existing algorithm. Here, the data is always stored in AWS storage i.e. dynamo DB(database), in the encrypted form with the help of our algorithm and when other person needs that data then a request is send to the owner regarding access to data and after verification the access is approved.

16. GRAB AND GO: IMPLEMENTATION OF A SMART SHOPPING TECHNOLOGY USING COMPUTER VISION

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The lines are blurring between online (eCommerce), and offline retail. As technology becomes more and more influential in our lives, retailers need to learn new skills and make them part of their business. There are several methods that can help reduce the time that customers spend to pay for the products and to customize their shopping experience. Amazon's brick-and-mortar stores enhance the shopping experience by combining the online and the offline world. The Amazon Go stores use a combination of Computer Vision, Deep Learning, and Sensor Fusion technology to automate the payment and checkout process. This means that customers can enter the store, pick-up items, and leave without queuing or checking out, while the payment is automatically made through the Amazon Go app. Amazon Go uses what they call, "Just Walk Out Technology". The proposed design aims at emulating the 'Just Walk Out' technology on a prototype level and uses Computer Vision algorithms to track customers throughout the store and identify their movements. Pose estimation and Human Activity Detection are used to identify the customer's actions. Once a product is picked up by the customer, the product is identified using a neural network classification model with a testing accuracy of 74%. The low accuracy can be overcome by using a dataset having many images with slight variations for training. The accuracy can be increased by applying Bounding Box or YOLO for feature extraction on the dataset. The proposed design uses weight sensor to detect the weight of the product picked up by customer. In the end, the proposed design is able to identify which customer picked up what product and he/she is charged accordingly.

Keywords—Amazon Go, computer vision, deep learning, Just Walk Out Technology, prototype, track, pose estimation, human activity detection, weight sensors

Introduction

Customers' shopping experiences have witnessed a revolutionary transition over the years right from introduction of supermarket shelves to barcode scanners and self-checkout lines. Though the advent of online retail created quite an impact, the majority of people still prefer to shop in-store. Moreover, shifting to online shopping completely for certain categories is not feasible since the powerful sensory experiences of visiting a physical store combined with the importance of fresh products in consumers' diets keep shoppers returning to stores to restock. This is applicable in countries across the globe, including India where the brick and mortar still continues to be the mainstay of food retailing.

The average time spent by a customer in a grocery store is about 41 minutes. Most of this time is usually spent standing in long checkout queues which poses to be an inconvenience. Other hassles faced by customers include waiting at the cashier desk till all their items get scanned and transactions get completed, facing crowds even at 'Express Checkout' counters and carrying credit/debit cards or appropriate change at all times.

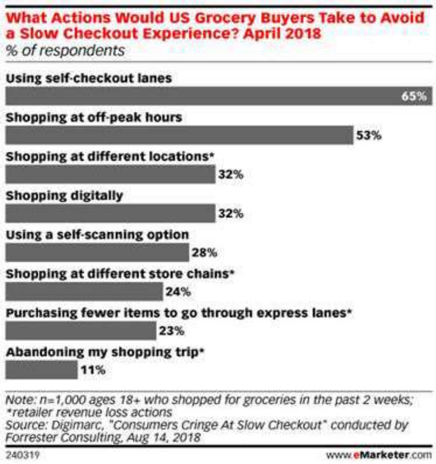

Fig. 1. eMarketer.com stats based on actions US grocery buyers take to avoid a slow checkout experience.

Based on a survey conducted in the US by eMarketer.com (Fig. 1), the above problems with respect to a slow checkout reveal the dire need for a hassle-free checkout experience. Keeping all this in mind, Amazon came up with "Amazon Go" showcasing 'Just Walk Out' experience - a new kind of shopping sense with no checkout required. Amazon is using a combination of Artificial Intelligence, Computer Vision and data pulled from multiple sensors to ensure that customers are only charged for the products they pick up. With the advent of AI technology, computer integrated systems enable the customer to take products off the shelves, put them in their virtual carts, and leave the store without going through a checkout line and automatically charge their account linked with a credit/debit card logged in on their phone. Before entering the Amazon Go store, a QR code needs to be scanned which appears on the Amazon Go app when a customer logs in to his/ her Amazon account. Then the customer can pick up things he/she needs and put it into their bag. The cameras in the store record all movements, a computer identifies each product and the action of picking it or keeping it back on the rack with the help of weight sensors. The technology also covers for putting things back on the wrong shelves so that the customer won't be charged.

