Evolution in Electrical and Electronic Engineering Vol. 1 No. 1 (2020) 368 - 377

EEEE

Homepage: http://penerbit.uthm.edu.my/proceeding/index.php/eeee
ISSN : 0000-000X e-ISSN : 2756-8458

Development of Vision Based on Recycling Material Identification for Reverse Vending Machine Platform

Khairulbadri K.H.[1], **Tomari M.R.**[1]*

[1]Faculty of Electrical and Electronic Engineering,
Universiti Tun Hussein Onn Malaysia, 86500 Parit Raja, Batu Pahat, Johor Darul Ta'zim, MALAYSIA

DOI: https://doi.org/10.30880/eeee.2020.01.01.044
Received 01 August 2020; Accepted 06 September 2020; Available online 30 October 2020

Abstract: Reverse Vending Machine (RVM) is one of interactive platform that can boost recycling activities. It works by providing reward to a user that return the recycle items to the machine. To achieve that, the RVM must be equipped with material identification capability so that each inserted recycle materials can be rewarded accordingly. In this project a vision based recycle material identification system was proposed using Convolutional Neural Network (CNN) concept and also implementing the Yolo object detection algorithm. In this thesis, the convolutional neural network (CNN) concept and Yolo algorithm will be implemented in detecting the sample images, and sample video for obtaining the efficiency of detection rate by using Yolo algorithm. The main approach of this thesis is to focus on development of vision based on material identification for reverse vending machine platform. Regarding on the aim of the project development, CNN is a better platform as it can learn discriminative patterns automatically from images by stacking convolutional layers. Besides that, CNN is being classified as one of the most powerful image classifiers and currently responsible for computer vision field in machine learning. The sample of images are required in this project as the images will undergoes the training and validation process which is one of the important parts of having convolutional neural network. The convolutional neural network in Reverse Vending Machine is for beverage containers recognition and sorting purpose. In general, the overall operation of the reverse vending machine will need the support from the CNN in order for the machine to function as a detecting recycling material. In this project, a dataset of recycling materials that contains around 20 images for each class which are PET bottle and aluminum can are used for training purpose. It is expected that the system would recognize the targeted objected when tested for image detection process, video detection process, and real time detection process.

Keywords: RVM, Yolo, CNN, Image Detection Process, Video Detection Process, Real Time.

Corresponding author: mdrazali@uthm.edu.my

1. Introduction

The beverage containers such as glass bottle, plastic bottle, aluminum can, and liquid paperboard (tetra pack) are widely used around the world for packaging purposes. These containers need to be organized properly in order to overcome pollution in our country. Besides that, these containers which are not the reason that causing the pollution to our country. It is caused by the improper way to manage all the waste products. The 'Reverse Vending Machine' (RVM) is introduced as one of the methods to manage beverage containers properly which can help to reduce the rate of waste products pollution [1]. Reverse Vending Machine is a device which take the used beverage containers and exchange it into a monetary value to the users [2]. This machine is called 'Reverse' because it uses the concept of 'Return-to-Retail' where the users can obtain monetary value from the product which is stated by TOMRA itself [3].

The RVM works by accepting the beverage containers in the in-feed section then will further scanned and recognize by the machine. This RVM machine use the material recognition process and barcode reader in order to classify the type of containers inserted in the machine. This project will be focused on recognizing the material shape by using Central Neural Network (CNN). Based on the previous design, the machine is trained to identify the material by using Zbarcam while this project will train several samples of three different class which are PET bottle, aluminum can, and liquid paperboard (tetra pak). The disadvantage of the previous method is that, the Zbarcam will not able to detect the barcode pattern if the barcode is damaged or the misposition of the container. The previous design might not be very practical as it uses the PVC for the chute. The environment of the chute might be disrupted by the external substances that caused by the material which has been inserted. The flowing process will not be efficient and require external force for the material to move.

2. Materials and Methods

Based on the project which will be used to recognize the shape of the recycling material, the Convolutional Neural Network (CNN) and You Only Look Once (Yolo) approach are been used in developing the object detection system. Basically, the camera module will be used in order to identify the shape of the product that is placed in the detecting section. [25] In general, the environment of the entire detecting area needs to have an optimal condition which is the position of the camera and the optimal light density need to be considered for better detection process.

