helps lighten the financial burden of the government[3]. More and more attention has been paid to study the mode and technology of the energy saving and emission reduction of household waste. In the legislation level, it is clearly stated that the charge system should be determined by the local situation to realize the goal of differentiating price calculation[4-6].

The current garbage fee methods consist of (1) a flat-fee plus the fee of collecting garbage by the company, charging by "water consumption coefficient method", collection with bags and more. However, those charging systems are not mature enough and cannot attain the best status in terms of technology and financial levels[7]. With the successful use of machine learning models, they have been increasingly used in smart garbage sorting at a yearly rate[5,9]. Under this background, it is an inevitable way to develop an intelligent garbage sorting system. To address the problems that exist in present garbage fee systems combined with the environment trend of carbon peaking and carbon neutral, we develop a novel garbage fee system based on the deep learning model using the relevant waste fees of carbon emissions of waste. Specifically, a garbage sorting system can be quickly developed and used to drastically shorten the amount of time of manual sorting using Python-based programming language. This also increases the efficiency of garbage recycling. We first improve the smart garbage sorting system in an image recognition system for garbage classification. After that, we follow the carbon emission requirements in Intergovernmental Panel on

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Climate Change (IPCC) to calculate costs of different garbage processing modules. Finally, the garbage identification and charging system is established based on the deep learning and carbon emissions.

Deeper understanding of garbage processing and garbage emission for residents is brought about by the garbage charging classification system, the enthusiasm of waste classification is promoted, carbon emission is reduced and environmental awareness and responsibility of garbage processing is raised.

2. Methods of Calculating Garbage Processing Fees and Carbon Emissions

2.1. Methods of calculating garbage processing fees

Considering the background of "carbon peaking and carbon neutral", it is crucial to provide a system for calculating garbage sorting fees based on carbon emissions. However, too many factors that can affect the constitution of city household garbage, it is difficult to predict the carbon emissions during different processing stages. In addition, through the process of garbage classification, not only the environment conditions can be improved, the garbage can also be transformed into resources. By comparing the results of carbon emissions, the classified garbage (collecting + food waste Anaerobic fermentation + reusing recycled waste+ burning other garbage) emits less carbon than simply processing the unclassified (collecting+ mixing) garbage[11]. Based on garbage sorting, the garbage can be divided into recyclable garbage, food waste, other garbage and hazardous waste. Taking the carbon of the whole process into account, combining the deep learning model, and setting carbon emission as the main part, a garbage charging system with processing cost as the foundation is established.

Different household waste has different requirements for energy consumption, so as their emit distinct products. The products of CO_2, CH_4, and more also have varied carbon emissions. Thus, different household waste has distinct contributions to carbon emissions[12]. To devise a model for calculating the carbon emissions of household waste, different disposal methods, such as sanitary landfill, burning and compost are studied. According to the statistics in *Greenhouse gas emission coefficient set for the whole life cycle of Chinese products (2022)* with UOD tables used to search for the patterns of carbon emissions behind different treatments as given in Eq. (1).

$$Y=(Q_1K_1+Q_2K_2+Q_3K_3+Q_4K_4)\times 365/1000 \tag{1}$$

where the Y is the total carbon emissions of domestic waste classification and treatment in year t;

Q—Average daily domestic waste disposal in the year, t/d;

Q_1—the daily recyclable processing amount in the year, t/d;

Q_2—the average daily anaerobic treatment of kitchen waste in this year, t/d;

Q_3—the average daily sanitary landfill treatment volume in this year, t/d;

Q_4—the average daily incineration power generation treatment capacity in the year, t/d;

K_1 is the recyclable garbage emission coefficient, -169.4 kg CO_2-eq/t, due to the fact that downstream emission coefficient of household waste and waste paper exist in the garbage, the coefficient of recyclable garbage can be estimated by the carbon emission of waste plastic. This coefficient is set to 0.7;

K_2 is the food waste anaerobic emission coefficient, -27.54 kg CO_2-eq/t, from household waste-food waste-anaerobic downstream emission coefficient;

K_3 is the landfill emission coefficient, 612.64 kg CO_2-eq/t, from household waste-mixed waste-landfill downstream emission coefficient;

K_4 is the incineration power generation emission coefficient, -124.3 kg CO_2-eq/t, from household waste-mixed waste-incineration downstream emission coefficient;

Among them, the K_1 coefficient refers to the measured data of city household waste, and the proportion of various city household waste components are: fabric 8%, food waste 41%, rubber and leather 6%, plastic 12%, metal and glass 2%, other and inert waste 31%[14]. Based on this, a calculation formula for household waste carbon emissions can be constructed for calculation.

