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Automatic Machine of Plastic Bottles and Aluminum Cans Collection for Recycling

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Abstract:

Reduce, reuse, recycle is one of the key directions in the development of science and technology at this time. However, it is not enough to create opportunities for reusing PET containers. It is necessary to create mechanisms that will motivate people to collect and hand over such containers. In this article, we propose the creation of a reverse vending machine, which will issue a monetary reward to a person for handing over PET containers.

Key words: Reverse vending machine, PET container, Recognition, Barcode, Arduino

Introduction

The automatic device for receiving containers made of polyethylene terephthalate (PET) and aluminum is designed for collecting PET and aluminum for reuse – as raw materials in production. At the same time, its relevance also lies in the possibility of implementing the environmental task of minimizing environmental pollution by harmful substances [1], [2]. Various methods and algorithms can also be used here, which have found recognition in various fields of research [3]-[13].

Such machines are known all over the world as "fandomats" (in English, reverse vending machine). They are widely used in Europe, in particular in Germany, where it is found in every supermarket. The reverse vending machines do not significantly differ in its structure from ordinary vending machines for dispensing food, drinks, etc. But with just a couple of DC motors, a barcode scanner, and a display that lets users see their reward for each product that's turned in for recycling, an automatic PET container collector does the following:

- cleaning the environment from garbage disposal;

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- the use of PET and aluminum products in re-production, thereby bringing the industry closer to zero-waste production;
- allows users of the machine to receive a reward for used containers [14].

In Ukraine, the relevance of this device is extremely high, because the repeated processing of materials will economically help some manufacturers, and the device also allows each user to keep the environment clean and receive a reward for it [15].

Therefore, in this work, we propose the development of a hardware part of an automatic device for the collection of secondary aluminum and polyethylene terephthalate containers, which provides automatic collection using a barcode scanner. At the same time, it should be convenient for users and good for the environment.

Related works

Recycling of PET containers is becoming more and more in demand nowadays. Many scientists deal with this problem. On the one hand, this will help save resources, on the other hand, this is an important task in the field of ecology. To solve these problems, it is first necessary to implement a system for receiving such containers. For this purpose, special reverse vending machines are used, which are being developed by many researchers. Let's look at some of their scientific works.

Rahim, N. H. A., & Khatib, A. N. H. M. in [16] propose their own reverse vending machine with shredding features that can shred the polyethylene terephthalate bottles. They note that the project can benefit the consumers in a way that they do not have to go to recycle centre to recycle PET bottles to the shredded form of plastic.

In [17] authors aim to build a Reverse Vending Machine for collecting plastic bottles with reward feature. Once the number of bottles is identified depositor can claim the points by entering a unique ID and the accumulated points can be used to generate promo code for online shopping.

Paper [18] presents the concept of reverse vending machine which is proposed to serve as a solution to the problem of pollution caused due to plastic items especially plastic bottles. Authors developed a low-cost automatic machine, which crushes the plastic bottle to a reduced size, thereby, requiring less storage space for final disposal.

Researchers in [19] designed reverse vending machine specifically for the recycling concept with a reward feature. The design is expected to aid in accelerating the motivation among different people to recycle their waste. The study [20] proposes

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a three-step optimization process of a reverse vending machine, a small automatic recyclable waste sorter/collector system, for acquiring an optimal design and enhanced efficiency. The a reverse vending machine system categorized recyclable wastes as plastics, glass, and cans using barcode, vision, and near infrared sensors.

Scientists [21] propose to use reverse vending machine with material identification module is proposed to accept only empty recycle items and reject the rest. The research project [22] was intended to develop reverse vending machine (RVM) to sorting waste of beverage containers either plastic bottles or cans as a campaign to reduce the production of waste. This RVM machine uses barcode scanning as the sorting system to determine whether the plastic bottle or can could be recycled or not. Zia, H. and co-authors have developed an incentive-based low-cost RVM for the collection, identification, classification, and sorting of used plastic bottles with the addition of a reward-based user application [23].