The proposed design in this paper aims at emulating the 'Just Walk Out' technology on a prototype level by combining the latest offerings of Computer Vision, Sensor Fusion and Deep Learning. The underlying concept presented in the proposed design is prevalent at the various Amazon Go Concept Stores spread across in Seattle, Chicago, New York and San Francisco in the US.

The paper begins with related work which summarizes similar research carried out on the subject matter, followed by the proposed system which includes a brief description of the system flow and the detailed explanation of the system architecture, followed by the results and discussion which focuses on the analysis of the obtained results and lastly conclusion which summarizes the benefits, value and the future scope of the proposed design.

RELATED WORK

In order to formulate the flow of the proposed design, multiple research papers based around the concept of Amazon Go were studied. This section presents a brief gist of the research papers that have been referred to, in order to lucidly understand the foundation of the concept.

Just Walk-Out Technology and its Challenges: A case of Amazon Go- This paper discusses how the 'Amazon Go' technology works and the process which goes behind it with regards to Facial Recognition and Customer information [1]. The database is traced which may include images of the user, details about the customer such as height and user biometrics. That then allows the store's surveillance system to identify the customer so that it can track them as they move throughout the store. Cameras pick up images of the customer when they come in front of shelves, of the items they picked up and whether the item picked stayed in the customer's hand or kept back on the shelf. This advanced shopping technology completely eliminates queues and checkout.

Transfer learning for image classification- Convolutional neural network (CNN) gained great attention for robust feature extraction and information mining [2]. Various CNN architectures were proposed to improve the respective system performance. Among these, AlexNet, VGG16 and VGG19 are the famous CNN architecture introduced for object recognition tasks. In this paper, they make use of transfer learning to fine-tune the pre-trained network (VGG16) parameters for image classification tasks. Performance evaluation has been carried out using average recall, precision and F-score, accuracy. Performance analysis shows that fine-tuned VGG16 architecture outperforms the other CNN and hybrid learning approach for image classification tasks.

3) Action Recognition from 2D skeletons- From a video stream (RGB images), a two-dimension skeleton of 18 joints for each detected body is extracted with a DNN-based human pose estimator called Open Pose [3]. The skeleton data are encoded into Red, Green and Blue channels of images. State of the art deep neural networks are designed for image classification to recognize actions. The classification of images and videos has been very successful with the development of deep learning. The highest accuracy is obtained with ResNet: 83.317% cross-subject and 88.780% cross-view which outperforms most state-of-the-art results.

PROPOSED SYSTEM

The system flow has been conceptualized by combining various concepts like Object Tracking, Pose Estimation, Human Activity Recognition, Product Identification along with weight sensors and Arduino UNO microcontroller. This section explains entire flow of the proposed design briefly along with detailed description of the software-based and hardware-based concepts used.

System Flow

The system flow presents the sequential representation of the major steps involved. The development of a system flow diagram was crucial in understanding the different sections present in the system and how they will be integrated.

