A REPORT

ON

DETECTION OF FRUIT DISEASES VIA OBJECT DETECTION TECHNIQUES

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AT

Central Electronics Engineering Research Institute, Pilani

A Practice School-I Station of

BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE, PILANI (JULY, 2021)

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BY

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Vedant Tripathi	2019B5A30582P	Physics + Electrical and Electronics Engineering

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Acknowledgement

In the present world of competition, there is always a race between people to succeed, in which those who have the will to come forward and accept challenges undoubtedly move ahead. The projects are like a bridge between theoretical and practical learning. I feel obliged in taking the opportunity to sincerely thank my Industry mentor, **Dr Dhiraj Sangwan** (Principal Scientist at CEERI, Pilani). A special thanks to my esteemed PS instructor, **Dr. Sandeep Joshi** (Assistant Professor at Department of Electrical and Electronic Engineering, Birla Institute of Technology and Science, Pilani Campus), who was a source of constant guidance and paramount support throughout the project. I would like to also thank the Members of Practice School Division for their generous and friendly attitude, and for conducting this program so that we may get a valuable industry experience. At last, I am thankful to all my teachers and friends for always helping and believing in me. My thanks and appreciations also go to my colleague in developing the project and people who have willingly helped me out with their abilities.

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Title of the Project: DETECTION OF FRUIT DISEASES VIA OBJECT DETECTION TECHNIQUES

ID No.	Name(s)	Discipline(s) of the student(s)
2019B5A30582P	Vedant Tripathi	Physics + Electrical and Electronics Engineering

Name(s) and designation(s) of the expert(s): Dr. Dhiraj Sangwan, Principal Research at CEERI Pilani.

Name(s) of the PS Faculty: Dr. Sandeep Joshi

Key Words: 3D Object Detection, Convoluted Neural Networks, Generative Adversarial Network.

Project Areas: Deep Learning, Computer Vision, Agriculture.

Abstract:

The purpose of this project is to classify and segment various diseases on apples.

Vedant Tripathi

Signature(s) of Student(s)

Date: 25/06/2021

Dr. Sandeep Joshi

Signature of PS Faculty

Date: 25/06/2021

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Introduction

INTRODUCTION TO THE ORGANISATION:

Central Electronics Engineering Research Institute (CEERI) is a national laboratory established first in Pilani, Rajasthan and then subsequently in Chennai and Jaipur for the advancement of Research and Development in the field of Electronics. It has made immense contributions to the growth of electronics and pioneered the steps of R&D in the country. It has established state-of-the-art infrastructure and encouraged innovations in various areas such as Plasma Tubes, MEMS and Microsensors, Microwave Tubes, VLSI Design, Nano Structures, Power Electronics, Embedded Systems and many more. It is one of the premier research institutes coming under **Council of Scientific & Industrial Research** (CSIR).

The mentor of my project is Dr. Dhiraj Sangwan, who is a Senior Scientist at CEERI Pilani. He has a lot of experience in the field of Computer Vision and Deep Learning and he has worked on several projects under this field. He is currently head of the department of Intelligent Systems at CEERI Pilani.

Introduction to the project

The scope of the project is to provide a suitable method for agriculturists to survey their fruits (apples in this case) and sort out diseased ones from healthy ones via object detection techniques. This report covers several salient features of my research, such as artificial data generation, use of object detection techniques on sample datasets, as well as overall learning from the project.

The project is divided into 2 facets, one where I am using Faster RCNN for disease detection purposes and the other where I am using Mask RCNN for segmentation purposes.

MAIN TEXT:

Apple Diseases

Apple Rot **Apple Blotch** **Apple Scab**

Mainly, three diseases affect apples, namely, apple rot, scab and blotch. Our task shall be to identify, classify and segment the diseased areas.