In paper [24], some approaches in computer vision and image processing and their application to the problem of automatic recognition of empty recyclable containers (bottles and cans) and detecting fraud were considered. Authors in [25] note that sensor-based reverse vending machines suffer from a high configuration cost and the limited scope of target objects, and conventional single image-based reverse vending machines usually make erroneous predictions about intentional fraud objects. The paper [25] proposes a dual image-based convolutional neural network ensemble model to address these problems.

Researchers in [26] detect and train reverse vending machine using haar cascade classifier. This allows them to do the device not so expensive.

Thus, we see a huge variety of different reverse vending machines with a similar operating principle. It should be noted that due to the huge variety of existing PET containers, recognizing the type of container is quite difficult. We suggest using a barcode for these purposes. Further in the article we will present the development of such a device.

Container recognition in reverse vending machines principles analysis

The block diagram in Figure 1 provides an explanation of the step-by-step operation procedure of the PET and aluminum containers automatic reception device.

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On the block diagram, waste plastic materials act as an input signal and are then checked by several sensors. The initial criteria are shown in Figure 1.

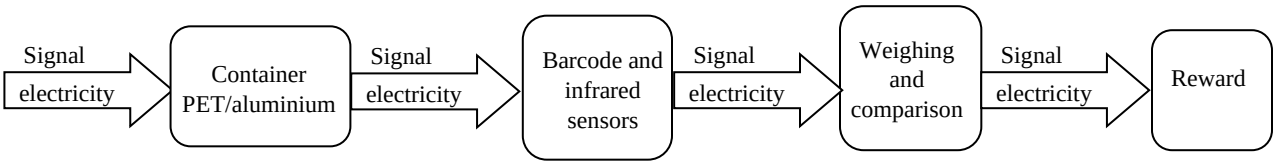

Figure 1: Automatic PET and Aluminum Packaging Device Operation Block Diagram

The operation of the device has the main functions, which are described below:

– the user can insert a plastic container of any shape into the machine with the barcode facing up;

– after user input, the package is checked by three sensors, first by an optical barcode sensor, then by a capacitive proximity sensor, then by an infrared photoelectric sensor, and finally by a load cell weight sensor. The user will then be rewarded based on the weight and material of the container.

The optical sensor for scanning barcodes is used to scan the container handed over by the user and then find the material and weight of the container in the database.

An infrared photoelectric sensor is used to detect the presence of non-ideal matter in the object entering the machine, i.e. water, liquids, stones, etc. This sensor uses standard visible LEDs that pass light through the water and probe it with a wavelength of 1450 nm.

The tensor resistor weight sensor is used to determine the weight of objects up to 1 kg. It is shaped like a straight strip and converts pressure or force into an electrical signal [27].

Automatic device for collecting containers block diagram

The automatic device for collecting containers made of polyethylene terephthalate and aluminum operation (Figure 2) begins with the automatic receiving of containers made of PET or aluminum.

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After the container has been placed by the user in the opening with the barcode up, scanning is performed by the optical barcode scanner.

If the user does not place the container with the code up, it will not be scanned and the process will stop. And if the user did everything correctly, the scanner processes the barcode and the process moves on.

Immediately, an infrared photoelectric sensor detects the presence of excess substances (water, other liquid or stones) in the incoming container, and if liquid is present, the device also stops the process, informing the user that the liquid must be poured out, because it can damage the device.

When there is no water and the sensor does not detect anything, the next stage begins after the scan, according to the algorithm, the reverse vending machine control program finds the required container in the existing base and compares its weight with that shown by the tensor resistor weight sensor.

If the weight matches (there may be a deviation of ±5 g), the user is charged a reward depending on the weight and material of the container, and when the weight is significantly different from the desired one, the process is stopped.

