Underwater Waste Detection using GPU

B.E. Project Report-B

Submitted in partial fulfillment of the requirements

For the degree of

Bachelor of Engineering

(Electronics Engineering)

by

Sanjay Sharma (18EE2026)

Suraj Shinde (18EE1028)

Dikshant Sable (18EE1158)

Supervisor

Mr. Chaitanya Jage

D Y PATIL
DEEMED TO BE
UNIVERSITY
RAMRAO ADIK
INSTITUTE OF TECHNOLOGY
NAVI MUMBAI

Department of Electronics Engineering
Ramrao Adik Institute of Technology,
Sector 7, Nerul , Navi Mumbai
(Affiliated to University of Mumbai)
May 2022

Ramrao Adik Education Society's

Ramrao Adik Institute of Technology

(Affiliated to the University of Mumbai)

Dr. D. Y. Patil Vidyanagar,Sector 7, Nerul, Navi Mumbai 400 706.

Certificate

This is to certify that, the project report-B titled

"Underwater Waste Detection Using GPU "

is a bonafide work done by

Sanjay Sharma (18EE2026)
Suraj Shinde (18EE1028)
Dikshant Sable (18EE1158)

and is submitted in the partial fulfillment of the requirement for the degree of

Bachelor of Engineering

(Electronics Engineering)

to the

University of Mumbai.

Examiner 1	Examiner 2	Supervisor
Project Coordinator	Head of Department	Principal

Declaration

I declare that this written submission represents my ideas in my own words and where others' ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

_____

(Signature)

_____

(Name of student and Roll No.)

Date: _____

Abstract

Underwater waste is a type of man-made or human generated leftover which had been by mistake or intentionally discarded into oceanic waters, sea, freshwater body or a reservoir. This leads to marine pollution which is mostly caused due to wastes which are non-biodegradable such as polythene bags, plastic bottles, metal cans, fiber fishing-nets, etc. out of which a large percentage of marine debris is plastic. At present, marine or scuba divers are helping to overcome this problem of marine waste, where each and every type of waste is handpicked and collected, which is tedious and can sometimes be dangerous. In this project, we aim to use Image processing which is a method used for en- hancement of an image or to extract some useful information from the image. Underwater object detection has always faced the problem of imbalance in colour distribution and we will use image detection to specify the waste based on the data set we create. So that we can help to our very best to deal with critical issue as due to waste disposed many aquatic beings have lost their habitat.
Graphics Processing Unit (GPU) is a processor that is specially designed to handle intensive graphics rendering tasks. It is a single-chip processor primarily used to manage and boost the performance of video and graphics. Central Processing Unit (CPU) performs its operations in a sequential manner, so the first operation must run on the entire image before the second one can start whereas in GPU the operations are highly parallel in nature and hence the speed of processing is more, so we can obtain the results in comparatively less time.

Keywords:
Image processsing, Underwater image detection, Algorithm,CPU, GPU.

Contents

List of Figures

Abbreviations

GPU	Graphics Processing Unit
CPU	Central Processing Unit
OpenCV	Open Source Computer Vision Library
CUDA	Compute Unified Device Architecture
IEEE	Institute of Electrical andElectronic Engineers
ROV	Remotely Operated subwater Vehicle
BIOS	Basic Input Output System
ALU	Arithmetic Logic Unit
RTL	Register-transfer level
I/O	Input/Output
AI	Artificial intelligence
FPGA	Field Programmable Gate Array
API	Application Program Interface
OS	Operating System

Chapter 1

Introduction

1.1 Motivation

The earth's surface is 71 percent covered by water and the ocean holds about 96.05 percent of all earth's water. Water constantly move from one place to another due to water cycle , And due to this it becomes accessible to the human kind .

In today's time contamination of water bodies is one of the most critical issue that human kind has to deal with . Due to this many aquatic species are on the verge of extinction and there is continuous reduction in pure water. This is one of the problem for which we humans are responsible as we are the one contaminating the water bodies so it is our duty to properly dispose the waste that we have dumped.

So to deal with this issue we came up with the idea for this project as we wanted to contribute from our side in this noble cause without causing any damage to the aquatic beings.

Waste Management in the present time is known to everyone but unfortunately, it is neglected by numerous people that are utilized to portray exercises for waste segregation to take care of issues brought about by wrong garbage disposal [28]. Illegal dumping has been a constant issue in numerous urban communities on the planet. The smells and pollutants brought about by deserted household things and unloaded trash, and construction leftovers ruin the city as well as threatens the wellbeing of the citizens. To diminish illegal dumping, a couple of urban areas have planned network-based voluntary reporting frameworks and observation camera-based monitoring frameworks. But these methodologies require manual observing and recognition, which are vulnerable and expensive against false alarms. Garbage is a worldwide issue that affects everybody and every single living being. An examination shows that 74 percent of the plastics spilling into the ocean from the Philippines originate from the garbage [29]. In our, everyday lives we may neglect to separate accurately the garbage of our homes, and industrially the organizations in charge of this part need to spend a lot of money on labor and work. The procedure in which the garbage is segregated is splitting of garbage into divergent components. This is regularly done by handpicking physically which some the time causes hazardous and dreadful to human health if not appropriately done. To solve this issue, waste classification, and identification is acquainted which helps everyone particularly the government authorities and officials to effectively segregate wastes specifically the recyclable ones.

