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A Mask Detection Method for Shoppers under the Threat of COVID-19 Coronavirus

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ABSTRACT: Object detection, which aims to automatically mark the coordinates of objects of interest in pictures or videos, is an extension of image classification. In recent years, it has been widely used in intelligent traffic management, intelligent monitoring systems, military object detection, and surgical instrument positioning in medical navigation surgery, etc. COVID-19, a novel coronavirus outbreak at the end of 2019, poses a serious threat to public health. Many countries require everyone to wear a mask in public to prevent the spread of coronavirus. To effectively prevent the spread of the coronavirus, we present an objectdetection method based on single-shot detector (SSD), which focuses on accurate and real-time face masks detection in the supermarket. We make contributions in the following three aspects: 1) presenting a lightweight backbone network for feature extraction, which based on SSD and spatial separable convolution, aiming to improve the detection speed and meet the requirements of real-time detection; 2) proposing a Feature Enhancement Module (FEM) to strengthen the deep features learned from CNN models, aiming to enhance the feature representation of the small objects; 3) constructing COVID-19- Mask, a large-scale dataset to detect whether shoppers are wearing masks, by collecting images in two supermarkets. The experiment results illustrate the high detection precision and real- time performance of the proposed algorithm.

KEYWORDS: Object detection; masks; feature fusion; COVID-19; spatial separable convolution.

I. INTRODUCTION

In December 2019, the World Health Organization (WHO) China Country Office was informed of cases of pneumonia of unknown aetiology in Wuhan City, Hubei Province, China [1]. So far, many confirmed cases have been confirmed in many countries, including medical staff. The Chinese government has taken timely public health measures including strengthening surveillance, conducting epidemiological surveys and limiting the inflow and outflow of population in Wuhan. This provides valuable experience for countries around the world to fight the coronavirus. Epidemiological investigations and genotyping have confirmed that COVID- 19 is a highly infectious virus. To prevent the spread of the virus, scientists recommend that all people wear face masks in public.Supermarket belongs to the personnel intensive place, beinfected possibility is very high. Although there are inspectors at the door of the supermarket to check the masks andtemperature of shoppers. However, in some supermarkets, there are still some people who do not wear masks, whichposes a great threat to public safety. This, in other words, raises the possibility of one infected person passing the virus to another. Therefore, in this paper, we focus on real-time face masks detection, created a new dataset called COVID-19 Mask, which aims to automatically detect whether shoppers are wearing masks. Besides, we improved the SSD algorithm and designed a lightweight facemasks detection algorithmbased on spatial separable convolution and FeatureEnhancement Module (FEM).

II. RELATED WORKS

With the rapid development of deep learning, especially deep convolutional neural networks (CNN), computer vision has been made significant advances in recent years on object recognition and detection [2]. The great majority of deep learning methods for object detection have been designed for large objects but their performances on small-object detectionare poor. Unfortunately, the objects in the created COVID-19-Mask dataset are smaller, generated from video captured bymobile devicesat a distance.

Some efforts, in many areas, have been devoted to addressing small object detection problems [3 - 8]. The common method[4] is to enhance the feature maps resolution of small objects by simply increase the scale of input images, which often results in heavy time consumption for training and testing. Some others [5 - 8] is centered on generating multi-scale representation which enhances high- level small-scale features by combining multiple lower-level features layers, which is simply increase the feature dimension. Next, we will introduce small object detection research in two areas.

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A. Small object detection in remote sensing images

Small object detection in remote sensing images has been a popular problem in computer vision and various methods [9-13] have been proposed to address this challenging task. Traditional methods for this task include [9] [10].In recent years, thanksto the development of deep learning, CNN-based approaches have been widely adopted in remote sensing small object detection due to their high accuracy. Zou et al. [11] designed a singular value decomposition network for ship detection in spaceborne optical images, which provides a simple yet efficient way to learn the features of remote sensing images. Cheng etal. [12] proposed a rotation-invariant CNN (RICNN) to detect multi object in high resolution optical remote sensing image. Ouyang et al. [13] proposed to combine CNN with the deformation model, which made the process of objection detection more sensitive through multiple models,multi-stage cascade, and other integrated approached.