Literature Review

Identification of Tomato Disease Types and Detection of Infected Areas Based on Deep Convolutional Neural Networks and Object Detection Techniques[3]

In this paper, Tomato disease types are identified using Deep CNNs and Object detection. Two object detection architectures, i.e., Faster R-CNN and Mask R-CNN , are combined with four different deep convolutional neural networks. Deep convolutional neural networks are used to automatically extract original image features, and object detection architectures are used to identify, classify, and locate diseased sites in feature maps. The purpose of Faster R-CNN is to identify and locate diseased tomatoes, while that of Mask R-CNN is to segment specific lesion areas on diseased tomatoes.

Adapted Approach for Fruit Disease Identification using Images[4]

In the second paper, diseases on apples are analysed using image processing techniques like image segmentation using the K-means algorithm, followed by feature extraction using Global Color Histogram, Color Coherence Vector, Local Binary Pattern, and Completed Local Binary Pattern. Training and classification is done by SVMs to identify 3 types of diseases : Apple Blotch, Apple Rot, and Apple Scab . More than 93% classification accuracy was achieved.

Disease Detection in Plum Using Convolutional Neural Network under True Field Conditions[5]

In the third paper, Plum fruit diseases were analyzed namely brown-rot, nutrient deficiency, shot-hole (leaves),and shot-hole. Data augmentation was performed to increase the number of images and make the dataset more challenging so that robust models could be trained. For this purpose, they opted to study both plain CNNs as well as those architectures where multi-scale processing is performed in an integrated manner (inception networks)(trained a collection of different CNNs like AlexNet,

VGG16, Inception-v1, and Inception-v3.). It is observed that the inception network yielded superior performance, even in the presence of background clutter. The optimized model successfully classified healthy and diseased fruits and leaves with more than 92% accuracy on mobile devices.

Fruit Disease Recognition and Automatic Classification using MSVM with Multiple Features[2]

Traditional fault detection in the fruit surface is carried out manually by means of human inspection which is very time consuming and laborious. In this paper we have proposed a method for fruit disease identification using segmentation techniques and use a supervised learning technique for classifying images based on data analyzed from RGB colored images. Three types of common apple diseases are taken into considerations in this paper.

Summary: The experimental results demonstrate that the proposed approach is promising and effective by showing the classification accuracy which has achieved more than 94% using several features.

Hybrid approach for apple fruit diseases detection and classification using random forest classifier[7]

In this paper three normal infections of apple fruit are considered i.e. Apple scab, apple rot and apple blotch. The image processing based proposed methodology is made out of the accompanying some state of the art color and texture features are extracted from the test image, then color and texture features are fused together and random forest classifier is used for diseases classification and if the fruit is infected by any of the one disease then the infected part is segmented using k-means clustering technique. The accuracy of the diseases classification will improve by feature level fusion.

PROJECT WORK:

Dataset Collection and Further Reading:

1. Used a web crawler script created in python to get around 700 images each of 3 classes,

with healthy class having around 300 images. Further filtering has been done to get around 300 images for each class.

2. This dataset, along with 2 received datasets from various authors has been combined to give a final dataset.
3. GANs were then suggested by my mentor for style transfer . Several papers were read, and a final algorithm was decided[8][10]. CycleGAN was decided to be used for the style transfer from diseased images to healthy images. This would later be expanded to patch based style transfer.
4. Healthy images were gotten from the publicly available Fruit360 dataset[7]

CycleGAN methodology:

The CycleGAN is a technique that involves the automatic training of image-to-image translation models without paired examples. The models are trained in an unsupervised manner using a collection of images from the source and target domain that do not need to be related in any way.

The CycleGAN uses an additional extension to the architecture called cycle consistency. This is the idea that an image output by the first generator could be used as input to the second generator and the output of the second generator should match the original image. The reverse is also true: that an output from the second generator can be fed as input to the first generator and the result should match the input to the second generator.

The architecture is comprised of four models, two discriminator models, and two generator models.

The discriminator is a deep CNN that performs image classification. It takes a source image as input and predicts the likelihood of whether the target image is a real or fake image. Two discriminator models are used, one for Domain-A (horses) and one for Domain-B (zebras).