1.2 Problem Definition

Garbage is a huge problem in the modern world and nowhere seems to have had a more negative impact than the sea. Marine waste, also called aquatic litter, is a human generated or released left-over that has been purposefully otherwise involuntarily discarded over in a water body. There has been an growing use of plastics that has made the human impact a question, as there are lots of kinds of plastic that are non-biodegradable. Plastics and its types stance a significant danger to animals like aquatic creatures, reptiles, sea-birds, fishes and, as well as small vessels plus shores or beaches. Various types of human prepared materials can source aquatic waste; Plastic-bottles, ropes, floats, glass, 2 medicinal discards and plastic hand baggage, cigarettes, drink cans, fishing-lines, various types and materials of nets, as well as various trashes released through vessels such as cruise-ships, tankers as well as cargo-ships were commonly found. The beach is washed with wastes like fishing-nets mostly prepared from plastic. A very large percent of this marine waste is plastic. Plastics pile up as they are non-biodegradable like most of the other wastes that get collected together.
Every year, approximately eighty lakh metric-tons of marine garbage is discarded in the rivers, sea and oceans. [1] . Asia is one of the major places of origin of plastic garbage. At a dangerous rate, piles of plastic have killed marine life, accelerating the campaign to clean up the underwater world [2] . Technology is absent in this field of problem. A model capable of detecting waste might have a positive impact in reducing water pollution.

1.3 Organization of Report

The report starts with the objectives of this project along with its problem definition. Chapter 2 deals with the literature survey of current issues of water pollution. Chapter 3 contains the model design , containing software to be deployed for implementation of the model. Chapter 4 consists of the results and analysis conducted during the making of this project. Chapter 5 focuses on the future concept of this project along with the conclusion.

Chapter 2

Literature Survey

Due to the importance of underwater exploration in the development and utilization of deep-sea resources, underwater autonomous operation is more and more important to avoid the dangerous high-pressure deep-sea environment. For underwater autonomous operation, the intelligent computer vision is the most important technology. Object detection is the identification of an object in an image along with its localization and classification. Software systems that can perform these tasks are called object detec- tors. Object Detection has important applications. Various tasks which require human supervision and attention can be automated with a software system that can detect objects in images.

As far as India is concerned, there are many techniques used for collecting waste, but all of these are based on collecting floating waste on water bodies. The underwater waste collection done only by use of divers where waste is handpicked.

On 5th June, 2019 which is the World Environment Day, personnel from Indian Coast Guard alongside members from Dive India undertook an underwater cleanup initiative off the coastline of Kovalam Beach in Tamil Nadu's state capital on that day. Consequently, 500 kilograms of sea garbage was removed by the divers. A related initiative had been conducted by divers from the Forest Department in Tamil Nadu off the Gulf of Mannar. A team of 8 divers, including forest rangers, received distinct training beforehand they undertook the dive and managed to remove 6 kilograms marine waste. Many such dives are conducted to clean waste found underwater in seas, lakes and rivers .

Trash Collecting Boats for cleaning rivers: Cleantec Infra, is a firm among many other which work to reduce the wastes accumulated on surfaces of water in rivers and other waterways in India. There is a conveyor-belt fitted in these vehicles which is controlled by the operators working in the firm. As soon as the capacity of the vehicle to store waste gets to full capacity, the boat or vessel moves towards the land where it discards all the trash which is then taken on top of alternative conveyor-belt which is going in another way.

Another project, Aagastya-Buoyant, executes the task of cleaning the water body with mechanism which has an inflated tube-like material which has metre extended net connected beneath it. The waste is caught in the nets which forms a obstruction, and this waste is brought to the land in many kilograms. The Mumbai's drainages, rivers of Yamuna as well as Ganga and some lakes in Bangalore have been cleaned by this system .

Sea-bin Project: The Sea-bin Project is a type of project which as its name suggests, is a trash can like structure put into water floating which filtrates the waste from water. It is created for usage in seaports, harbours and dockyards as it is buoyant, it floats upward as well as downward alongwith the waves. When trash alongwith seawater is drawn in the Sea-bin, a bag is there which catches waste inside, a water pumping motor underwater is filtering clean water eventually. Creators of this project tell that this Sea-bin has the ability of cleaning out a percent of toxins and oil-like impurities that are lying on the surface which are released from ships and other vessels, which hence helps the nature. The main disadvantages of this product are that it is a stationary product and can only be used to clean at the banks of the river or ports but not far away from it [49] [50].

Ocean Cleanup:It has been also called as 'the biggest clean-up in the history', with Ocean-Cleanup installing huge eco-friendly poly-ethylene tubes which are buoyant and slide on the water surface, having screen-like nets connected to the tubes so as to collect plastic waste and many other types of waste floating, in the time period the current of flow of water overcomes securely down the screen alongwith marine life[51] [52] .

