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Smart Distancing

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***Abstract*: In this paper, an integrated smart distancing that fuses mask detection, degree of store crowdedness and zero contact billing system is proposed. The proposed system acquires real time data and determines whether the person is wearing a mask or not utilizing the Machine Learning packages like TensorFlow, Keras, OpenCV and MobileNetV2 architecture. MobileNetV2 is fine tuned to implement COVID-19 face mask detector training script. Furthermore, With the help of A.I combined with edge computing, Object tracking and object detection the degree of store crowdedness can be measured and recorded in real time using OpenCV. An alert in the form of mail is triggered in case of breach of threshold. This obtained dynamic data is rendered in our customized website created using HTML, CSS and JavaScript. The intervals of this operation are monitored by a scheduler. Finally, a smart shopping system is designed by employing the concepts of RFID modules and tags integrated with NodeMCU alongside IoT. This system aims at developing an automated self-billing system that would save the customers time and helps the people abide by the rules of the pandemic.**

***Keywords*: Machine Learning, face recognition, object detection, RFID, IoT.**

1. Introduction

The existing pandemic has brought the world to a full stop. Nevertheless, humans have to adapt and move on. The foremost rule imposed by WHO and CDC is to maintain social distancing meaning there must be a distance of six feet or more between people. The COVID-19 pandemic is showing negative effects on human health as well as on social and economic life. Globally as of June 2021, there have been 179,241,734 confirmed cases, including 3,889,723 deaths reported to WHO. About half of the world's population is under some form of lockdown, with more than 3.9 billion people in more than 90 countries or territories having been asked or ordered to stay at home by their governments to prevent the spread of the virus. It is a critical and challenging task to revive public life while minimizing the risk of infection. Reducing interactions between people by social distancing is an effective and prevalent measure to reduce the risk of infection and spread of the virus within a community. Social distancing is a method used to control the spread of contagious diseases. It implies that people physically distance themselves from one another, reducing close contact, and thereby reducing the spread of an infectious disease. Essential stores like pharmacies, groceries and so on are allowed to be open if and only if the guidelines are followed. However, practicing social distancing in limited spaces has its own drawbacks. Even though the vaccinations are being rolled out, there has been several new strands modifying, evolving itself into a more severe threat for humans. Current developments in several countries show that this measure can be technologically accompanied by Machine Learning, Deep Learning and IoT. In order to combat this, we need to accept the social distancing as the new normal. This brings us to the project idea, an integrated system beginning with a mask detector, which is absolutely necessary during these and future times. The virus that causes COVID-19 is mainly transmitted through droplets generated when an infected person coughs, sneezes, or exhales. These droplets are too heavy to hang in the air, and quickly fall on floors or surfaces. Masks are a simple barrier to help prevent the respiratory droplets from reaching others. Studies show that masks reduce the spray of droplets when worn over the nose and mouth. One should wear a mask, even if he/she does not feel sick. The proposed mask detection system detects whether the person entering the facility is wearing a mask or not. The same algorithm can be used to detect other key features depending upon the type of facility in which it is being implemented. Many states have already set public use guidelines and capacity limits for places like grocery stores, retail stores, and other businesses. To protect employees and customers and comply with local regulations, retailers generally have two ways to control traffic: limiting capacity to a certain number of people per square footage or by percent of occupancy. The most advanced solution is to deploy automated people counters for 24/7, real-time traffic and occupancy monitoring. The degree of store crowdedness is used as a precise estimation of the people entering and leaving the public place with every data recorded and the real time data of total people inside the facility logged. This dynamic data is displayed in our custom website. This can also be in several other places with many integrations in order to provide security. Finally, an automatic billing system is implemented which offers a seamless, futuristic shopping experience with hassle free human intervention during these difficult times. This is also being used in several market chains which decreases the labor cost. Covid-19 has demonstrated the interconnected nature of our world that, No one is safe until everyone is safe!

2. Literature Survey

In [1] the authors "S. Susanto, F. A. Putra, R. Analia and I. K. L. N. Suciningtyas" proposed a system that aims to develop the face mask detector which is able to detect any kinds of face mask. In order to detect the face mask, a YOLO V4 deep

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learning has been chosen as the mask detection algorithm. The experimental results have been done in real- time application and the device has been installed at Politeknik Negeri Batam. From the experimental results, this device is able to detect the people who wear or do not wear the face mask accurately even if they are moving to various position.