Basically, the main approach of this project is to access system performance for detection recycling material from images, video, and live feed camera. This system requires several samples from these classes which are PET bottle and aluminum can as it will later being used to obtain the training and validation rate of the system in recognizing these objects. The efficiency of the system in detecting the recycling materials will depend on the tuning parameters of the system in interpreting the objects with high level of accuracy based on the samples that is used to train this system. There are several ways to increase the validation accuracy which are by increasing the training data set, by tuning the parameters. The programming code is developed and designed by using python language which later been compiled by using PyCharm compiler.

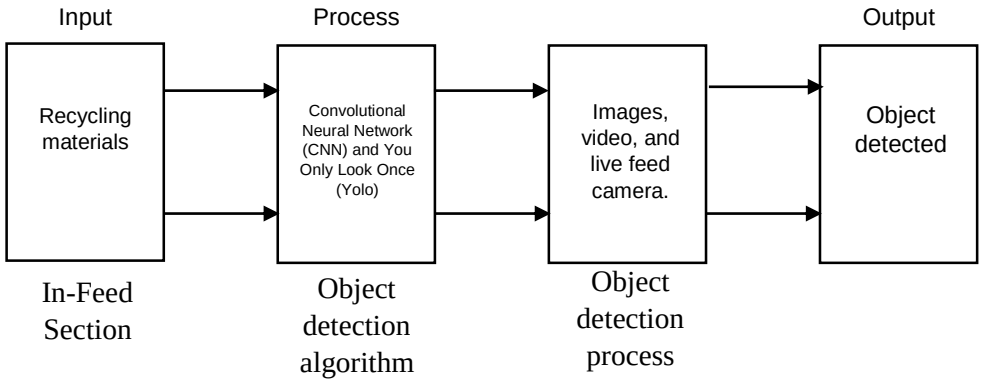

Figure 1: The process flow of the system

2.1 Materials

The electronic part is one of the main parts in developing the project. Every component has their own role in generating the targeted results and making the machine more reliable, thus having a system which can successfully perform in a correct way.

USB Endoscope camera module is used in this project as for detection process of the recycling material. Camera is one of the important components in this project as it will detect the recycling materials for detection process of the input images, video, and real time object detection. Basically, the USB endoscope camera module is used for capturing images of the recycling materials which later will be used for detection process in the Yolo algorithm. The output captured image for the sample images are in JPEG format and the resolution for each of the captured image is 640 * 480. Table 1 shows its specifications. Besides that, the USB endoscope camera module also will be used for capturing video for object detection process and for real time object detection process.

Table 1: The USB Endoscope camera module specification and details

Product Specification	Details
Camera size	Camera head Outside diameter: 7MM
USB length	Total length (optional): 2M
Protection	Waterproof level: IP67
Image type and resolution	Resolution: 640 * 480: Format JPEG
Lighting	6 adjustable white LED

2.2 Methods

In general, the operation will start by preparing the sample images of the recycling materials. The captured sample images later will be used for object detection process for detecting image, video, and real time detection process. Basically, the programming code will be designed and executed in PyCharm which already been installed by the object detection library and dependencies such as numpy and OpenCV. Besides that, to have a better detection process, the pre-trained model from coco datasets is used. The flowchart for overall operation of vision-based recycle material platform is described in the Figure 2.