Wilhelm H. Highlighted the advances achieved in digital image processing and de- velopment over the last decade. The topics covered digitisation and coding, scanning, enhancement and repair, projection reconstruction, hardware and software, feature identification, pairing, segmentation, texture and form interpretation, object recognition and scene assessment.

K. P. Indulekha Kumar A. presented a method wherein at initial stages raw video data is collected by using underwater cameras and analysis is performed at each frame to detect presence of any moving objects . Since in underwater video retrieval has a high level of difficulty the background is always changing either due to a change the intensity and the movement of water currents, researcher proposed a model which implements an adaptive modelling method based on the pixel intensity of frames for background subtraction .

At the TechCrunch Disrupt Hackathon, "Auto Trash" has been made by a group which is an automatic garbage bin that sorts trash dependent on the features of recycling and composting. Their framework uses a raspberry pi camera and has a pivoting top. The group utilized the engine of Google's TensorFlow AI and constructed their layer on top of it for object detection.

Abubakar Yamin et al (2017) [53], worked on the color images for detection and classification of blood group. Authors applied RGB to HSV conversion, morphological operations along with other image processing techniques like histogram derivative, segmentation then binary image is used to measure the density of pixels in each object and based on observations, were able to classify the blood sample according to blood group.

Choubeila Maaoui et.al (2005)[54], attempted to design a robust color object detection and recognition system. Their work is divided into two stages, first stage concerned to the color segmentation and then image conversion into binary for the detection of objects and background. The Connected Component Labelling algorithm is used to distinguish among various objects present in an image. Second stage is concerned to the recognition

of extracted objects and utilizes the shape descriptor based on Zernike moments for this purpose.

The support vector machine classifies objects. M.J.C.S. Reis et al (2012) conducted research on automated color based grape bunch detection system for outdoor natural location. In the development phase, authors determined the possible and valid RGB values of pixels of Red grapes as well as white grapes independently, during application phase, the designed system searched for the pixel values falling within the bounds of those central values respectively.

Zalhan, Mohd Zin et al (2016), could successfully design a simple vision-based egg grade classifier. Authors could accurately measure diameters of eggs of various sizes with the help of a Coordinate Measuring Machine (CMM), which is widely used in industry to measure the physical geometry of an object. To validate the same, authors used image processing technique in which the RGB image of an egg is converted into grayscale image and then by using thresholding technique, it is converted to binary image.

A comparison study was performed by Mindy Yang et al. [6] to classify garbage between SVMs with scale-invariant feature transform (SIFT) [7] and an eleven-layer CNN design like AlexNet [8]. The result shows that the SVM beats CNN. The accuracy level was 63

Due to their large amount of parallel processors GPU architectures are becoming exceedingly essential in the multi-core era. It's a major challenge for computer programmers to program thousands of massively parallel threads, but it's even more challenging to grasp the performance disruptions of those parallel programs on GPU implementations to boost application performance. To provide guidance into the performance bottlenecks of parallel applications on GPU architectures, Sunpyo Hong and Hyesoon Kim proposed a basic analytical model that calculates massively parallel program execution period. When considering the number of operating threads and memory capacity, the major component of their model was estimating the number of concurrent memory requests (known as memory warp parallelism). The model calculates the cost of the memory requests depending on the degree of memory warp parallelism, thereby determining the average execution time of a code.

Chapter 3

Background

3.1 Neural Networks

The core component of machine learning (including deep learning) is the artificial neuron. With the help of neurons, the learning calculations are performed. In an Artificial Intelligence model, a huge number of neurons are working together to execute the complex numerical/mathematical calculations. The formation of the network which is being formed by these neurons is known as the artificial neural network. The idea of artificial neurons has come from the neurons which are biologically present in the human sensory or nervous system. Like the neural network in the body of the human, an artificial neural network is partitioned into layers. The dendrites are only the information terminals of the neurons in an artificial neuron. Through synapses and dendrites of another neuron, the input is being processed by the axon and its output is passed to different neurons. Input signals which are traveling by the line of the input get increased by the weight of the line in the computational model. The weighted input signal is being processed by the mathematical function. This particular function is termed as the activation function f.

The signal which is already being processed is again passed to the following layer neurons for additional processing. In this model, a learning element is known to be the weight of the association between neurons. The value of this model is changed during the duration of the training with the end goal that the error is merged to zero. In the body of the human, the signals which are being carried by the dendrites get added in the cell body, and if the value of the sum goes beyond the threshold value, then at that point signals are started up by the axon. In a mathematical or numerical model, a similar methodology is utilized. The threshold value is determined by the activation function f. Sigmoid Function is known to be the standard decision of the activation function. The sigmoid function takes the summation value as input and converts it to a reach somewhere in the range of 0 and 1 [31].

3.2 Convolutional Neural Networks (CNN)

The main function of convolutional neural networks (CNN) is to essentially group or classify the pictures, cluster the images by similarity, and perform object detection with the assistance of artificial neural networks. The convolutional neural network takes the information of the image and processes the picture as a tensor, which is the matrices of

numbers with extra dimensions and carries out a sort of search [32].