In [2] the authors "Madhura Inamdar, Ninad Mehendale", proposed a system where a dataset of 35 images were used to train the Facemasknet model which resulted in an accuracy of 98.6% in identifying face-masked and without face- masked photographs. Calibration nets are used to stimulate face detection. The proposed model is least complex and it does not demand segmentation, bounding-box regression and can recognize faces at different angles.

In [3] the authors "Subashree D, Shrushti Rohidas Mhaske, Sonal Rajesh Yeshwantrao, Ayush Kumar" proposed a real time crowd counting method using OpenCV. With reference to edge recognition, morphological filter, SVM order which are not real time applications, our method trains the system using video streaming and provides result in real time. OpenCV for people counting, image processing and deep learning object detector are used. This method leverages both object detection and tracking to improve the accuracy of the people counter.

In [4] the authors "Badhan Hemangi, K. Nikhita" This paper develops a distributed people counting system using raspberry pi with OpenCV. A people counter is a device used to count the number of pedestrians walking through a door or corridor. Most of the time, this system is used at the entrance of a building so that the total number of visitors can be recorded.

In [5] the authors "Bhagyashree Bhumkar, Tejasvini Changal, Bhagyashri Dahifale, Ganesh Deshmukh", proposed a system in which products are attached with RFID tags. RFID tags will be read by RFID reader which is attached on trolley. Reader will send this information of item to micro- controller then micro-controller executes the code embedded in it. The total amount will be displayed on LCD. Using Zig- Bee, micro-controller will send this information to central billing server. Billing server will print the bill. This system will take less time to calculate bill for large scale applications.

In [6] the authors "P. Chandrasekar and T. Sangeetha", proposed a system where each product of shopping mall, super markets will be provided with a RFID tag, to identify its type. Each shopping cart is designed or implemented with a Product Identification Device (PID) that contains microcontroller, LCD, an RFID reader, EEPROM, and ZigBee module. Purchasing product information will be read through a RFID reader on shopping cart, meanwhile product information will be stored into EEPROM attached to it and EEPROM data will be send to Central Billing System through ZigBee module. The central billing system gets the cart information and EEPROM data, it accesses the product database and calculates the total amount of purchasing for that particular cart.

3. Proposed System

The proposed system is divided into three stages:

1) Mask detection.
2) Measuring adherence to social distancing guidelines by A. I system and analysing the output statistics for the degree of store crowdedness through our customized website.
3) Zero Contact Billing Cart using RFID.

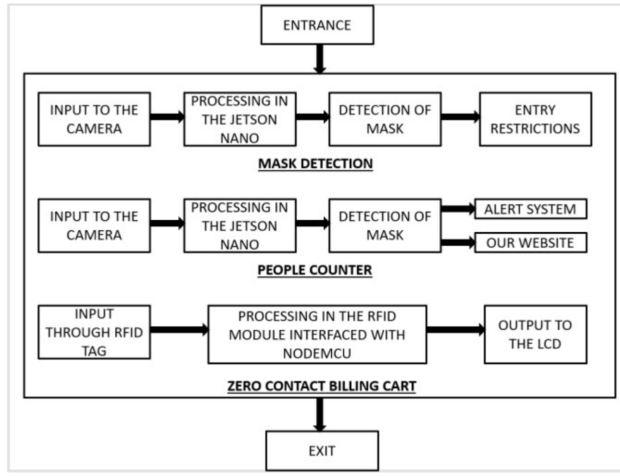

Fig. 1. Zero contact billing cart

4. Methodology

A. Mask Detector

Our goal is to train a custom deep learning model to detect whether a person is or is not wearing a mask. In this model, the dataset used to train our custom face mask detector is reviewed. A Python script is implemented to train a face mask detector on our dataset using Keras and TensorFlow. This Python script is then used to train a face mask detector and review the results.