The discriminator design is based on the effective receptive field of the model, which defines the relationship between one output of the model to the number of pixels in the input image. This is called a PatchGAN model and is carefully designed so that each output prediction of the model maps to a 70×70 square or patch of the input image. The benefit of this approach is that the same model can be applied to input images of different sizes, e.g. larger or smaller than 256×256 pixels. The output of the model depends on the size of the input image but may be one value or a square activation map of values. Each value is a probability for the likelihood that a patch in the input image is real. These values can be averaged to give an overall likelihood or classification score if needed.

The idea is to use this technique to transfer the style from diseased apples to healthy apples to create images of diseased apples.

GENERATION OF DATASET:

Several articles were searched and experimented on until a working model of CycleGAN was found. Failed attempts include Tensorflow’s implementation of CycleGAN and other Github Repositories.

The working article uses Keras as a backend for image generation via CycleGAN, and produces images of the ongoing style transfer model every 5 iterations and saves the model every 20 iterations.

After updating the code[11] to our requirements, CycleGAN was used on 3 different classes on official CEERI systems, generating fresh images after having the disease transferred over to them via style transfer. Before passing the images, they were also cropped and segmented and given white backgrounds to ensure minimum feedback from the background.

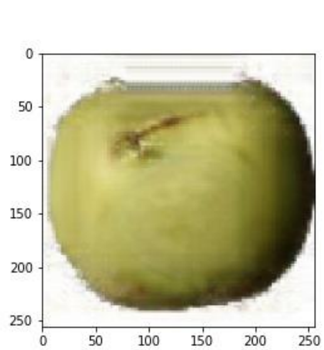
RESULTS: SAMPLE DATASET

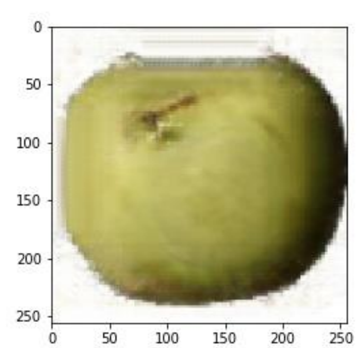
Diseased: Web-crawling

Healthy: Fruit360

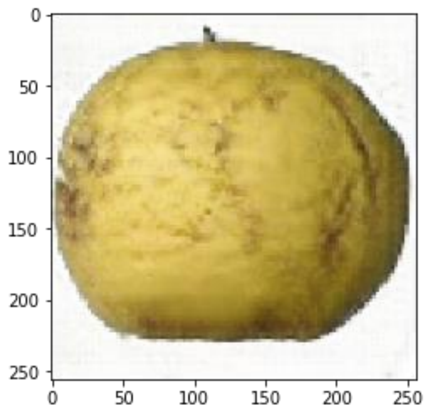
RESULTS: EXAMPLES OF GENERATED IMAGES

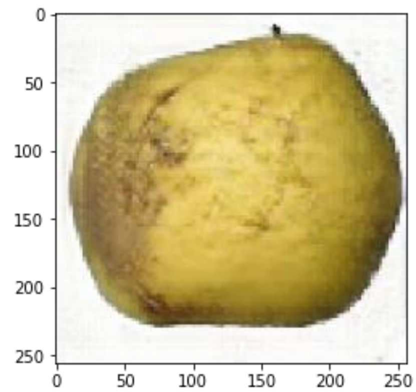
Scab:



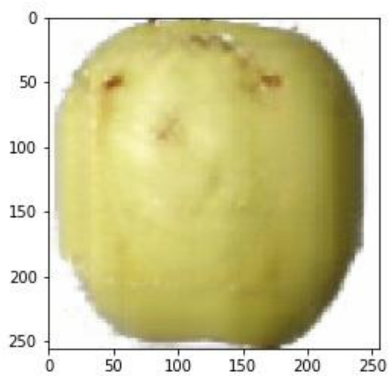


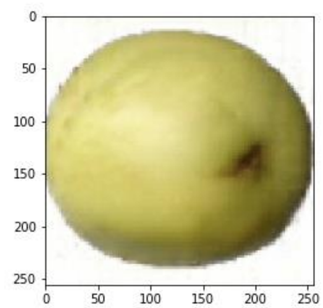
Blotch:





Rot:





As we can see in the images above, the healthy images are having their diseases transferred to the healthy apples below. Further removal of background of diseased images ensures minimal contribution of background to style transfer.