The 3D objects are a portion of the instances that recognize the images as volumes [33][34]. It is being uploaded in numerous applications, including recognition of the face and object identification. It's one of the best non-trivial assignments [35][36]. In constituent to neural networks, the convolutional layer, subsampling layers, and fully connected layer are the three distinctive layer types that are viewed as a part of CNN [37]. CNN is mainly used for image recognition as this method has got more advantages in comparison with other strategies.

3.3 Image Processing

Image processing is one of the main parts of a structure of signal processing, where the input is in the form of an image; for instance, a photograph or video clip [38]. The performance of an image processing can likewise be an image or plenty of characteristics or parameters related to the image [39][40]. The main objective of image preprocessing is to upgrade the image information where superfluous images were taken out, and the significant images are added for additional processing [41][40]. Preprocessing approaches mean to improve the details of the image with an end goal to eliminate undesirable distortions and upgrade a few qualities of the input picture [42]. Image processing can eliminate needless features and can change over the RGB picture to grayscale and pairs it [43][44].

The picture of the image is obtained by an advanced digital device, for example, a camera, and then it changes over it into grayscale. The grayscale transformation comprises of figuring the average estimation of the three components of the two colors (0 and 255, separately) [45]. A fixed limit, 127 for this situation, is utilized to determine the color intensity and is changed over to 0 and which, to 255. Image processing, either as an improvement for the human viewer or autonomous analysis software offers the advantages of flexibility, speed, and costs [46].

3.4 Object Detection

Object Detection is a part of the computer vision technique where a software framework can detect, trace, and locate the object from any given video or image. One of the special traits of object detection is that it recognizes the object's class (for instance, person, table, chair, and so forth) and the coordinates of the location of the object in the given picture. By drawing a bounding box around the object, it states that the region is being pointed out [47]. The bounding box might or might not precisely find the location of the object.

The capability of locating the object inside a picture describes the accuracy of the performance of the algorithm which is being used for detection. Face identification is one of the instances of object detection.

For the most part, the object detection task is completed in three stages:

• The little rectangular portions are being produced upon the input image.

• Feature extraction is completed for each portion of the rectangular region to predict whether the rectangular shape contains a valid object.

• Finally, the rectangular boxes which are overlapped get combined into a single bounding box showing the detection result of the object.

3.5 TensorFlow Object Detection API

TensorFlow is referred to as an open-source library developed by Google which is utilized mainly for numerical calculations and large scale machine learning programs with an end goal to process received data along with model training, serving predictions, and refining future outcomes.

The algorithms of Machine Learning models and Deep Learning models are being bundled together by TensorFlow. In the front-end, it utilizes Python and in the back end, it runs productively in advanced C++.

TensorFlow permits the developers to make a chart/graph of calculations which is getting performed. Every hub in the graph defines a mathematical activity and every connection represents the data information. Subsequently, rather than managing with low-subtleties like sorting out appropriate approaches to hitch the output of one function to the input of others, the developers can fully be able to concentrate on the logic of the application.

At present, TensorFlow is the most famous software library. There are many applications from the real world of deep learning which makes TensorFlow very famous. As it is an open-source library for both Machine learning (including deep learning), that's why it can play a very vital role in the field of text-based applications, voice search, image detection, and so on. TensorFlow is also being used in Facebook's image recognition system for image recognition known as DeepFace. It is also being utilized by Apple's Siri for voice recognition. Each Google application that you use has utilized TensorFlow to improve your experience.

TensorFlow Object Detection API is an open-source structure, based on TensorFlow which can easily construct, train, and deploy the models of object detection. As of now, there are many preprepared and pre-trained models in their structure which are termed as Model Zoo [48]. The Model Zoo consists of multiple pre-trained models that are being trained on different datasets commonly known as Open Images Dataset, KITTI dataset, and Common Objects in Context (COCO) dataset.

There are different models (such as, ssd-mobilenet, ssd-resnet, ssd-inception [47], faster R-CNN inception, Faster R-CNN resnet, etc) which are available in the Model Zoo. But the main difference among these various models is they have distinctive architecture and hence give various accuracy rates along with the different speed of execution and accuracy in setting up the bounding boxes.

Here the mean average precision (mAP) is the result of the product of accuracy and recall on recognizing bounding boxes. It's a decent joined measure that shows how the

network sensitivity develops the objects of interest and how correctly it evades the false alarms. The accuracy of the model increases as the mAP score gets higher, nevertheless, that comes at the cost of implementation speed which we need to keep away from here.

