Project Synopsis

on

Automated Retail Checkout System using YOLOv5 in Computer Vision

Submitted as a part of the course curriculum for

Bachelor of Technology

in

Computer Science

Submitted by

Nandita Yadav (2000290120100)

Kshiteesh Kumar (2000290120088)

Kumari Bhavya Chaubey (2000290120089)

Under the Supervision of

Assistant Prof. Anmol Jain

Department of Computer Science

KIET Group of Institutions, Ghaziabad

Department of Computer Science

Dr. A.P.J. Abdul Kalam Technical University

2022-2023

DECLARATION

We hereby declare that this submission is our work and that, to the best of our knowledge and belief, it contains no material previously published or written by another person nor material which to a substantial extent has been accepted for the award of any other degree or diploma of the university or other institute of higher learning, except where due acknowledgment has been made in the text.

Signature of Students:

Nandita Yadav	Kshiteesh Kumar	Kumari Bhavya Chaubey
2000290120100	2000290120088	2000290120089

Date:

CERTIFICATE

This is to certify that the Project Report entitled "**Automated Retail Checkout System using YOLOv5 in Computer Vision**" which is submitted by **Nandita Yadav, Kshiteesh Kumar, and Kumari Bhavya Chaubey** in partial fulfillment of the requirement for the award of degree B. Tech. in Department of Computer Science of Dr A.P.J. Abdul Kalam Technical University, Lucknow is a record of the candidates own work carried out by them under my supervision. The matter embodied in this report is original and has not been submitted for the award of any other degree.

Date:

Supervisor Signature

Mr. Anmol Jain

Assistant Professor (CS)

ACKNOWLEDGEMENT

It gives us a great sense of pleasure to present the synopsis of the B-Tech Mini Project undertaken during B.Tech. Third Year. We owe a special debt of gratitude to Assistant Professor Anmol Jain, Department of Computer Science, KIET Group of Institutions, Delhi- NCR, Ghaziabad, for his constant support and guidance throughout our work. His sincerity, thoroughness, and perseverance have been a constant source of inspiration for us. It is only his cognizant efforts that our endeavors have seen the light of the day.

We also take the opportunity to acknowledge the contribution of Dr. Ajay Kumar Shrivastava, Head of the Department of Computer Science, KIET Group of Institutions, Delhi- NCR, Ghaziabad, for his full support and assistance during the development of the project. We also do not like to miss the opportunity to acknowledge the contribution of all the faculty members of the department for their kind assistance and cooperation during the development of our project.

Last but not the least, we acknowledge our friends for their contribution to the completion of the project.

Signature:

Date:

Name: Nandita Yadav	Kshiteesh Kumar	Kumari Bhavya Chaubey
Roll No: 2000290120100	2000290120088	2000290120089

ABSTRACT

There have been rapid advancements in the field of technology since the arrival of computers and internet. With the advent of technology, the retail sector has witnessed significant changes that once used to be believed too unfathomable. Self-service checkout systems have been established in a variety of stores in which customers have to scan all the bought items with a barcode reader and then pay for the bought items. However, these services could result in thefts in these stores and reduce customer experience and impersonal communication between employees and customers. Technologies such as Amazon Go, released by Amazon in 2017, which is based on "Just Walk Out Technology", eased the self-checkout process as the customers do not have to wait in queues to pay for the purchased items. After installing the Amazon Go app, customers scan their iPhones as they enter the store. The track of their purchases is maintained. They can leave the store without physically checking out as their accounts are charged automatically. It makes use of deep learning, computer vision, and sensors. It is built on technology like self-driving cars. However, this technology can hinder customer experience as customers unfamiliar with the app would find it very difficult to shop. Besides the technology used in apps like Amazon Go is expensive. Therefore, to solve these problems and produce an outcome that could favor both the customer and the retailer is described in this paper. Our implementation focuses on enhancing customer experience by creating a system that can scan the bought items, detect these items with the help of a pre- trained model, and generate a bill containing the total cost that needs to be paid.

TABLE OF CONTENT

CHAPTER 01

INTRODUCTION

Nowadays automation techniques have proved to be a lot beneficial in the retail sector. They play a crucial role in the retail sector by providing better efficiency, reducing costs, enhancing customer experience as well as giving a competitive edge in today's fast-paced market. Many applications make use of Computer Vision techniques to simulate the behavior of human eyesight. The study of Computer Vision allows systems to extract useful data from digital photos, videos, and other forms of media.