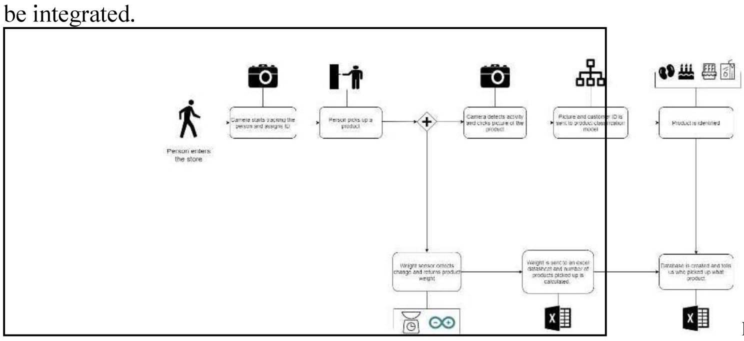

Fig. 2. System flow graph

First when a person enters the store the camera detects the person and assigns a unique ID. The customer is tracked through the store and their ID is retained. When the person performs the action of picking up a product, a trigger is sent to the camera to click a picture of the product. This picture is sent through a classification model along with the person's ID to accurately identify the product picked up. Once the product is identified the product details along with the customer ID is sent to an excel sheet. When the customer picks up a product the weight sensor mounted onto the rack also gives the product's weight. This weight is used to identify the number of units picked up by the customer and calculate the amount to be paid. These values are also sent to the excel sheet.

System Architecture

The proposed design uses several deep learning algorithms to accomplish the task of customer tracking, customer action recognition and product identification. YOLOv3 is used for customer detection and Deep SORT is used to track the customer throughout the store. To recognize the action of a customer picking up a product, pose estimation is done using OpenPose. This pose is then used to identify the customer's action. The product picked up is identified using a classification model. The classification model is based on pre-trained VGG16 weights. The proposed design uses Arduino UNO microcontroller along with HX711 module and a 10kg load cell to detect the weight of the product picked up by the customer. The prototype consists of a custom-made rack that has been built for demonstration with the 10kg load cell mounted onto the rack. When a product is picked up by the customer, the load cell detects a change in weight and this information is sent to the microcontroller by HX711 module. The weight of the product is displayed on Arduino UNO through the serial monitor.

Object Tracking and Pose Estimation:

Object Detection and Tracking:

Real-time Multi-person tracking for a video is achieved by using YOLO v3 and Deep SORT with tensor flow. YOLOv3 (You Only Look Once), is a model for object detection. The object detection task consists of determining the location on the image where certain objects are present, as well as classifying those objects.

Previous methods for this, like R-CNN and its variations, used a pipeline to perform this task in multiple steps. This can be slow to run and also hard to optimize because each individual component must be trained separately. YOLOv3, does it all with a single neural network. YOLOv3 predicts an objectness score for each bounding box using logistic regression.[4]

Simple online and realtime tracking (SORT) is a much simpler framework that performs Kalman filtering in image space and frame-by-frame data association using the Hungarian method with an association metric that measures bounding box overlap.[5] SORT is an online tracker which works on the principle of tracking by detection. SORT tracks each detection by assigning unique id to each bounding box, as soon an object is lost due to occlusion, wrong identification, etc. tracker assigns a new ID and starts tracking the newfound object.[6]

Hence in the proposed design, customer tracking would start with all possible detections in a frame and give them an ID. In subsequent frames it tries to carry forward a person's ID. If the person has moved away from the frame then that ID is dropped. If a new person appears then they start off with a fresh ID.

In this algorithm, tracking is based on not just distance and velocity but also what that person looks like. Deep sort allows us to add this feature by computing deep features for every bounding box and using the similarity between deep features to also factor into the tracking logic. While performing visual object detection and tracking tasks, video is broken down into frames and each frame as well as a video output is saved with detection and tracking information obtained for each input video after using YOLO and SORT for object detection and tracking respectively.

Pose Estimation and Action Recognition:

The first step to recognize human activity is to extract the motion from the video. As a result, the essence of the motion is extracted, namely, the skeleton of people. Skeleton extraction is done using OpenPose, a DNN-based detection system that extracts a 2D skeleton of 18 joints for each detected body. Second, motion sequences are converted to RGB images. The classification of images and videos has been very successful with the development of deep learning. We exploit these advantages by transforming the skeleton-based action recognition task into an image classification task. The motion parameters are encoded in the three R, G, B channels and an action sequence becomes an RGB image. Finally, image classification neural networks can be retrained to recognize actions. [3]

Human Pose Estimation is defined as the problem of localization of human joints (also known as keypoints - elbows, wrists, etc.) in images or videos. It is also defined as the search for a specific pose in space of all articulated poses. A Human Pose Skeleton represents the orientation of a person in a graphical format. Essentially, it is a set of coordinates that can be connected to describe the pose of the person. Each coordinate in the skeleton is known as a part (or a joint, or a keypoint). A valid connection between two parts is known as a pair (or a limb).