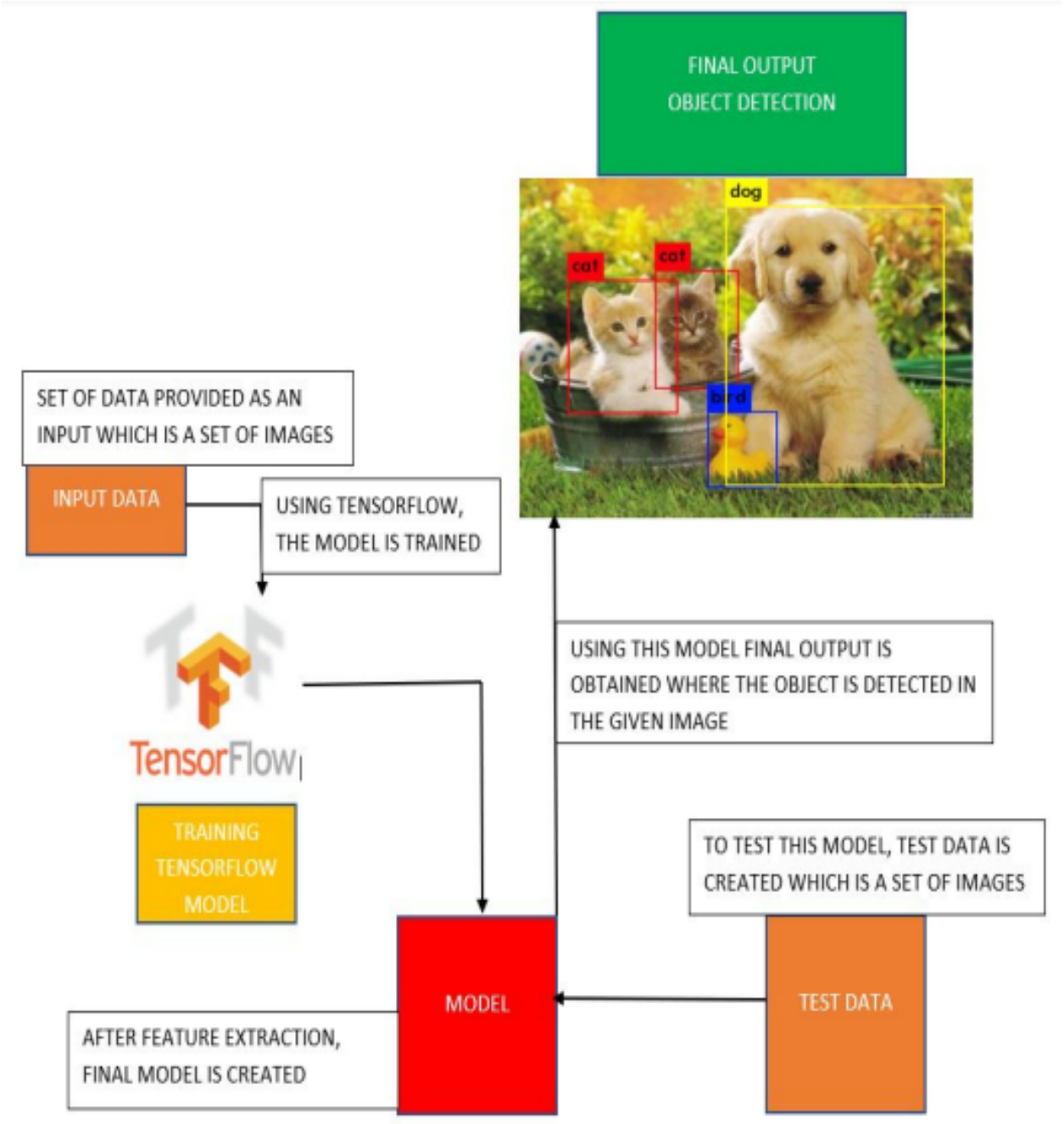

Figure 3.1: Mechanism of Object Detection in TensorFlow

Chapter 4

System Design

4.1 Hardware Design

Image processing is far more time-consuming to do image filtering on Central Processing Unit (CPU), because image filtering has a major computing prerequisite. In comparison to CPU, Graphics Processing Unit (GPU) is a good way to speed up the transfer of images. Through contrast and evaluation, it has come to the conclusion that GPU is ideal for the operation of high performance computation of large-scale data-parallel load.

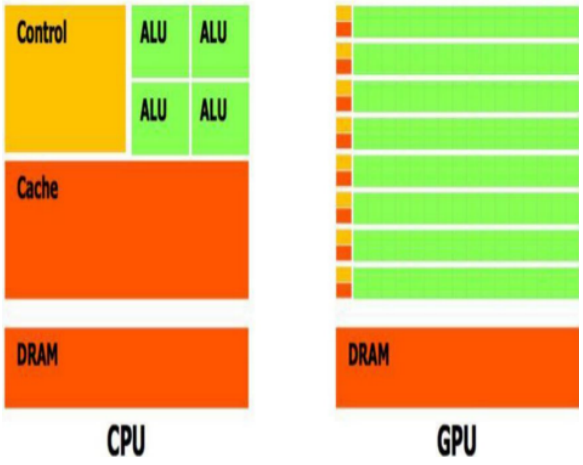

Figure 4.1: CPU and GPU Architecture

As shown in figure(3.1), The fundamental distinction when evaluating the GPU with the CPU is that the CPU has very less processing units with some cache and control units, but there are several more processing units in GPU with their own independent cache and control units specified with designated and different works for each unit. GPUs are often of hundreds of cores that operate in addition to the data processing, but usually CPUs are performed on few cores with little or no parallelism.

4.1.1 Central Processing Unit

The Central Processing Unit (CPU) is the component that carries out almost all of the work within a computer. The CPU depends heavily on a circuitry which is a collection of

microchips placed on the motherboard to monitor commands and data flows to and from other sections of the computer.