Our system is based on the YOLOv5 technique of object detection. It is a model in the YOLO series of Computer Vision models and is used to detect multiple objects in an image with fast speed and better accuracy.

We have implemented an automated retail checkout system which generates the bill of the bought products by taking images or videos of the bought products. The main objective of this system is to ease the process of checkout at the retail stores. It can help to reduce the long queues at the checkout counters and can therefore, save customers' time. The system checks whether the items present in the image/video are present in the dataset or not. For pre-processing the dataset, Roboflow is used. Roboflow has an inbuilt feature that can be used to give annotations. Using it, we put labels on each of the photos. Along with this, Roboflow increases the dataset by rotating every image with different angles. After processing the dataset from Roboflow, we import data in YOLOv5 for further detection. Object Detection and Object Recognition are performed through YOLOv5 which is trained on the COCO Dataset. YOLOv5 is used to achieve better accuracy in object detection. It is trained on custom datasets. The system can then generate an automated bill that includes the information like name of the product, its quantity, and its price. The final amount of all the bought items is also written at the end of the report.

PROBLEM STATEMENT

With the advent of technology, it has been noticed that tasks are now performed without human intervention at a larger scale. In retail stores, it has been observed that there are longer queues for customers to checkout and pay the bills for the bought items.

Though security cameras and high-level automated machines that scans the barcode are present in today's market, these are cost ineffective. Amazon Go, which was launched in 2017, eased the process of checkout but in a much-sophisticated way. It degraded the customer-employee experience and is too costly. Hence there needs to be a system that is cost effective and can easily generate the bill without much human efforts.

OBJECTIVE

The sole objective of this project is:

- To **pre-process the dataset** and convert it into the required .yaml format.
- To prepare the **YOLOv5 model** using Roboflow.
- To provide a user interface through Python GUI-Tkinter.
- To empirically evaluate the outcomes of the proposed model.

SCOPE

Automated checkout systems that generate bills for products typically fall within the realm of retail automation technology. These systems streamline the checkout process by allowing customers to scan items themselves and automatically generate a bill detailing the items purchased and their respective prices.

Itemization: As customers scan items, the system itemizes them, creating a list of products and their corresponding prices.

Bill Generation: After payment is processed successfully, the system generates a digital or printed receipt for the customer.

CHAPTER 02

LITERATURE REVIEW

Many researchers have investigated the applications of Computer Vision in managing retail stores. They have successfully carried out studies and explained the methodologies that could help the retailers manage these stores. A brief literature review is explained in this section.

In 2019, D. A. Mora Hernandez, O. Nalbach, and D. Werth introduced a conceptual tracking system that could generate movement tracks over time for individual customers. In 2020, N. Shekokar, A. Kasat, S. Jain, P. Naringrekar, and M. Shah, prepared an innovative model 'Shop and Go' which makes use of deep learning and sensor fusion. Sensors were used to detect whether the weight had been changed if the item was picked or not. They also stated some real-time applications along with their pros and cons. Figure 3 points to the real-time applications of Self-Checkout Systems.

Besides there was also research conducted as to how computer vision can be used to manage product stock at offline retail stores. In 2020, M. A. Majdi, B. Sena Bayu Dewantara, and M. M. Bachtiar proposed a system to find out which goods were nearly empty and misplaced. A camera was used to capture all the displayed products and the products were recognized using YOLOv3, which resulted in achieving the accuracy of 97.61% and 76.67% for misplaced detection. In 2020, C. G. Melek, Elena Battini Sonmez, and Songul Albayrak compared various object detection algorithms and concluded that YOLOv2 is a far better object detection algorithm in terms of both performance and speed for object detection in shelf images.

S. K. Yedla, V. M. Manikandan, and V. Panchami in 2020, proposed a novel approach for real-time scene change detection with object detection for automated stock verification. They used a scene change detection technique based on a Structural Similarity Index (SSIM) with the goal of optimizing the processing of video frames.

In the work proposed by M. Sugadev, K. Sucharitha, I. R. Sheeba, and B. Velan, the design and implementation of a hardware-based automated billing system aimed for fruit shops and achieving the Granny Smith Accuracy of 98.896%, was described. It proposed more efficient and accurate billing system than traditional billing systems. They used neural network to classify the fruit and load cell to find the weight of the fruit. In 2020, H. Y. Putra proposed a fraud detection system to detect fraud at self-checkout stores using Data Mining. He predicted fraud using classification techniques and visualized the results to obtain new insight. J48 model had the best performance with F-measure 0.921.