2.2. Design of garbage identification and charging system

The flowchart of designing garbage identification and charging system based on the deep learning and carbon emission can be seen in Fig. 1. As we can see from the figure, with the obtained dataset, the fundamental model of image identification is loaded based on the Python programming language. After the deep learning for image identification is trained using the training data, it is evaluated based on the testing data. Next, after receiving the results of garbage classification, the carbon emission coefficients of IPCC required for different waste processing modules are used to calculate the charge for garbage processing. Namely, the carbon emission of the waste and the price of processing can be known by inputting the weights. Aside from this, there is an accumulating function that used for calculating the prices of multiple pieces of waste. Finally, the system based on the deep learning (coded in Python) and carbon emission is integrated into the interface design and is built into an exe software system. This system is more convenient, smart and thorough than the garbage charging system that presently exists.

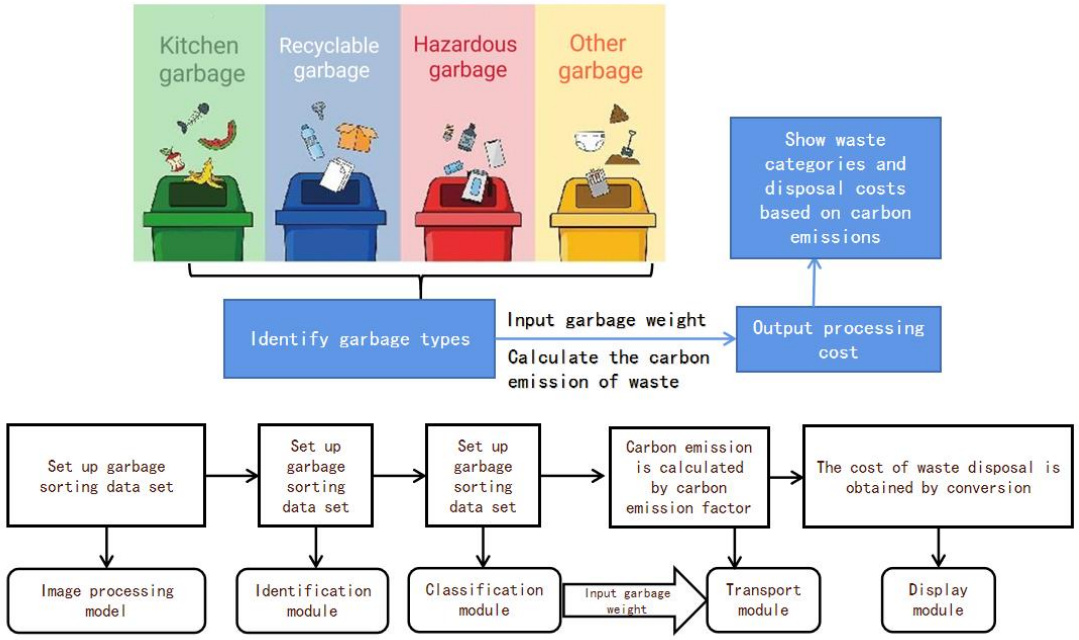

Fig. 1: The flowchart of designing garbage identification and charging system based on the deep learning and carbon emission

2.3. Model construction

Based on the image identification of open-source coding that presently exists[15,16], the garbage image samples are fed into the deep learning model to train the classification model with given labels. Classification and characteristic extraction are carried out by the CNN of the deep learning model. By using multiple layers of convolution layers, pooling layers, activation functions, fully connected layers and Softmax classifier, a complex network structure is constructed and the goal of classifying garbage achieved. Based on the model constructed by training, the results of garbage types are recognized and transferred to the output of the garbage sorting interface to show the results. This process greatly reduces the time of garbage identification (by human) with high accuracy. After successfully constructing the model and nesting the calculation program, the carbon emission calculation method and the emission coefficients of sorting are also aggregated into the system. The carbon emission can be obtained after simple calculations, and the processing fees are calculated based on the carbon emissions.