The CPU has two components:

Control Unit (CU): It extracts and decrypts the memory commands, then executes them

Arithmetic Logic Unit (ALU): It handles arithmetic and logical operations.

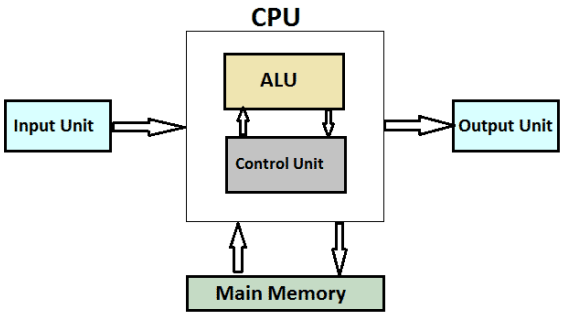

Figure 4.2: CPU Architecture

The CPU depends on device clock, power, secondary storage, and data and address buses to operate efficiently. A computer's heart and brain is the CPU. It collects raw data, implements commands, and processes data. It interacts with input/output (I/O) modules that transmit and receive data to and from the CPU. The CPU does have an internal bus, named the backside bus, for communicating with the local cache memory. The front-side bus is considered the principal bus for data flow to and from the CPU, memory, motherboard, and Accelerated Graphics Port (AGP) port. The CPU is made of internal memory modules, called registers. These registers include data, commands, counters and addresses used in the processing of information at the ALU.

Some computers utilize multiple processors. These comprise of distinct physical CPUs on the same board placed side by side or on different boards altogether. Each CPU has a distinct monitor, separated cache, and distinct front-side bus pathways to the device. Multiple processors are suitable for heavy simultaneous activities involving multitasking. Also popular are multicore CPUs that contain multiple CPUs on a piece of silicon.

CPU is needed to operate most engineering software and office applications. There are also a plethora of functions that can overpower the central processor of a device. This is when it is necessary to use GPU for computation.

The CPU we will bw using in this project is Intel i5-8250U with integrated graphics card i.e. Intel UHD Graphics 620. The detailed specifications of the CPU is provided in the table below:

4.1.2 Graphics Processing Unit

A Graphics Processing Unit (GPU) is a computer chip that executes fast mathematical computations, predominantly for image rendering purposes. The Central Processing Unit (CPU) conducted such operations in the initial days of computing. However, as more

graphics-intensive applications like AutoCAD were created, their requirements put a lot of stress on the CPU and deteriorated it's performance. GPUs emerged as a means to detach certain activities from CPUs and free up computing power.

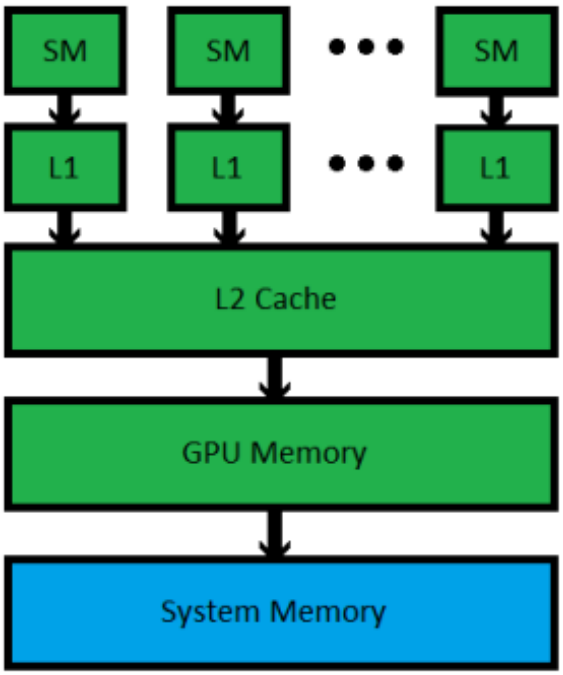

Figure 4.3: Architecture of GPU

GPUs are being developed nowadays to collaborate CPU function and develop deep neural networks for AI purposes. A GPU can be located on the same circuit known as integrated GPU or as a discrete graphics or on a server. Some of the major competitors in the GPU sector are NVIDIA, AMD, Intel and ARM.

A graphics card, like a motherboard is a printed circuit board that hosts both a processor and RAM. It also has an input/output machine (BIOS) chip, which retains the 9 configurations of the card and executes memory, input, and output diagnostics at initialization. A GPU is explicitly designed to run the advanced mathematical and graphical calculations needed for rendering the graphical illustrations. Several of the high spec'd GPUs have higher number of transistors than the typical CPU. A GPU generates a lot of heat, so it's normally put under a heat sink or a fan. As the GPU generates images, the details and finished photos ought to be stored elsewhere. It utilizes the card's RAM for this motive, and stores data about each pixel, its color and its location on the screen. Portion of the RAM can also function as a memory buffer, meaning it stores finished images before the time has come to exhibit them. Video RAM usually runs at very high speeds and is dual ported, which ensures that the device can read and write to it simultaneously. The RAM explicitly interfaces to the Digital-to-Analog Converter, called DAC.This device, also labeled the RAMDAC, converts the image into an analog signal which can be used by the display. Some chips have multiple RAMDACs that can enhance performance and handle multiple display. The Streaming Multiprocessor(SMs) is the component that operates CUDA modules in the GPU. Every SM is allocated an unique L1 cache, and the GPU has a general L2 cache.