Along with these, there have been research on various object detection algorithms and how do they differ from each other in terms of various factors. The application requirements as well as several other factors, such as speed, accuracy, handling small objects, training complexity, and real-time object detection capacity, influence the choice of object detection method. YOLO excels in real-time object detection as compared to other algorithms. SSD provides a good compromise between speed and accuracy and can handle small objects efficiently.

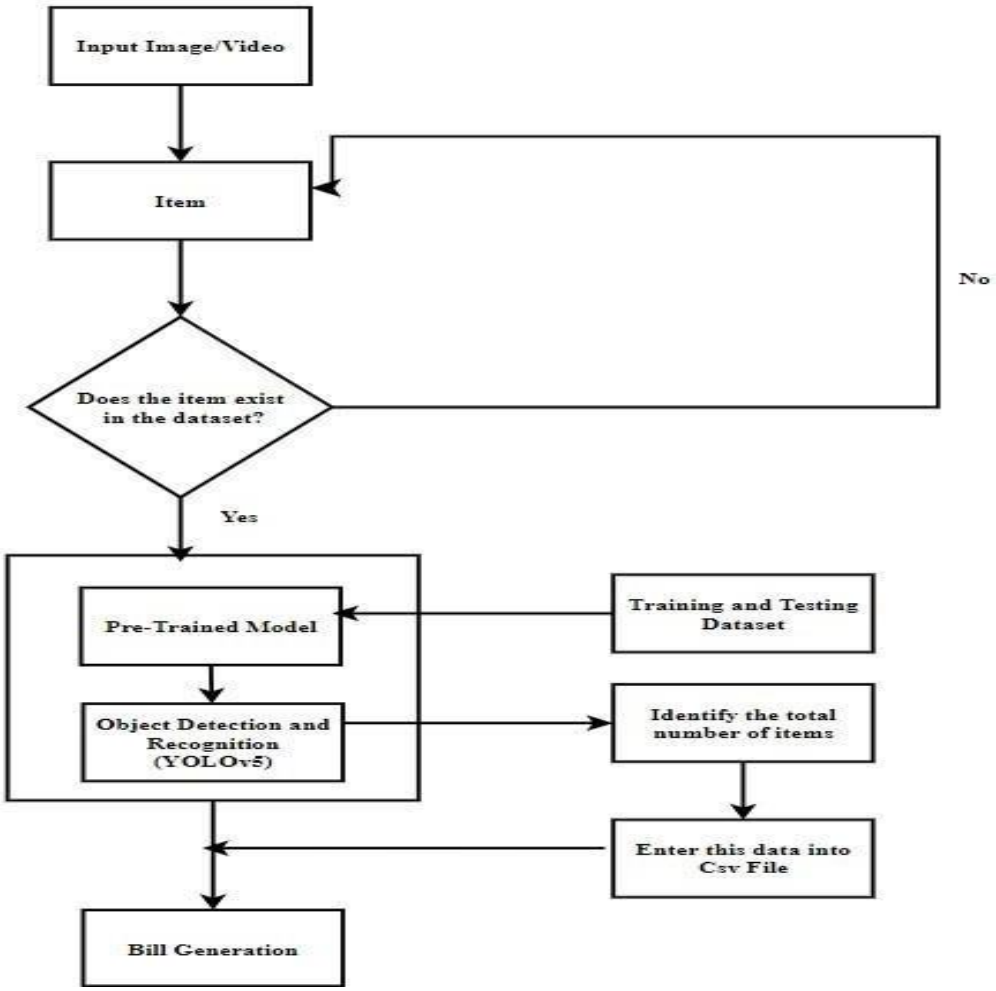
In the table below, one-stage object detection methods - SSD and YOLO, and two-stage object detection methods - R-CNN, Fast R-CNN, and Faster R-CNN, are compared based on various parameters like speed, real-time object detection, accuracy in detecting small objects, and training complexity.

Point of Difference	**R-CNN**	**Fast R-CNN**	**Faster R-CNN**	**SSD**	**YOLO**
Speed	Slow	Medium	Medium	Fast	Fast
Real Time Object Detection	Low	Better than R-CNN	Better than R-CNN and Fast R-CNN	Best	Best
Accuracy in Detecting Small Objects	Low	Better than R-CNN	Better than YOLO	High	Low
Training Complexity	High	Easier than R-CNN	Easier than R-CNN and Fast R-CNN	Easier than two-stage detection methods	Low

Each of these algorithms serves some purpose and is utilized according to the need.