To be specific, the implementation of the model and calculation is achieved by first constructing a singular equation of carbon emission (based on *Greenhouse gas emission coefficient set for the whole life cycle of Chinese products (2022)*), the carbon emission coefficients are used to calculate the carbon emission of a single piece of waste. After that, each part of the associated fee and emission is calculated according to carbon trading, combining with the processing costs of the waste for the fee calculation. This model uses the carbon trading price of 7.75 dollar per ton as an example. This value can be adjusted based on the carbon trading and by adding the initial stage of processing costs of 77.9 dollars per ton[8], then the final fee is

calculated. Fig. 2 shows the food waste identification and calculation (the remains of an apple). As we can see from the figure, the garbage type is first identified (apple). After that, the fee is calculated. It is worth noting that the calculation here is based on the carbon coefficients in *Greenhouse gas emission coefficient set for the whole life cycle of Chinese products (2022)* for further calculation. Specifically, inputting the garbage weight (5 kg), the fee of the food waste is 0.386 dollar. Similarly, for the lunch boxes waste identification and calculation as shown in Fig. 3, a piece of waste (used cutlery box) is fed into the system, the type of the waste is obtained after image recognition. With the weight of 5 kg of cutlery box, the processing fee is 0.382 dollar.

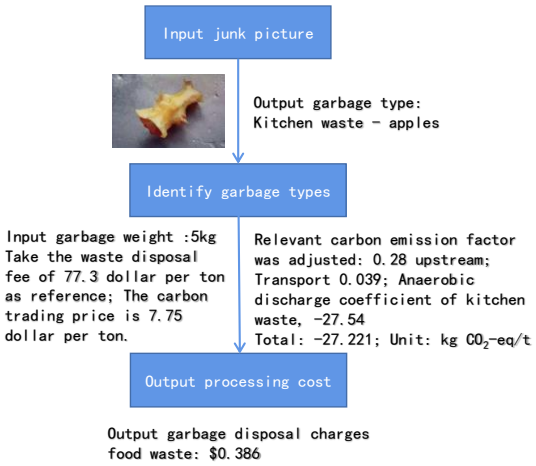

Fig. 2: Food waste identification and calculation

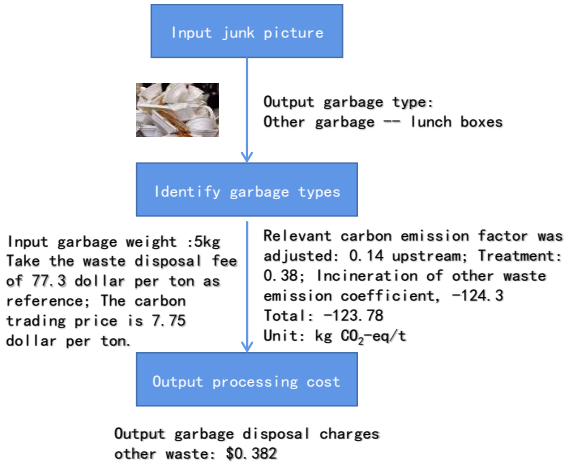

Fig. 3: Lunch boxes waste identification and calculation

It can be calculated using the software that the cost of processing 1 ton of hazardous waste is 4.6 dollars, and the total garbage processing fee is 80.3 dollars; the fee of processing 1 ton of recyclable waste is -1.3 dollars, and the total processing fee is 74.4 dollars. The carbon emission of recyclable waste is lower than hazardous waste, resulting in the lower waste processing fee. The current garbage processing cost is roughly 84.3 dollars per ton, so the calculation is reasonable.

2.4. Interface design

To better use the system in real-world applications, a convenient user interface of the system needs to be designed for by turning it into an exe software system. The user interface design and the calculation model are all transformed into the exe software system using Python, among which the main body of image recognition and calculation program is included, allowing image recognition and charging system to work independently. Details of the interface design Fig. 4.