The Graphics Processing Unit (GPU) is widely used for real time graphics rendering in applications like high definition gaming, computer aided design software, etc. GPU is becoming popular as cheap parallel supercomputer whose processing power can be utilized. Even though original purpose of GPU is graphics rendering, in recent years the GPU is increasingly being used for scientific computations. GPUs are also used for general purpose computations like scientific computations, encryption/decryption etc. This type of GPUs are called as General purpose GPUs(GPGPUs). Nowadays, GPU is used in video processing, image processing and in many more general-purpose works.

4.1.3 Why prefer GPU over CPU?

Algorithms for image analysis typically use a great deal of computational power. The constantly increasing efficiency of CPUs found in powerful PCs is adequate in many cases to manage these tasks within the designated time frame. Nevertheless, leading manufacturers of image processing equipment and applications are continually on the lookout for quicker ways to increase performance beyond the feasible speed on current CPUs. Standard approaches for obtaining greater speed in the rendering of images include the allocation of computational tasks among several multi-core processors or the use of customized Field Programmable Gate Arrays (FPGA). Both of these systems has its own benefits and drawbacks but the GPU is used to achieve the quickest process.

A GPU is a customized category of microprocessor designed specifically for rapid processing of images. GPUs emerged as a solution to graphically demanding applications that posed a strain on the CPU and deteriorated the device efficiency. They have been a way to transfer certain tasks from CPUs but, aside from rendering, modern graphics processors are effective enough to do rapid mathematical computations for many other applications. The CPUs and GPUs perform functions in diverse ways. In regards to interconnections, they are also compared to brain and brawn. A CPU (the brain) can operate on a number of specific tasks, while it is easier for a GPU (the brawn) to concentrate all the computational resources on a particular task. That's because a CPU is made up of a few (up to 24) cores designed for linear sequential operation. It is structured to optimize the efficiency of a particular task within a job; however, there is a wide variety of activities involved. On the other hand, a GPU utilizes thousands of smaller and much more powerful cores with a highly parallel architecture designed to simultaneously perform several functions.

CPUs execute sequential operations, such that the first operation will operate on the whole image before the next can begin. For this case, consider that every step in the algorithm requires 6 ms to execute on the CPU; thus, the overall run-time is 24 ms. Now consider the same algorithm running on the GPU. Since GPUs are heavily parallel in natural, every one of the four operations in this algorithm can operate simultaneously at distinct pixels of the image. It means that the amount of time to retrieve the first rendered pixel is just 2 ms and the amount of time to render the whole image is 4 ms which factors in a cumulative processing time of 6 ms. This is considerably faster than the CPU execution.

Modern GPUs offer superior processing power, memory capacity and performance over their equivalent CPU. In operations involving many parallel systems, like machine learning and big data processing, the GPUs are 50 to 100 times faster. Graphics processors in certain technological respects surpass other image optimization systems, even as opposed to the best usable FPGAs. For instance, they are clocked at frequencies 10 to 20

times higher than traditional FPGAs, meaning that data processing speeds of up to 500 times higher than regular FPGAs can be accomplished in tandem with larger memory offerings.Image processing is far more time-consuming to do for image filtering on CPU, because image filtering has a major computational prerequisite. In comparison to CPU, the GPU is a great way to speed up the rendering of images. Through comparison and evaluation, it is obvious that GPU is ideal for the operation of heavy-density computation on a large scale data-parallel load.

.....

4.2 Software Design

4.2.1 Tenserflow

Tensor-Flow is throughout from one device to another device open-source platform designed for machine-learning. It takes a complete, malleable environment of tools, libraries and community resources that allows researching personnel drive the advanced in ML as well as designers effortlessly build and deploy ML power-driven applications.

Figure 4.4: Tenserflow

Tensor-Flow gives numerous stages of perception as a result we be able to choose the right one for our requirements. Build then train models by means of the complex Keras-API, that sorts us in getting underway using TensorFlow and machine-learning easy-to-use. It stands cast-off for additional elasticity, ready implementation allowing for instant iteration plus instinctive de-bugging. On behalf of bulky ML training jobs, usage of the Distribution-Strategy-API intended for distributed-training on diverse hardware-configurations minus altering the model explanation. At present, are similarly using TensorFlow Lite, aimed at on-device interpretation. It picks a fresh model otherwise retrains a remaining one. TensorFlow model converted into a compacted even buffer by means of the Tensor-FlowLite Converter, at that point it takes the compacted even buffer .tflite file then upload it onto a embedded-device.[19].