B. Traffic sign detection

As everyone knows, for the unmanned vehicle to run safely, one of the most import factors is traffic sign detection and recognition. Sermanet et al. [14] proposed to feed multi-stage features to the classifier using connections that skip layers to boost traffic sign recognition. Zhu et al. [15] designed two CNNs for simultaneously localizing and classifying traffic signs. Jin et al. [16] proposed a hinge loss stochastic gradient descent method to train convolutional neural networks (CNNs), whichprovides better test accuracy and faster stable convergence.

COVID-19-Mask DATASET

In the first module, we developed the system to get the input dataset for the training and testing purpose. We have takenthe dataset from kaggle
Link: https://www.kaggle.com/omkargurav/face-mask-dataset The dataset consists of 5777 A Mask Detection Method images.3725 Images of Face with Mask
3828 Images of Face without Mask.

III. PROPOSED METHOD

In this project we focus on real-time face masks detection, created a new dataset called COVID-19- Mask, which aims to automatically detect whether shoppers are wearing masks. Besides, we improved the SSD algorithm and designed a lightweight facemasks detection algorithm based on spatial separable convolution and Feature Enhancement Module (FEM). The task includes two modules, the training module and the detection module. In the training section, the COVID-19- Mask dataset was used to train the model to obtain a mask detector. In the detection stage, images are obtained in realtime from thesurveillance video, and then use the trained detector to determine whether the shoppers in the pictures are wearing masks. A warning will be issued if a shopper is detected not wearing a mask.

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A. Lightweight backbone network

The proposed lightweight backbone network for face masks detection is based on SSD and spatial separable convolution. Our method is based on the facts that: 1) feature maps from the shallow layer in VGG-16 contains more features about small objects[18], and 2) the computational cost of conventional convolutions and deep networks is large, which can lead to slower detectionspeeds.
Deep neural networks have great challenges in practical applications, because their CPU or GPU occupies a high amount, it isdifficult to deploy on small devices, and their real-time performance is poor. In order to solve the problem of high CPU or GPU occupancy, many lightweight neural networks, such as Mobilenet [19] and EffNet [20], have been proposed. The core of EffNet is spatial separable convolution.
Different from conventional convolution, spatial separable convolution splits the convolution kernel into two smaller convolution kernels, and then performs convolution with two small convolution kernels respectively. The most common caseis to split the 3 × 3 convolution kernel into 3 × 1 and 1×3convolution kernels.

B. Feature Enhancement Module (FEM)

Small objects detection is one of the rather challenging tasks in computer vision due to its limited resolution and information.In order to improve the detection accuracy of small objects and Inspired by the structure of Inception [21], we introduced the Feature Enhancement Module (FEM) to fuse the features generated by convolution layers with

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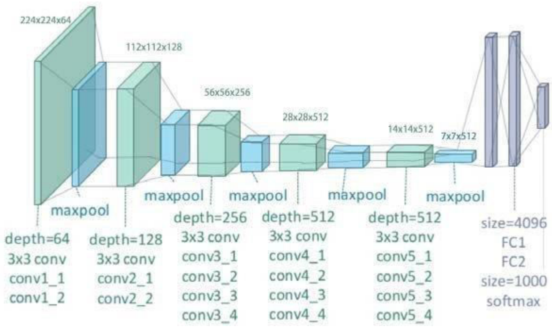
different kernel sizes, so as to enhance the representation capability of the network to the small objects. The Feature Enhancement Module (FEM)