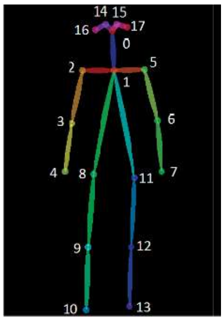

Fig. 3. OpenPose skeleton joints

From a video stream (RGB images), a two-dimension skeleton of 18 joints for each detected body is extracted with a DNN-based human pose estimator called OpenPose. OpenPose represents the first real-time multi-person system to jointly detect human body, hand, facial, and foot keypoints (in total 135 keypoints) on single images. OpenPose can operate in real-time detecting facial expressions, body and hand joints by feeding RGB images through deep convolutional neural networks (CNNs).

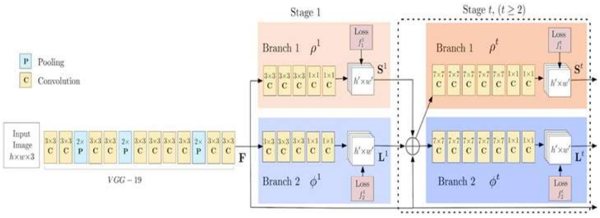

Fig. 4. OpenPose Network

The OpenPose network first extracts features from an image using the first few layers (VGG-19 in the above flowchart). The features are then fed into two parallel branches of convolutional layers. The first branch predicts a set of 18 confidence maps, with each map representing a particular part of the human pose skeleton. The second branch predicts a set of 38 Part Affinity Fields (PAFs) which represents the degree of association between parts.

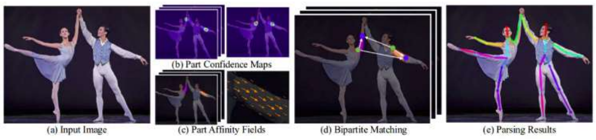

Fig. 5. Steps involved in human pose estimation using OpenPose.

Overall pipeline. (a) Our method takes the entire image as the input for a CNN to jointly predict (b) confidence maps for body part detection and (c) PAFs for part association. (d) The parsing step performs a set of bipartite matchings to associate body part candidates. (e) We finally assemble them into full body poses for all people in the image.[7]

Successive stages are used to refine the predictions made by each branch. Using the part confidence maps, bipartite graphs are formed between pairs of parts (as shown in the above image). Using the PAF values, weaker links in the bipartite graphs are pruned. Through the above steps, human pose skeletons can be estimated and assigned to every person in the image. We further use these key points to extract robust motion features considering their movements in consecutive frames'. Then, a Recurrent Neural Network (RNN) with Long Short-term Memory cells (LSTM) is used to recognize the activities associated with these features.[8]

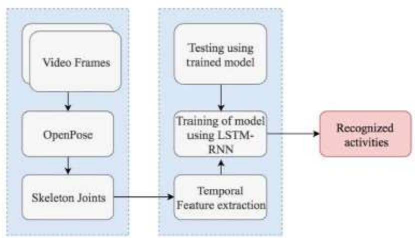

Fig. 6. Human Activity Detection framework

Product Identification:

A product classification model is implemented to identify the product picked up by the customer**.** The Freiburg Groceries Dataset is used to train the model which consists of 5000 256x256 RGB images of 25 food classes. The model is currently trained for 4 different products (classes) namely Beans (0), Cake (1), Chocolate (2) and Juice (3), which consists of around 100-200 images per class. Data augmentation strategies like rotation, zooming, flipping, varying brightness, etc. have been used to increase the number of images in the dataset. The Keras framework has a utility called ImageDataGenerator that can help in doing all the preceding operations. As seen in an example shown below (Fig. 7.), a new version of training images is created after applying each data augmentation technique while the label for these images remain same so that the model can extract relevant features from these images.