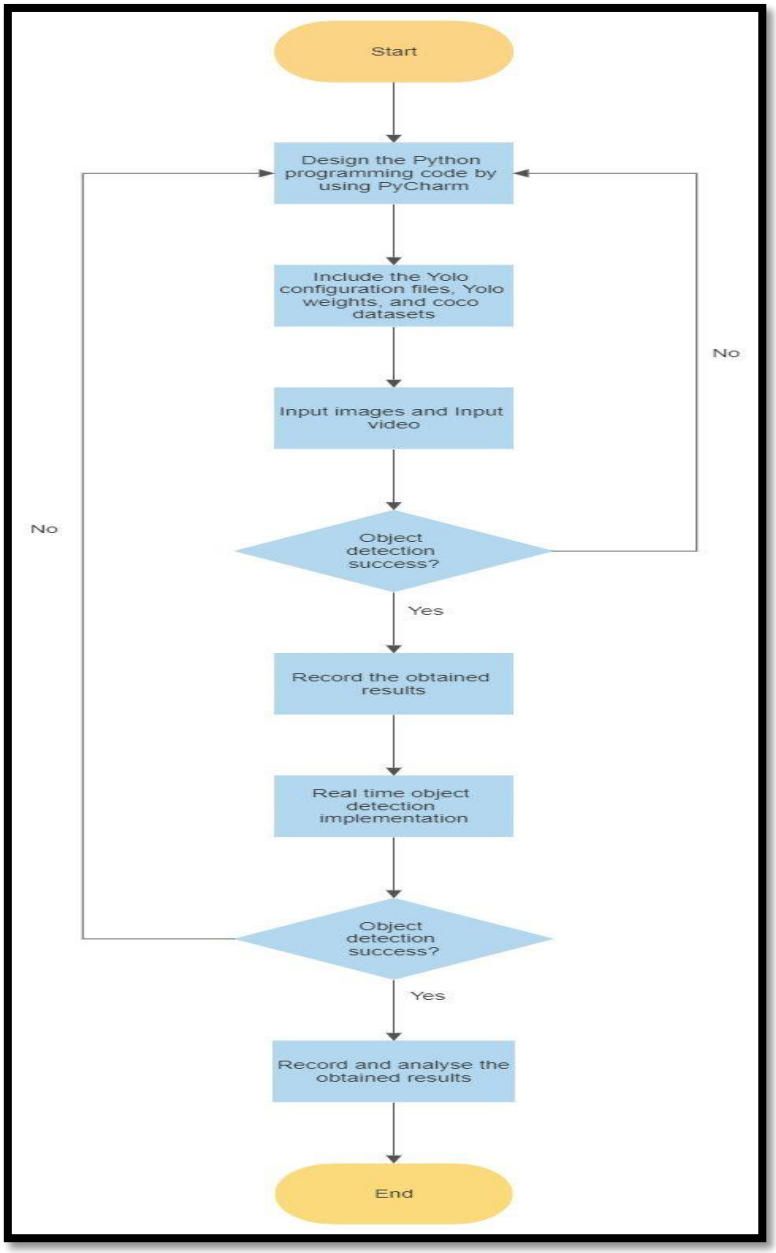

Figure 2: Flowchart for overall operation of vision-based recycle material platform

3. Results and Discussion

The results and analysis that is obtained along the project development process will be discussed for the object detection process of the sample images through image, video, and real time detection. The current progress is to enable the system with classification method which is by using object detection algorithm of Yolo method as it is one of the main process for developing a vision-based operating machine. All results that is obtained regarding the developing progress will be recorded in this chapter.

3.1 Obtaining training and validation accuracy

The sample images will undergo several stages in Convolutional Neural Network (CNN) as the image will be modified according the parameters which have been set by the designer. Several packages are required for this process such as tensorflow, keras, and numpy. Based on the Table 2, shows the

parameters that were used for training purpose in Spyder software as it will be set according to the given data for generating the results. Basically, the training and validation results obtained are in the form of percentage. Besides that, the Spyder software that is used for compiling the programming code will generate the information on step accuracy, validation accuracy, training lost, and validation lost, so from that any improvement regarding the training and validation process can be done in the future.

Table 2: The tuning parameters that is used for training purpose

Epoch	Batch Size
100	1
50	30
30	20
20	50

Based on the Table 3, shown that the average detection accuracy that is obtained for detecting the PET bottle of several samples which are repeatedly used for recording purpose of the detection accuracy of the system. The average detection accuracy of the system in detecting the waste material of the PET bottle is 95.9 percent.

Table 3: Detection accuracy for testing repeated samples continuously

Number of PET Bottle	**Detection Accuracy (%)**
1	100
2	100
3	98
4	99
5	97
6	82
7	88
8	84
9	100
10	99
11	99
12	100
13	88
14	98
15	98
16	99
17	100
18	100
19	100
20	100

21	88
22	84
23	100
24	100
25	98
26	98
27	99
28	100
29	100
30	90
31	97
32	82
33	99
34	100
35	91
36	88
37	90
38	100
39	99
40	100
41	91
42	98
43	100
44	99
45	82
46	96
47	99
48	100
49	99
50	99
∑	**95.9**

3.2 Figures

According to the sample images that have been captured on the beginning of this project is used for the input process of obtaining the object detection process. There are several type of PET Bottle from the sample images will be used for detection process. The compiler that is use for executing the

object detection process through image is by using PyCharm which already installed with object detection library and configuration files of Yolo algorithm. The sample images will be resized for a better detection process which will be adjusted in the programming code. Basically, the image format that is used for the system to run the input images is in JPEG format.