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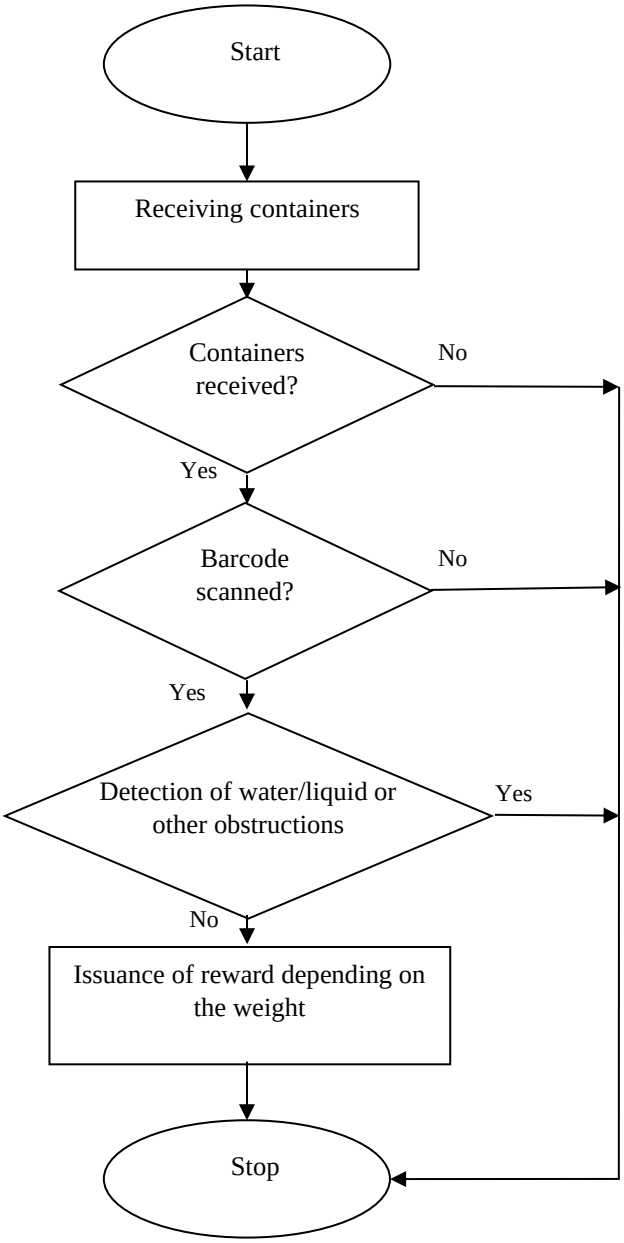

Figure 2: The Automatic Device for Collecting Polyethylene Terephthalate and Aluminum Containers Operation Algorithm

Figure 3 shows a diagram of a signal transmission in the device principle simplified version.

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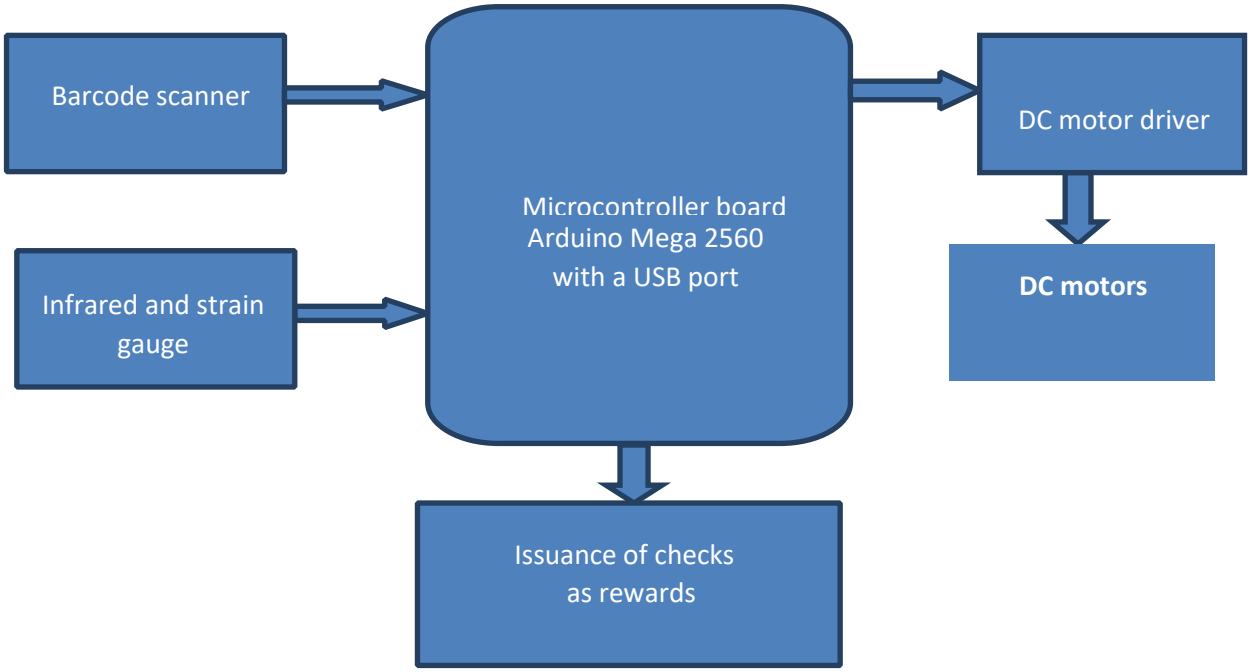