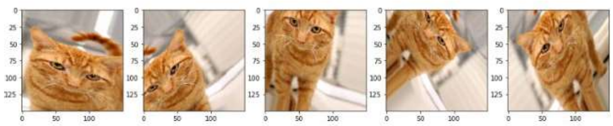

Fig. 7. Image Augmentation on a cat image

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Since the proposed design covers for only four classes of products, the amount of data available for training a model from scratch is limited. Besides conventional Machine Learning models are trained to solve particular tasks and have to be rebuilt from scratch if the feature-space distribution changes. To deal with this and lack of data, the proposed design makes use of a technique called transfer-learning. Transfer learning is a method of reusing the knowledge of a pre-trained model meant for an existing task for a new, related task. Transfer Learning using pre-trained VGG16 weights has been used to build the model.VGG-16 is one of the most popular models used in the field of Computer Vision. The precise structure of VGG-16 network is shown below:

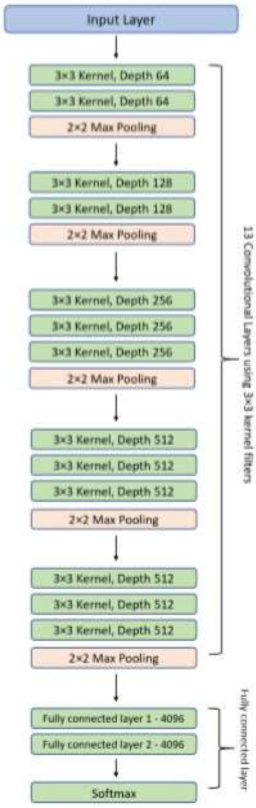

Fig. 8. VGG-16 model architecture

VGG-16 model architecture consists of 13 convolutional layers and 2 Fully connected layers and 1 SoftMax classifier VGG-16 - Karen Simonyan and Andrew Zisserman introduced VGG-16 architecture in 2014 in their paper Very Deep Convolutional Network for Large Scale Image Recognition. Karen and Andrew created a 16-layer network comprised of convolutional and fully connected layers. Using only 3×3 convolutional layers stacked on top of each other for simplicity. [9] The proposed design uses the convolution blocks of the VGG-16 model and flattens the final output from the feature maps which is fed into the dense layers added for our classifier.

The training set is used to train the classifier which learns how each class looks. This is followed by feeding the model test images that it has not encountered before. An average pooling layer has been used on top of it to reduce the variance of the learned weights from the previous layers. Dropout rate used is 30% to reduce overfitting which means 30% data is randomly dropped in order to make the dataset more generalised. A dense layer with 4 neurons has been used for representing the 4 classes of grocery products in the dataset. "Softmax" has been used as the activation function as it is a multi-class classification problem. "Adam" optimizer has been used with a learning rate of 0.001 and categorical cross-entropy has been used as the loss function for the model. The model has been trained for 25 epochs with a batch size of 128.An excel database comprising the product details including the weight and price per unit is created for calculation of number of units and price based on the results obtained from the weight sensor.

3) Weight Sensor (Load Cell with the HX711 Module):

The number of units of each product picked up by the customer is validated using different weight sensors employed for each rack. The programming for the same is done using Arduino UNO.

A Load cell is a transducer, which transforms force or pressure into electrical output [10]. Magnitude of this electrical output is directly proportional to the force being applied. Load cells come in various ranges like 5kg, 10kg, 100kg and more, here we have used a Load cell, which can weigh upto 10kg.