OBJECT DETECTION TECHNIQUES

Monk Object Detection was then used on a sample dataset to illustrate its usefulness, and to gain familiarity with it.

Monk is a low-code deep learning toolkit to leverage computer vision resources. It has plenty of use cases in computer vision-based problems such as image processing, image classification.

Monk Object Detection library contains object detection using transfer learning, image segmentation and localization, activity recognition, pose estimation, OCR and some other use cases.

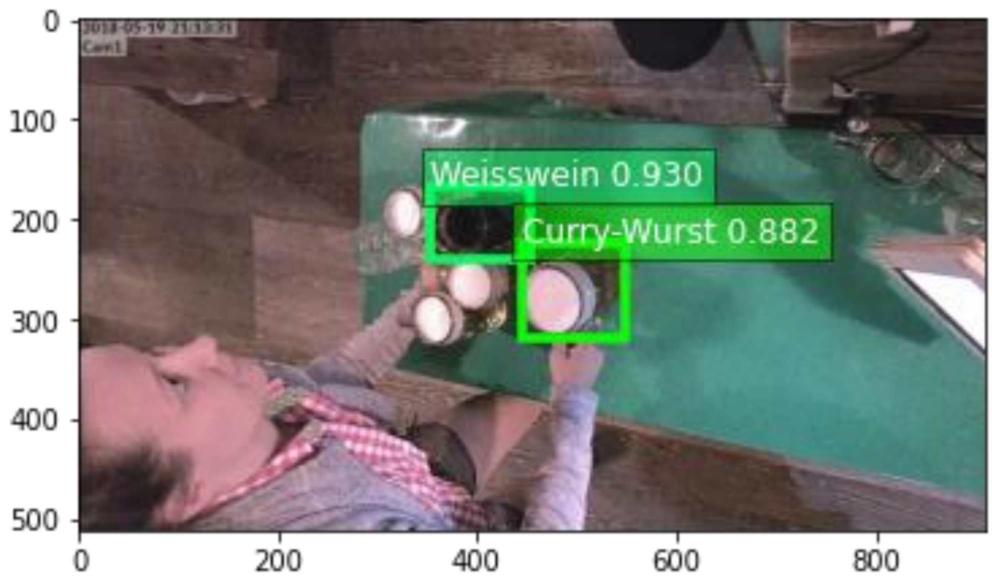
It is being used here due to its features like easy installation and usage, Support for custom annotation formats – COCO, YOLO, PASCAL VOC, etc and easy deployment.

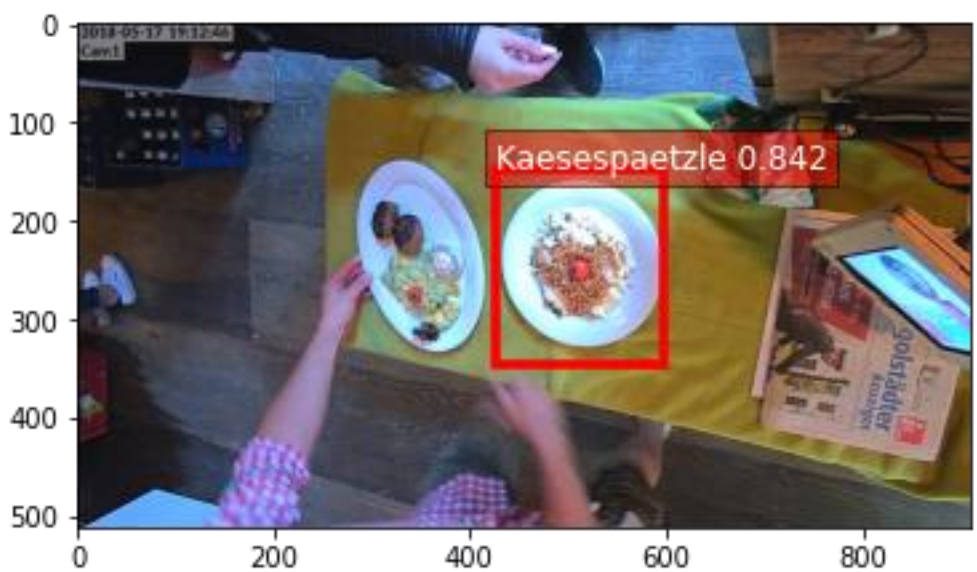
This repository will be used in the future for object detection on our generated dataset.