After running the exe program, the interface garbage processing fee system can be found in Fig. 5. The first step is to click “select the picture to be identified” button to select an image. This allows the system to automatically identify the garbage type and exhibit the description in the “Image recognition subject” section.

After inputting the weight of waste and click the “calculation” button to calculate the fee. If the fees of multiple pieces of waste are calculated, then click the “save” button and then the results will be saved. Next, it is easy to get the total fee by clicking the “sum” button. To empty the values in the text boxes, click the “empty” button to start a new round of calculation. Finally, to close the software, just click the “quit” button.

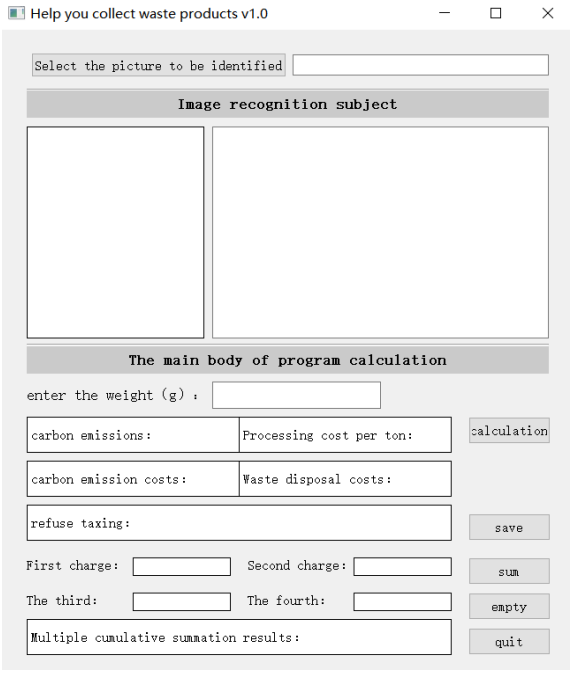

Fig. 4: Interface of the garbage processing system

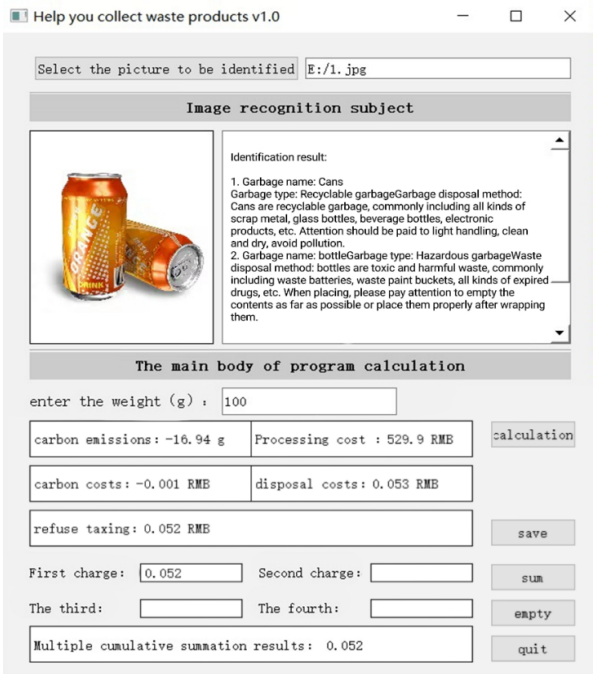

Fig. 5: Interface garbage processing fee system

3. Conclusions

In this paper, a uniform standard for garbage processing fee system was established based on the deep learning for the waste identification and the carbon emission for calculating the garbage processing fee. Namely, by identifying the image of the garbage and inputting the weight of the garbage, the waste processing fee based on carbon emission is received. The garbage processing system and the garbage processing fee system have shown great potential in practical use. The main contributions include: it is able to alleviate the problem of resource squander of incomplete household waste sorting and relieve the pressure

of the large financial burden of the government and relevant companies for garbage processing; it also provides a solution for charge fee calculation in other areas. By using this system to encourage the waste classification and magnitude reduction, it, to some extent, promotes ecological harmony and facilitates the construction of a green and healthy environment.

In the further work, more state-of-the-art deep learning models will be investigated for garbage classification with higher accuracy. In addition, the charge fee system will be explored in the real-world scenario.

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