CHAPTER 03

PROPOSED METHODOLOGY



EXPLANATION

The proposed system takes video or image as input and generates a bill containing the price and quantity of the bought items. When an input image/video containing the items is passed to the system, the system detects whether the data exists in the dataset or not. If yes, then the pre-trained model detects and recognizes the object. Then the detect method, which makes use of Tkinter, has a list that contains the per unit cost of each item. The bill is then created in the data frame and the price of each item is calculated. These price values are then added to the data frame and output is displayed.

ALGORITHM PROPOSED

The dataset contains 50-50 images of each of the products in various categories. These products include Apples, Oranges, Bananas, Coconut, and Eggs. We have used Robo Flow, which is a development framework for Computer Vision, used for enhancing data collection to pre-process the data and train the model. It is used to meet the following two objectives:

1) Pre-processing There is an inbuilt feature in Roboflow for giving annotations. We had put labels on each of the photos. Apart from this, Roboflow also rotated the image from different angles. It was done for every image and hence 2000 approx. images were achieved in comparison to the earlier 720 images.

2) Data Production In this process, Roboflow divided our dataset into three folders, that is, Training, Testing, and Validation. In each of these folders, there were 2 subfolders - images and labels. Data.yml files extracted all the labels that we gave and then allotted respective labels on respective items. After processing the dataset from Roboflow we received 1 API key and this API key was used to import data in Yolo for further detection.

SOFTWARE AND HARDWARE REQUIREMENTS

- **SOFTWARE REQUIREMENTS:**

1. Visual Studio Code

2. Python and its libraries

- **HARDWARE REQUIREMENTS:**

1. Camera Module

2. Laptop

CHAPTER 04

TECHNOLOGY USED

- **Language:**

• Python

- **Toolkit:**

• Rob flow:

It is a Computer Vision developer framework used for better data collection, pre-processing, and model training techniques.

• YOLOv5:

It is a novel convolutional neural network (CNN) that detects objects in real time with great accuracy. This approach uses a single neural network to process the entire picture, then separates it into parts and predicts bounding boxes and probabilities for each component.

- **User Interface:**

• Tkinter: It is the standard GUI library for Python.

.

CHAPTER 05

CONCLUSION

This system provides an innovative solution that can help the masses to smoothen their checkout experience. It can help the retailers and the customers to effectively checkout using a simple approach. It can generate the bill of the items that contain the information regarding the bought products like name of the time, quantity, weight, price as well as the total bill. The system uses YOLOv5, a very precise and efficient object detection model, to efficiently detect the objects in the video or the image. Since this model uses fewer resources and is cost-effective in comparison to the technologies existing in the market, it can provide an easier approach to checkout services. Retailers as well as customers can benefit from it. It provides a solution to the long queues the customers must stand in to pay the bill.

This system shows great promise but there are certain limitations and areas for further improvement. Retailers must maintain up-to-date datasets for object detection. Apart from this, there might be some errors in accurately identifying and classifying the objects in situations like poor lighting in photos or low-resolution pictures. Future work can be done regarding the improved and novel models for object detection tasks and enhancing the training strategies like transfer learning or domain learning.

REFERENCES

[1] D. Triphena Delight and V. Karunakaran, "A Comprehensive Analysis of Methodologies used for Object Detection and Localization," in 2021 7th International Conference on Advanced Computing and Communication Systems, ICACCS 2021, Institute of Electrical and Electronics Engineers Inc., Mar. 2021, pp. 448–453. doi: 10.1109/ICACCS51430.2021.9441916.

[2] Y. Hu, X. Li, N. Zhou, L. Yang, L. Peng, and S. Xiao, "A Sample Update-Based Convolutional Neural Network Framework for Object Detection in Large-Area Remote Sensing Images," IEEE Geosci. Remote Sens. Lett., vol. 16, no. 6, pp. 947–951, Jun. 2019, doi: 10.1109/LGRS.2018.2889247.

[3] "Object Detection: Models, Architectures & Tutorial [2023]." Accessed: Oct. 31, 2023. [Online]. Available: https://www.v7labs.com/blog/object-detection-guide

[4] "One-stage object detection." Accessed: Oct. 31, 2023. [Online]. Available: https://machinethink.net/blog/object-detection/

[5] Anhui da xue et al., Proceedings of the 32nd Chinese Control and Decision Conference (CCDC 2020) : 22-24 August 2020, Hefei, China.