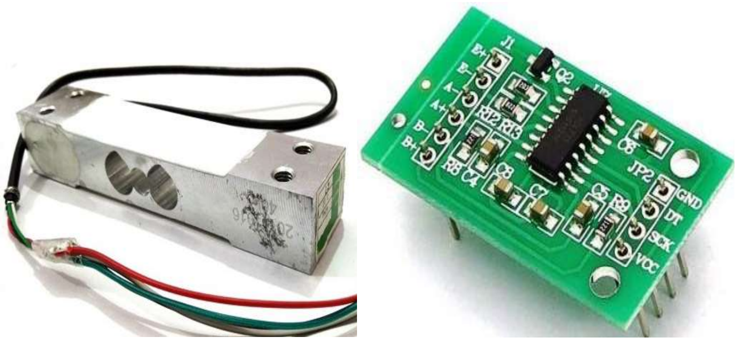

Fig. 9. Load Cell along with HX711 Module

HX711 Weighing Sensor Module has a HX711 chip, which is a 24 high precision A/D converter (Analog to digital converter). HX711 has two analog input channels and we can gain up to128 by programming these channels. So the HX711 module amplifies the low electric output of Load cells and then this amplified & digitally converted signal is fed into the Arduino to derive the weight. Weight Sensors are deployed on each rack and its functionality is only to validate how many units of the product a customer has picked up based on the weight. There is also a feature where in, if products in your shopping bag are kept back on the rack the weight gets deducted automatically. Hence concerns regarding being charged twice are omitted. This feature has been achieved by initializing variables and getting the weight of total number of objects kept on the rack which is then modified to get the weight of the product which has been picked up by using mathematical calculations. For accurate results, a calibration factor has to be set up, which helps maintain the actual weight of the product.

The weight sensor output gives the weight of the product. The weight of the product picked up is stored in an excel file with the help of a simple add-on for Microsoft Excel that make it easy to create log excel sheets. Parallax Data Acquisition tool (PLX-DAQ) is a software add-in for Microsoft Excel and it acquires up to 26 channels of data from any Parallax microcontrollers and drops the numbers into columns as they arrive. PLX-DAQ provides easy spreadsheet analysis of sensor data. Hence the weight of the product is stored and the number of units picked up along with the amount to be paid can be calculated from this data.

RESULTS AND DISCUSSION

The proposed design is able to successfully track multiple customers in a frame and assign unique IDS to them as soon as they enter the frame along with recognizing the action being performed using Object Tracking, Pose Estimation and Human Activity Recognition. The product picked up by the customer is identified as per the classes of products defined under it using the Product Identification model. The weights of the products kept on the rack (fixed) and the product picked by the customer are correctly detected using the weight sensor (HX711 module and load cell) and Arduino UNO. These weights are correctly compared with the weights defined in the database to write the number of units and amount to be paid by the customer along with the product details and customer ID to the final receipt excel sheet. This section presents all the results obtained along with explanation.
Object Tracking, Pose Estimation and Human Activity Recognition:

The snapshots shown below are taken from a video that was recorded for testing purposes. First snapshot (Fig. 10.) shows the marking of key points on both the humans present in the frame. Second snapshot (Fig. 11.) shows assigning of IDs to both humans (based on who entered the frame first) and recognition of activities being carried out by the humans based on the estimated pose while simultaneously being tracked with the help of the bounding box. As seen in the second snapshot, Human 1 (ID 1) is walking hence activity shown is “walk” while Human 2 (ID 2) is picking up an object from the rack hence activity shown is “operate”. The third snapshot (Fig. 12.) shows how activity of Human 2 (ID 2) changes to “stand” as she stands up after picking the object while activity of Human 1 (ID 1) remains the same as she continues walking.