Figure 3: Diagram of a Signal Transmission in the Device Principle Simplified Version

Interaction of the barcode sensor during the containers input

The stage of selecting a barcode sensor is the most important stage of device development, because the operation of the entire machine depends on the interaction of the barcode sensor and the acquisition of barcode values. A unique barcode is printed on each bottle or jar. When the container is placed in the device, the barcode sensor reads the value of the barcode and sends a string to the microcontroller, which processes the data and makes a decision to accept or reject the container.

Actuators such as DC motors and receipt printing/display are required for bottle acceptance and reward delivery mechanisms. After reading the value from the barcode, if the bottle is accepted, the microcontroller sends a signal to the actuator to open the shutter which accepts the bottle and also displays the reward code/or prints the receipt.

Conclusion

Humanity has increasingly begun to think about the possibility of reusing resources. The 3R concept appeared - “Reduce, reuse, recycle”. The application of this approach to PET containers involves first collecting such containers. In theory,

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collection should be carried out by instilling in a person the habit of handing over such containers.

We propose to issue a cash reward for the delivery of PET containers. At the same time, we propose to create a reverse vending machine, which will weigh the deposited amount and issue an appropriate monetary reward.

This article presents the basic principles of operation of the device being developed, a Block diagram of the operation of an automatic device for collecting PET and aluminum containers and a Block diagram of a device for collecting PET and aluminum containers

References:

1. Benyathiar, P., & et al. (2022). Polyethylene Terephthalate (PET) Bottle-to-Bottle Recycling for the Beverage Industry: A Review. Polymers 2022, 14, 2366.

2. Mangold, H. & et al. (2022). The frontier of plastics recycling: Rethinking waste as a resource for high-value applications. Macromol. Chem. Phys. 2100488, 1–17.

3. Attar, H., & et al.. (2022). Control System Development and Implementation of a CNC Laser Engraver for Environmental Use with Remote Imaging. Computational Intelligence and Neuroscience, 2022.

4. Khan, A., & et al.. (2015). Some Effect of Chemical Treatment by Ferric Nitrate Salts on the Structure and Morphology of Coir Fibre Composites. Advances in Materials Physics and Chemistry, 5(1), 39-45.

5. Babker, A. M., & et al.. (2019). Information technologies of the processing of the spaces of the states of a complex biophysical object in the intellectual medical system health. International Journal of Advanced Trends in Computer Science and Engineering, 8(6), 3221-3227.

6. Al-Sherrawi, M. H., & et al.. (2018). Corrosion as a source of destruction in construction. International Journal of Civil Engineering and Technology, 9(5), 306-314.

7. Lyashenko, V., Ahmad, M. A., Sotnik, S., Deineko, Z., & Khan, A. (2018). Defects of communication pipes from plastic in modern civil engineering. International Journal of Mechanical and Production Engineering Research and Development, 8(1), 253-262.

ISSN (E): 2181-4570 ResearchBib Impact Factor: 6,4 / 2023 SJIF(2023)-3,778 Volume-1, Issue-11

8. Abu-Jassar, A. T., & et al.. (2022). Electronic user authentication key for access to HMI/SCADA via unsecured internet networks. Computational Intelligence and Neuroscience, 2022.

9. Baker, J. H., & et al.. (2021). Some interesting features of semantic model in Robotic Science. SSRG International Journal of Engineering Trends and Technology, 69(7), 38-44.