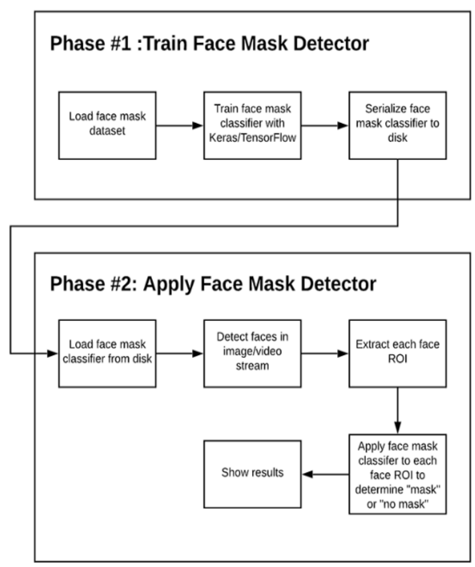

Fig. 2. Phases in mask detector

To train a custom face mask detector involves respective sub-steps:

1) *Training:* Here the face mask detection dataset is loaded from the disk, the model (using Keras/TensorFlow) is trained on this dataset, and then the face mask detector is serialized to the disk.

2) *Deployment:* Once the face mask detector is trained, the mask detector is loaded, performing face detection, and then classifying each face as with mask or without a mask. This dataset consists of 1,376 images belonging to two classes:
   - With mask: 690 images.
   - Without mask: 686 images.

Our goal is to train a custom deep learning model to detect whether a person is or is not wearing a mask. To create this dataset:

- Normal images of faces are collected.
- A custom computer vision Python script is created to add face masks to them, thereby creating an artificial (but still real-world applicable) dataset.

MobileNet V2 architecture, a highly efficient architecture that can be applied to embedded devices with limited computational capacity (ex., Raspberry Pi, Google Coral, NVIDIA Jetson Nano, etc.) is fine-tuned to implement face mask detector training script. Our data is segmented into 80% training and the remaining 20% for testing. During training, we'll be applying on-the-fly mutations to our images to improve generalization. This is known as data augmentation. Then the MobileNet V2 architecture is fine-tuned.

Once the face mask detector is trained, we need to:

- Load an input image from the disk.
- Detect faces in the image.
- Apply the face mask detector to classify the face as either with_mask or without_mask.

Similarly, Real-time video streams are captured using OpenCV, and face mask detection is applied to that.

Here in the proposed system, we have initialized our Face detector, COVID-19 face mask detector, Webcam video stream.

B. People Counter

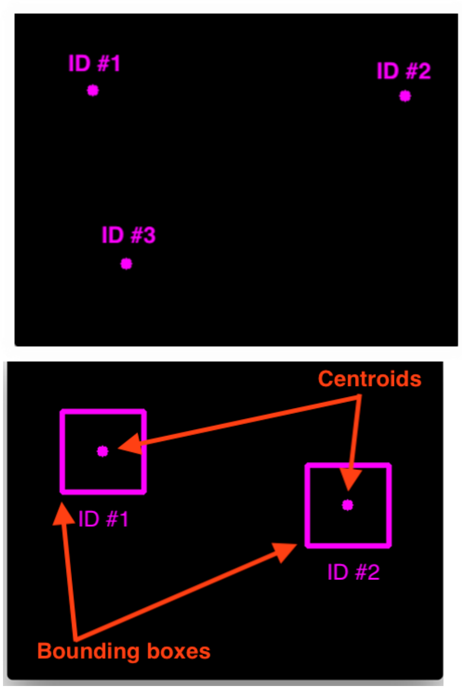

Fig. 3. People counter

This system involves counting the number of people in the stores/buildings/shopping malls etc., in real-time. An alert is sent to the staff if the people are way over the limit. It also automates features and optimizes the real-time stream for better performance (with threading), acts as a measure towards footfall analysis, and in a way to tackle COVID-19. We are using an SSD (Single Shot Detector) with a MobileNet architecture. In general, it only takes a single shot to detect whatever is in an image. That is one for generating region proposals, one for detecting the object of each proposal. Compared to the other 2 shot detectors like R-CNN, SSD is quite fast.

MobileNet, as the name implies, is a DNN designed to run on resource-constrained devices. For example, mobiles, IP cameras, scanners, etc. Thus, SSD seasoned with a MobileNet should theoretically result in a faster, more efficient object detector. For Object Tracking Centroid tracker is one of the most reliable trackers out there. To be straightforward, the centroid tracker computes the centroid of the bounding boxes. That is, the bounding boxes are (x, y) coordinates of the objects in an image. Once the coordinates are obtained by our SSD, the tracker computes the centroid (centre) of the box. In other words, the centre of an object. Then a unique ID is assigned to every particular object detected, for tracking over the sequence of frames. An optional email alert is sent in real-time in case if the total number of people (say 10 or 30) exceeded in a store/building, the proposed system alerts the staff. The maximum people limit is configured as a Threshold. This is useful considering the COVID-19 scenario.