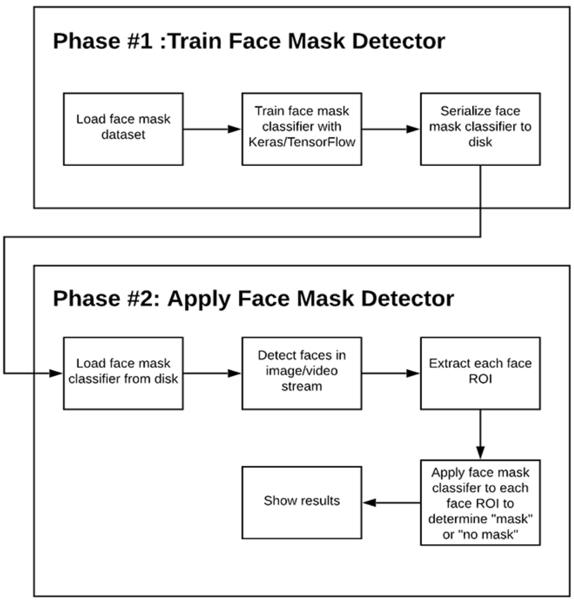
C. Constructing architecture

we construct our architecture based on the SSD framework, and then design proper detection layers and default boxes settings, which are essential for high detection accuracy.Lightweight backbone network. The backbone network based on SSD. we reserve the convolutional layers from 'conv1_1' to 'conv6' and remove othe layers because the too deeper convolutional layers behind is helpless for small objects detection but the computation is large. In order to obtain real-time detection effect, 'conv1_1' to 'conv6' were change into spatial separable convolution. We selectconv3_3, conv4_3, conv5_3 and conv6 as the detection convolution layers.Feature Enhancement Module (FEM). In order to enhance the representation capability of the network to the small objects, we introduced the Feature Enhancement Module (FEM). The detection layer of Conv4_3 and Conv6 is tailed by FEM.



D. Detection flow diagram

The task includes two modules, the training module and the detection module. In the training section, the COVID-19-Mask dataset was used to train the model to obtain a mask detector. In the detection stage, images are obtained in real-time from the surveillance video, and then use the trained detector todetermine whether the shoppers in the pictures are wearing masks. A warning will be issued if a shopperis detected not wearing a mask.



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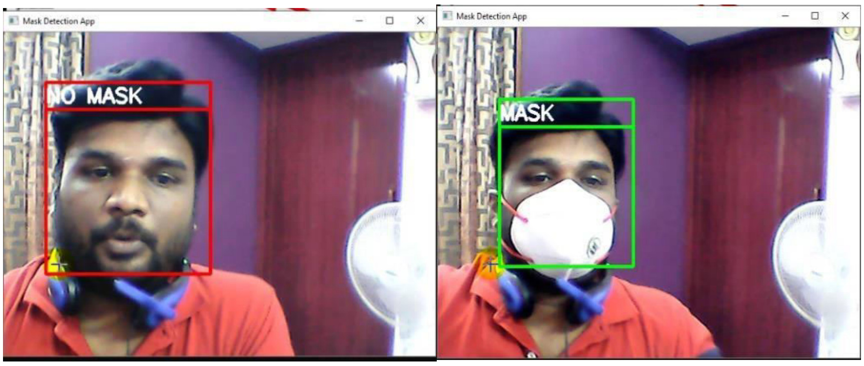
IV. RESULT



V. FUTURE WORK

This section reports several experimental results based on the COVID-19-Mask data set. We first evaluate existing architectures and on COVID-19-Mask dataset. Moreover, we evaluate proposed models' performance and analyze the effectiveness of backbone and FEM. All experiments are conducted using NVIDIA GTX1080TI video card,11GB memory, CPU E5-2620.We trained and tested built on the deep learning framework, Keras. We adopt Adaptive Moment Estimation (Adam) as the optimization function to train our model and the learning rate starts with 0.001 and decrease to 0.0001 after 20k iterations. After 100k iterations, we stop training and the last model snapshot is used to evaluate the performance of object detection on the test set.

First, we conducted a series of experiments on other popular algorithms. The comparison between our experimental results and other models is shown in Table 3. As can be seen from Table 3, compared with other algorithms, the proposed method has excellent detection accuracy and real-time performance on the COVID-19-Mask dataset. Experimental results show that proposed method can achieve 90.9% accuracy which is 18% and 15.7% higher than SSD and YoloV3 respectively on COVID-19-Mask dataset. In terms of detection speed, the average detection time for proposed method processing a 512 ×512 pixels images are 0.12s, which is higher than SSD but lower than YoloV3.

VI. CONCLUSION

In this project proposed a modified SSD method to detect whether shoppers are wearing masks in the supermarket. In order to detect whether shoppers are wearing masks, we created the COVID-19-Mask dataset, which can provide data for future studies. At the same time, in order to accurately detect masks in real time, we proposed a lightweight backbone network and Feature Enhancement Module (FEM), which improves the overall detection effect of the algorithm. We conducted a widerange of experiments and provided a comprehensive analysis of the performance of our model on the task of face mask detection. Experimental results show that the proposed method can effectively detect whether shoppers wear masks and can be applied to practice.

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