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Fig. 10. Marking of key points on both humans

Fig. 11. ID Assignment, Pose Estimation and Activity Recognition

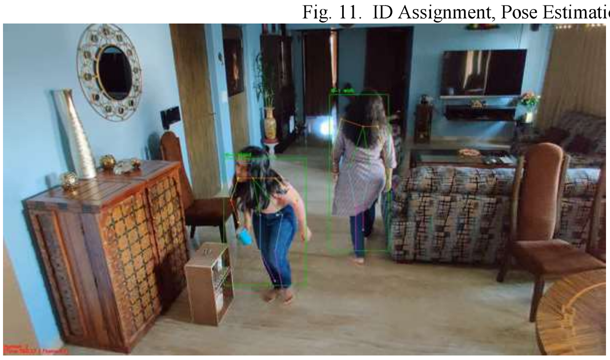

Fig. 12. Change in activity of human 2

Product Identification:

The classifier is currently able to predict labels accurately for most of the products. The model is currently trained for 25 epochs with a batch size of 128. Each epoch consists of 20 steps. The training accuracy achieved is 85% and validation accuracy achieved is 74%. Initially when the model was trained for only 2 products (classes), the validation accuracy achieved was 93%. It was observed that increasing the number of classes and the lesser number of samples present in the pre-existing dataset taken could be a reason behind the low accuracy. The value of testing accuracy can be improved by adding more variations of images in the dataset thereby increasing the number of samples per class. Custom dataset can also be created that caters only to the images taken at the particular top angle from where the picture (testing image) would be clicked in the actual scenario to improve the accuracy. Besides a different Neural Network architecture can be used. The results were visualized on tensorboard. The labelled outputs of the classifier are shown below for known images (from training set) and unknown images (external) of various products(classes).

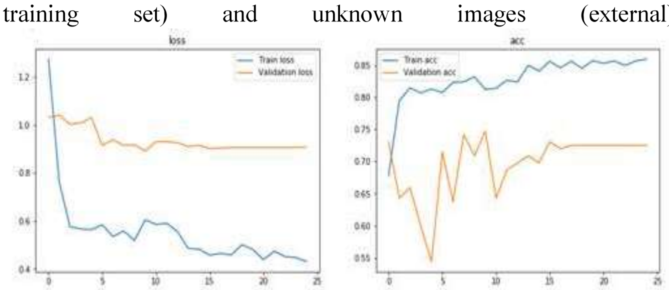

Fig. 13. Tensorboard Results

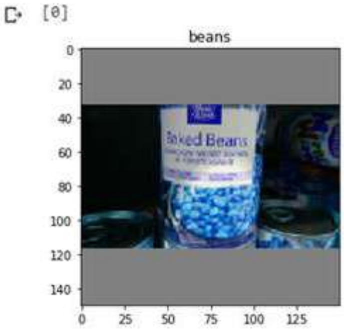

Fig. 14. Known image for beans

Fig. 15. Unknown image for cake

Arduino Setup with Load Cell

Fig. 16. Arduino setup with load cell on custom-made rack

Total weight of all products: It represents the total weight of all three products placed on rack.

Weight of Product(s): Weight of product picked up by the customer.

1. In this case no product is picked up

```
--------------------------------------------
Total weight of all products: 1.232 Kilogram
Weight of Product(s): -0.003 Kilogram
Calibration Factor is: -238060.00
--------------------------------------------
Total weight of all products: 1.232 Kilogram
Weight of Product(s): -0.002 Kilogram
Calibration Factor is: -238060.00
--------------------------------------------
Total weight of all products: 1.232 Kilogram
Weight of Product(s): 0.041 Kilogram
Updated Total Weight: 1.185 Kilogram
Calibration Factor is: -238060.00
```

Fig. 17. Arduino output

2. In this case product beans is picked up

```
--------------------------------------------
Total weight of all products: 0.754 Kilogram
Weight of Product(s): 0.463 Kilogram
Updated Total weight: 0.774 Kilogram
Calibration Factor is: -238060.00
--------------------------------------------
```

Fig. 18. Weight of product picked up

3. Hence, Weight of Product(s) displays the weight of beans.

The final receipt is presented below. The final receipt is saved as an excel and the proposed design is able to accurately determine which person picked up what product.

Customer ID	Product	Weight	Price	Units
1	Beans	0.920	260	2
2	Cake	0.52	290	1
2	Juice	0.2	30	1

Fig. 19. Final receipt

Hence it can be observed that customer 1 has picked up two cans of beans and customer 2 has picked up one box of cake and one packet of juice. The customers have been automatically charged according to the products he/she picked up. The pricing is also dependent on the number of units picked up.