[6] "A guide to Two-stage Object Detection: R-CNN, FPN, Mask R-CNN | by Sieun Park | CodeX | Medium." Accessed: Oct. 31, 2023. [Online]. Available: https://medium.com/codex/a-guide-to-two-stage-object-detection-r-cnn-fpn-mask-r-cnn-and-more-54c2e168438c

[7] N. Yadav and U. Binay, "Comparative Study of Object Detection Algorithms," Int. Res. J. Eng. Technol., 2017, [Online]. Available: www.irjet.net

[8] A. John and D. Meva, "A Comparative Study of Various Object Detection Algorithms and Performance Analysis," Int. J. Comput. Sci. Eng. Open Access Res. Pap., vol. 8, no. 10, 2020, doi: 10.26438/ijcse/v8i10.158163.

[9] Shandong da xue, Asia-Pacific Signal and Information Processing Association, and Institute of Electrical and Electronics Engineers, 2019 2nd IEEE International Conference on Information Communication and Signal Processing (ICICSP 2019) :

September 28-30, 2019, Weihai, China.

[10] J. Redmon, S. Divvala, R. Girshick, and A. Farhadi, “You Only Look Once: Unified, Real-Time Object Detection,” Jun. 2015, [Online]. Available: http://arxiv.org/abs/1506.02640

[11] D. A. Mora Hernandez, O. Nalbach, and D. Werth, “How computer vision provides physical retail with a better view on customers,” in Proceedings - 21st IEEE Conference on Business Informatics, CBI 2019, Institute of Electrical and Electronics Engineers Inc., Jul. 2019, pp. 462–471. doi: 10.1109/CBI.2019.00060.

[12] N. Shekokar, A. Kasat, S. Jain, P. Naringrekar, and M. Shah, “Shop and go: An innovative approach towards shopping using deep learning and computer vision,” in Proceedings of the 3rd International Conference on Smart Systems and Inventive Technology, ICSSIT 2020, Institute of Electrical and Electronics Engineers Inc., Aug. 2020, pp. 1201–1206. doi: 10.1109/ICSSIT48917.2020.9214256.

[13] M. A. Majdi, B. Sena Bayu Dewantara, and M. M. Bachtiar, “Product stock management using computer vision,” in IES 2020 - International Electronics Symposium: The Role of Autonomous and Intelligent Systems for Human Life and Comfort, Institute of Electrical and Electronics Engineers Inc., Sep. 2020, pp. 424–429. doi: 10.1109/IES50839.2020.9231673.

[14] B. Dumnić et al., IEEE EUROCON 2019 : 18th International Conference on Smart Technologies : 1st - 4th July 2019, Novi Sad, Serbia.

[15] S. K. Yedla, V. M. Manikandan, and V. Panchami, “Real-Time Scene Change Detection with Object Detection for Automated Stock Verification,” in ICDCS 2020 - 2020 5th International Conference on Devices, Circuits and Systems, Institute of Electrical and Electronics Engineers Inc., Mar. 2020, pp. 157–161. doi: 10.1109/ICDCS48716.2020.243571.

[16] M. Sugadev, K. Sucharitha, I. R. Sheeba, and B. Velan, “Computer vision based automated billing system for fruit stores,” in Proceedings of the 3rd International Conference on Smart Systems and Inventive Technology, ICSSIT 2020, Institute of Electrical and Electronics Engineers Inc., Aug. 2020, pp. 1337–1342. doi: 10.1109/ICSSIT48917.2020.9214101.

[17] H. Y. Putra, “Fraud detection at self checkout retail using data mining,” in 2020 International Conference on Information Technology Systems and Innovation, ICITSI 2020 - Proceedings, Institute of Electrical and Electronics Engineers Inc., Oct. 2020, pp. 211–216. doi: 10.1109/ICITSI50517.2020.9264919.

[18] “What is YOLOv5? A Guide for Beginners.” Accessed: Oct. 31, 2023. [Online]. Available: https://blog.roboflow.com/yolov5-improvements-and-evaluation/

[19] “YOLOv5 - Fine Tuning & Custom Object Detection Training.” Accessed: Oct. 31, 2023. [Online]. Available: https://learnopencv.com/custom-object-detection-training-using-yolov5/