Multi-Threading is used to thwart the lag/delay in the real-time stream. Threading removes OpenCV's internal buffer (which basically stores the new frames yet to be processed until your system processes the old frames) and thus reduces the lag/increases fps. If the system is not capable of simultaneously processing and outputting the result, there might be a delay in the stream. This is where threading comes into action. It is most suitable for solid performance on complex real-time applications.

An automatic scheduler is designed to start the software. Configure to run at every second, minute, day, or Monday to Friday. This is extremely useful in a business scenario, for instance, it can be run only at the desired time. A timer is also configured to stop the software at a certain time. All the data is logged to an excel sheet at the end of the day. It is useful for footfall analysis.

A customized website is designed using HTML, CSS, and JavaScript. The dynamic data obtained from the people counting model, which is the degree of store crowdedness is fetched onto the website using the fetch API. It is then rendered on the webpage and keeps updating every millisecond. Anyone who has access to the website can analyse the store's crowdedness, and plan accordingly to visit the store.

Here we use RFID cards and RFID readers with NodeMCU to build the Zero Contact Billing Cart project. The cart information and total value will be displayed on the webpage as well as on LCD. Each RFID card is associated with a certain product and an RFID reader is installed in the cart, which reads the product details like Price and Product details and sends them to NodeMCU ESP8266. Then NodeMCU process the available items and total value in the cart and send them to ESP8266 Webserver, which can be monitored on a web browser from anywhere in the world.

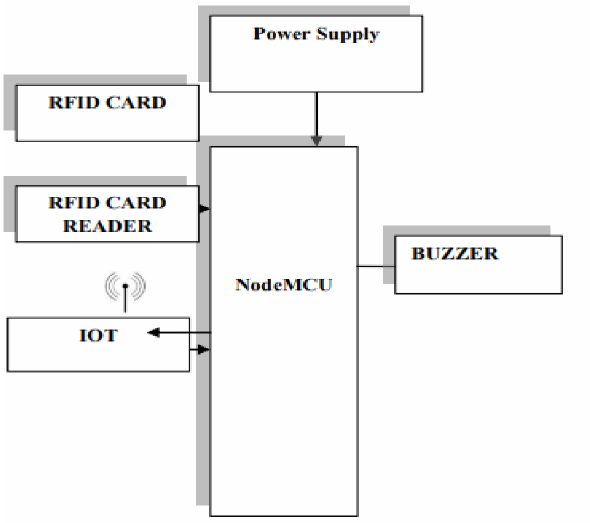

Fig. 4. Interfacing block diagram

The RFID based billing system consists of a trolley that is incorporated with a RFID reader. As soon as the customer places the product, they want to buy in the trolley, the RFID reader attached to the trolley detects the RFID tag number of the product to identify it. Each RFID tag number is linked to a product it describes. All the information regarding the product associated with the RFID tag is in database can be retrieved using centralized server. All the activities are coordinated together using a NodeMCU. The product can be directly scanned by the reader and if the customer wishes to remove any product, they just have to again scan the product, then the product should be deleted. After the purchasing product total amount of bill generated and display on LCD of the trolley and also at the billing section. When customer goes to billing section, he has to only pay the amount.

C. Applications

Smart distancing will help us be safe and efficient every time. Proposed system can be used for:

- No human intervention required for detection of masks and temperature.
- Contactless transactions.
- Automatic billing of products by using RFID technique will be a more viable option in the future.
- On a large-scale social distance monitoring can also be implemented in Railway Stations, Bus Stations, Airports, Museums or any other public places.

5. Conclusion and Future Scope

In brief, social distancing is the new normal and we need to be respectful of it for the health and safety of ourselves and the society.

In future the proposed system can be extended by the following ways:

- Assessing and standardizing different models.
- Improve the distance calculation module by considering perspectives.
- Show statistical and historical data in the GUI.
- Provide the ability for the user to customize and re-train models with task- specific datasets.

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