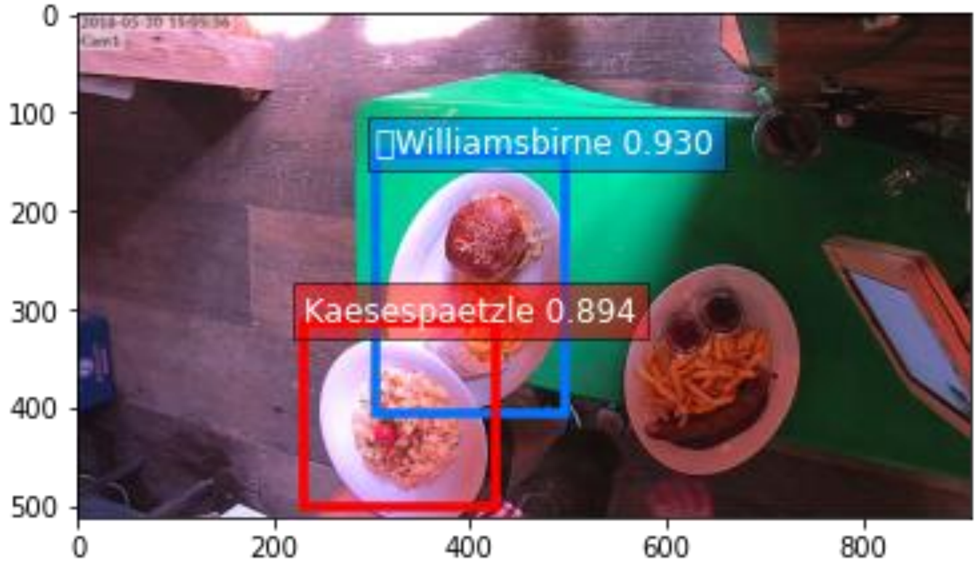
The sample dataset was of Oktoberfest, a festival in Germany, to recognise food items.

It consisted of 14 classes with annotations, around 500 images in training dataset, and 100 in test dataset. It ran for 20 epochs and gave satisfactory results.

RESULTS:







As we can see in the images above, the model is drawing well defined bounding boxes using SSD algorithm with a ResNet backbone.

Conclusio

Future Work

- Manual Annotation of generated dataset will be done using various tools found online.
- Masks will be generated around the annotations using Mask-RCNN.
- This dataset and Monk Object Detection Repository will be used to get accurate bounding boxes around the diseased parts of apples.
- The results will be compared with various other traditional Machine Learning techniques such as Classifiers, in the papers mentioned above.
- Various backbones will also be compared such as Inception Networks, VGG19 etc.

LEARNING OUTCOMES:

I learnt that/about:

- Various techniques can be used to overcome less amount of data such as artificial generation by GANs, dropout etc.
- About the Application and overlook of various Object detection techniques.
- Writing and reading code in frameworks such as Keras, TensorFlow
- Most importantly, how research gets carried out in a government laboratory, and whether I would want to pursure Deep Learning/Computer vision in the future.

Due to the excellent experience I had working under Dr. Dhiraj, I shall continue working under him till the completion of this project.

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