10. Abu-Jassar, A. T., Al-Sharo, Y. M., Lyashenko, V., & Sotnik, S. (2021). Some Features of Classifiers Implementation for Object Recognition in Specialized Computer systems. TEM Journal: Technology, Education, Management, Informatics, 10(4), 1645-1654.

11. Al-Sharo, Y. M., Abu-Jassar, A. T., Sotnik, S., & Lyashenko, V. (2021). Neural Networks As A Tool For Pattern Recognition of Fasteners. International Journal of Engineering Trends and Technology, 69(10), 151-160.

12. Lyashenko, V., Mustafa, S. K., Belova, N., & Ahmad, M. A. (2019). Some features in calculation of mold details for plastic products. International Journal of Emerging Trends in Engineering Research, 7(11), 720-724.

13. Lyashenko, V., & Sotnik, S. (2020). Analysis of Basic Principles for Sensor System Design Process Mobile Robots. Journal La Multiapp, 1(4), 1-6.

14. Berg, H. & et al. (2022). Overcoming Information Asymmetry in the Plastics Value Chain with Digital Product Passports: How Decentralised Identifiers and Verifiable Credentials Can Enable a Circular Economy for Plastics; Wuppertal Institut für Klima, Umwelt, Energie: Wuppertal, Germany.

15. Жарікова І. В. (2023) Автоматичний пристрій для збору вторинної тари з алюмінію та поліетилентерефталату. Матеріали VII-ої Міжнародної конференції Виробництво & Мехатронні Системи 2023, Харків, 110-112.

16. Rahim, N. H. A., & Khatib, A. N. H. M. (2021). Development of PET bottle shredder reverse vending machine. International Journal of Advanced Technology and Engineering Exploration, 8(74), 24.

17. Mariya, D., & et al. (2020). Reverse vending machine for plastic bottle recycling. Int. J. Comput. Sci. Technol, 8(2), 65-70.

18. Sambhi, S., & Dahiya, P. (2020). Reverse vending machine for managing plastic waste. International Journal of System Assurance Engineering and Management, 11, 635-640.

ISSN (E): 2181-4570 ResearchBib Impact Factor: 6,4 / 2023 SJIF(2023)-3,778 Volume-1, Issue-11

19. Wong, K. K., & Dahiya, P. (2019). Development of Reverse Vending Machine using Recycled Materials and Arduino Microcontroller. International Journal of Engineering Creativity and Innovation, 1(1), 7-16.

20. Kim, D., & et al. (2021). Designing of reverse vending machine to improve its sorting efficiency for recyclable materials for its application in convenience stores. Journal of the Air & Waste Management Association, 71(10), 1312-1318.

21. Tomari, R., & et al. (2019). Empirical framework of reverse vending machine (RVM) with material identification capability to improve recycling. Applied Mechanics and Materials, 892, 114-119.

22. Sinaga, E. F., & Irawan, R. (2020). Developing barcode scan system of a small-scaled reverse vending machine to sorting waste of beverage containers. TELKOMNIKA (Telecommunication Computing Electronics and Control), 18(4), 2087-2094.

23. Zia, H., & et al. (2022). Plastic Waste Management through the Development of a Low Cost and Light Weight Deep Learning Based Reverse Vending Machine. Recycling, 7(5), 70.

24. Kokoulin, A. N., & Kiryanov, D. A. (2019, June). The optical subsystem for the empty containers recognition and sorting in a reverse vending machine. In 2019 4th International Conference on Smart and Sustainable Technologies (SpliTech), IEEE, 1-6.

25. Yoo, T., & et al. (2021). Dual image-based cnn ensemble model for waste classification in reverse vending machine. Applied Sciences, 11(22), 11051.

26. Yaddanapudi, S. D., & et al. (2023). Collection of plastic bottles by reverse vending machine using object detection technique. Materials Today: Proceedings, 80, 1995-1999.

27. Гіль, А., Чала, О., Филипенко, О. (2021). Промислові інтерфейси та протоколи передачі даних інтегрованих систем для автоматизованого управління в умовах Industry 4.0. Виробництво & Мехатронні Системи 2021: матеріали V-ої Міжнародної конференції, Харків, 127-30.