Figure 3: PET Bottle successfully detected by the system

The object detection process will require the video source as the input for the system and need to be in the same place of the project directory. The video file that is used for the video detection process is in MP4 format. Basically, every object in the video will be detected by the system which the object will be bounded by a colored box and shown the name of the detected object. There is a drop of frame per seconds (FPS) in the video as the Yolo configuration that is used is 'yolo.weights' which run using the CPU.

Figure 4: PET Bottle are successfully detected in the video detection process

The real-time object detection process will require the use of external webcam that have been installed in this computer. The process of real-time object detection is the same as having a video detection process which the detected object will be bounded by a colored box and the name of the object will be shown. Basically, in order to use the webcam for real-time object detection process, the camera

source need to be set correctly so that system can recognize the which camera source that will be used by the system

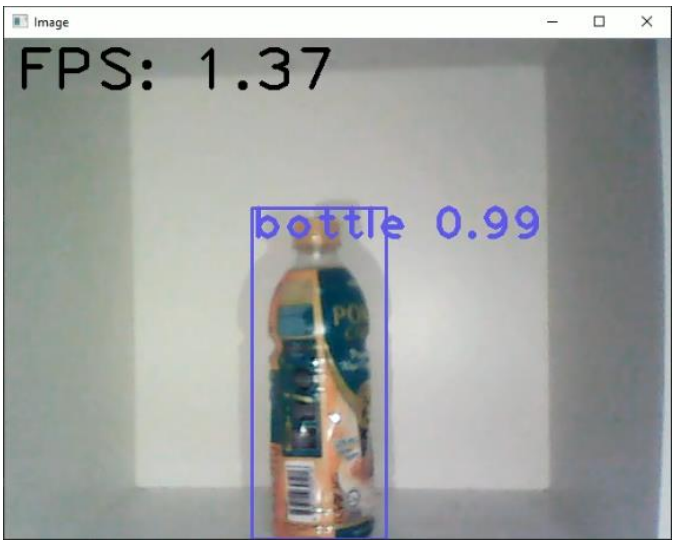

Figure 5: PET Bottle are successfully detected in the real time detection process

4. Conclusion

As a conclusion, the overall operation of developing a system for object detector of recycling materials are successful and it is a suitable method to implement the Yolo object detection algorithm for creating an autonomous recycling material sorting machine. According to the result obtained, there a several objects that are successfully detected by the system while some objects are unable to be recognized by the system. This detection performance can be improved in the future as there are many available open sources which is suitable to develop an object detection system to work efficiently. The object detection mechanism could help in developing a new feature of machinery system. This project is considered as accomplished in creating an object detection system by using Yolo according to the results obtained and the objective that have been successfully achieved.

Acknowledgement

The authors would also like to thank the Faculty of Electrical and Electronic Engineering, Universiti Tun Hussein Onn Malaysia for its support.

References

[1] Datuk Lim Kok Boon, “Littering, not packaging, pollutes.” New Straits Times. 5 May 2016

[2] Kramer, Brufsky, and Cifelli, “Reverse Bottle Vending, Crushing, and Sorting Machine”, United States Patent, Melchionna, 1994

[3] “Return to Retail Vending – Reverse Vending Machines.” [Online]. Available: https://www.tomra.com/en/collection/reverse-vending/case-studies/return-to-retail-model

[4] Zakri Abdul Hamid, “The problem with plastic.” New Straits Times. 1 May 2018

[5] Z.Zamani, “Malaysia’s recycling rate is still low.” The Sun Daily. 21 April 2015. Shah Alam, Malaysia

[6] Wanli Ouyang, Xiaogang Wang, Xingyu Zeng, Shi Qiu, Ping Luo, Yonglong Tian, Hongsheng Li, Shuo Yang, Zhe Wang, Chen-Change Loy, Xiaoou Tang, “DeepID-Net: Deformable Deep Convolutional Neural Networks for Object Detection.” Computer Vision Foundation