CONCLUSION

A futuristic cashier-less experience using powerful tools of AI is touted to be the game-changer of retail. And with digital India going cashless, the proposed design could prove to be an easy and efficient way to exercise it. It diminishes the absolute need to even carry one's card. As seen in the results and discussion section, the proposed design can successfully assign unique IDs to the customers when they enter the store, track them throughout the store while estimating their pose and recognizing the activity they are performing. As soon as the customer picks up an object, the product identification model identifies it. The training accuracy achieved is 85% and validation accuracy achieved is 74%. The model, which is currently trained for identifying 4 products is able to predict correct labels for most products except a few. The weight sensor output is used to calculate the number of units and the amount to be paid by comparing it with the database of products. The final receipt database (excel sheet) consists of the customer ID along with all the products purchased by him/her and the total price to be paid. It aims at having every customer at ease by not requiring them to stand in long queues or follow any kind of checkout procedures. Problems like instances of shoplifting and detection of fraudulent customers faced by the grocery stores can also be resolved because only verifiable customers can enter the store. Besides, bearing the cost of checkout personnel is one of the store's concerns which can be reduced. All in all, this entire concept is pertinent to the Indian conditions where crowds pose to be a major issue while considering even the 'Express' checkout counters. The proposed design is undoubtedly a major step towards an AI-driven retail world. Going forward, it is proposed to develop an app for scanning the QR code at the entrance, tracking the products purchased real time on a virtual cart and recovering the billing amount from customers' cards for the proposed design. Further customer purchase history can be analyzed using Data Analytics to get useful insights and prompt product suggestions to the customer via the app. It is also proposed to combine multiple camera feeds for seamless customer tracking throughout the store and train the product classification model to identify products belonging to multiple brands.

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17. ANALYSIS OF ADVANCED SPEED CONTROL METHODS FOR PLC-BASED INDUCTION MOTOR DRIVE

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Induction motor constitutes the majority of the machines used in the industry owing to their low cost and rugged construction. Hence their efficient control and stable operation are of vital importance. Programmable Logic Controllers (PLC) are robust devices widely used in industries and process control applications due to ease in programmability, fast operation and precise control. This paper presents an excerpt from a comparative analysis of advanced speed control methods for automated induction motor (IM) drive. A complete automation scheme is developed using PLC and AF-650 general purpose drive. Acquisition of real-time data of performance parameters, in particular speed, current, torque and power are achieved using Drive Control Tool (DCT). This data is studied to analyze the dynamic performance of IM drive operated under different speed control modes namely Vector control and Sensor-less vector control.

18. CONTROL, MONITORING, AND PROTECTION OF INDUCTION MOTOR USING PLC AND SCADA

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Due to their rugged construction, user-friendly interface and fast response, Programmable Logic Controller (PLC) and Supervisory Control and Data Acquisition (SCADA) have become popular tools in the field of industrial automation. The use of PLC and SCADA, along with Variable Frequency Drive (VFD) for control, monitoring and protection mechanism of the 3-phase Induction Motor (IM) drive is presented in this paper. Speed control of the IM drive under various operating conditions is achieved in the forward and reverse motoring mode. Real-time values of key parameters like speed, current, voltage is monitored in a personal computer using SCADA and their trend analysis will be carried out by Drive Control Tool. In addition to this, motor protection is achieved by using over-current and over-speed alarms.

19. COMPARISON OF MACHINE LEARNING ALGORITHMS FOR AIR POLLUTION MONITORING SYSTEM

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Today one of the topics that need to be addressed is Air pollution and that has to be done with the new, bold and effective techniques in order to have a control on the pollution levels. Recently there has been a rapid increase in dangerous and harmful pollutants in the air such as Sulphur Dioxides, Nitrogen Dioxide, Particulate Matter 2.5 and Particulate Matter 10, Ammonia and Ozone. The increase in the pollutants has been mainly due to the human activities. In this paper, data has been