[7] AlexKrizhevsky, Ilya Sutskever, and Geoffrey E. Hinton, "Image Net Classification with Deep Convolutional Neural Networks." University of Toronto

[8] Andrey N. Kokoulin1, Aleksandr I. Tur, Aleksandr A. Yuzhakov, "Convolutional Neural Networks Application in Plastic Waste Recognition and Sorting." Electrotechnical department Perm National Research Polytechnic University Perm, Russia

[9] A I Tur, A N Kokoulin, A A Yuzhakov, S V Polygalov, A S Troegubov and V N Korotaev, "Beverage Container Collecting Machine Project." IOP Conf. Series: Earth and Environmental Science, pp 3-5, 2019

[10] Yann LeCun, Lèon Bottou, Yoshua Bengio, and Patrick Haffner. "Gradient-Based Learning Applied to Document Recognition." PROC. OF THE IEEE. NOVEMBER 1998, pp 5-20

[11] Aditya Gaur, Dilip Mathuria, and Dr. Rashmi Priyadarshini. "A Simple Approach to Design Reverse Vending Machine." International Journal of Electronics, Electrical and Computational System. March 2018

[12] Envipco, "ENVIPCO LISTS ON EURONEXT AMSTERDAM." EURONEXT. 27 June 2018

[13] Melissa Lim Siew Sean, "SMART RECYCLE AND REWARD BIN." May 2011

[14] Jere Liukkonen, "Machine vision system for a reverse vending machine." School of Electrical Engineering. 15 October 2015

[15] Steinar Solgirdal, Hvalstad, Norway, "METHOD FOR IDENTIFICATION OF METAL BOXES OR CANS AND AN APPARATUS FOR CARRYING OUT SAID METHOD." United States Patent. 6 August 1985

[16] Envipco, "Envipco Announces Launch of Revolutionary RVM Bulk Feed Technology." Available: www.envipco.com. 12 March 2015

[17] Ken R. Powell; Hon Zhang, both of Centreville, Va. "FILTER AND FILTER CLEANING SYSTEM FOR A REVERSE WENDING MACHINE." United States Patent. 26 December 1995

[18] Leo B. Baldwin, Horseheads, N.Y. "Machine for Inspecting the shape of a container having a two-dimensional camera for viewing the shadow of the projection of the container." United States Patent. 18 January 1994

[19] PRWEB, "TOMRA Introduces Flow Technology®, a Fast and Versatile Sensor Solution for Retail RVMs." PRWeb Online Visibility from Vocus. Available: www.tomra.com. 19 August 2015

[20] Guenter Baitz, Berlin (DE); Wolfgang Malke, Berlin (DE); Uwe Krueger, Berlin (DE); Oliver Schaefer, Berlin (DE), "Reverse Vending Machine." United States Patent Application Publication. 23 June 2016

[21] Nathan J. Hammond, 885 Tanglewood, E. Lansing, Mich. "REVERSE VENDING APPARATUS HAVING IMPROVED ARTICLE ROTATING MECHANISM." United States Patent. 10 November 1992

[22] Harald S. Harung, "A world-leading learning organization: a case study of Tomra Systems, Oslo, Norway." The Learning Organization. Volume 3, Number 4, pp 22 – 34, 1996

[23] Jacob Opshaug & Eivind Svamo, “Valuation of Tomra Systems ASA.” MASTEROPPGAVE. 22 May 2017

[24] Anders Jorgensen, Drammen (NO), “METHOD, SYSTEM, REVERSE VENDING MACHINE AND USE THEREOF FOR HANDLING EMPTY PACKAGING.” United States Patent Application Publication. 3 November 2005

[25] Tom Oystein Kavli, Nittedal (NO); Johnny Njastad, Oslo (NO); Geir Saether, Asker (NO), “METHOD AND APPARATUS FOR DETECTING FRAUD ATTEMPT REVERSE VENDING MACHINES.” United States Patent. 17 November 2015

[26] Joseph Redmon, Santosh Divvala, Ross Girshick, and Ali Farhadi, “You Only Look Once: Unified, Real-Time Object Detection.” Computer Vision Foundation