4.2.2 Python

Python is a general-purpose programming language, intended to be easy to read and write. It is necessary to make the argument that it is not a complex language. The developers put less emphasis on traditional syntax and made it simpler for non-programmers or developers to work with. Python has a range of possible benefits for image processing and visualization of the images. The language is open source, and its use does not require any price or authorization. It works with Microsoft Windows, Mac OS, and Linux and is ported to the virtual machines of Java and .NET. An English-like syntax, introspection, object orientation, intuitive scripting and a high level of self-documentation are some of the technological benefits of Python. dMost notably for image processing applications, a wide range of modules are present both in the Python core and as add-ons; handy in different areas of image processing to execute different kinds of image manipulation and data presentation tasks. These include NumPy for the manipulation of the array needed in image processing, and matplotlib for displaying graphs and data plots.

Figure 4.5: Python

There are a number of libraries available for python for image processing (more suitably Computer Vision) and AI (explicitly Machine Learning and Deep learning). aMany are also available for other programming languages (such as C++ or Java) though not all. Also they are much easier to use in python because of the simplicity of python language. OpenCV, Dlib, etc., are some of the good general computer vision libraries. More specific libraries like for face detection and recognition for example OpenFace are only available for python and torch which is based upon deep neural networks. Already popular libraries include Tensorflow, Keras, Caffe, Theano etc. for Machine Learning and Deep Learning. All are available for python but not all can be used with C++, Java and other programming languages.

Since as stated above Python is simple and has fairly simple and easy syntax and also supports a large number of packages and modules it is the programming language of choice for our project. The Python version used in our codes is Python 3.5. We have made use of some popular Python modules such as NumPy, math, sys, time, etc.

4.2.3 OpenCV

OpenCV is an open source computer vision library. The library is developed in C and C++, operating within Linux, Windows, and provides Python, Ruby, Matlab, and other languages modules. OpenCV library includes a variety of specialized mathematical tools, image processing features, and computer vision functionalities covering multiple vision domains.
It is free for use under the open source BSD license. The library is crossplatform. It focuses mainly on real-time image processing. Following are some of the standout features of OpenCV:

1. Read and write images

2. Capture and save videos

3. Process images (filter, tansform)

4. Perform feature detection

5. Detect specific objects such as faces, eyes, cars, in the videos or images.

6. Analyze the video, i.e., estimate the motion in it, subtract the background, and track objects in the video.

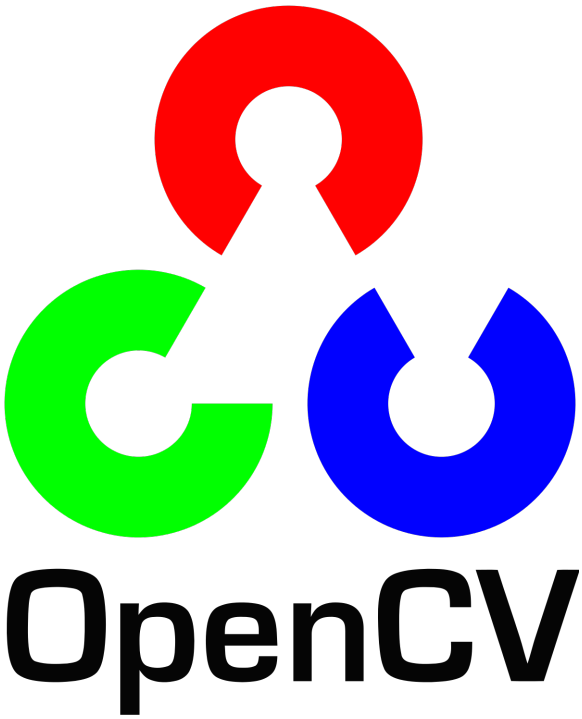

Figure 4.6: OpenCV

Even though C and C++ are faster when compared to Python, Python is used in complex computations because of its simplicity. Another important attribute of Python is that it can be extended to C and C++. This functionality allows us to implement complex codes

in C or C++ and to build a Python wrapper which can then be used as Python modules. This holds two benefits for us:

1. Our program doesn't compromise on speed (because in actuality the C++ code is what is running in the background)

2. Programming in Python comparatively easy.

OpenCV offers the functionality to retrieve image from a pre-recorded video source, camera input feed, or directory path directly. An image can be identified on the bases of the spectrum of hue, contrast, and color value (HSV) by using open source computer vision library. The basic functions in the library are used for image handling and analysis. Basic library functions are used to load an image, build windows to retain image at run time, store images, and distinguish images based on color values.

NumPy support in OpenCV makes the mathematical calculations simpler. NumPy library is specifically designed for mathematical operations and is also highly optimised for the same. OpenCV-Python is a capable tool for speedy handling of computer vision issues. In our program we are making use of OpenCV version 4.1.2.

4.2.4 Anaconda

What is Anaconda? Anaconda is a free software that provides you with a toolkit that is tailored for research and science. Installing Anaconda gives you access to different environments that allow you to code in either Python or R. These environments, also known as integrated development environments (IDEs), are platforms or apps that greatly ease the development of code. They serve a similar role to text processors like Microsoft Word, Google Doc and Pages for writing text, but in truth they are so much more. IDEs contain many useful features to write, edit and debug code, visualize and inspect data, store variables, present results, and collaborate on projects. While the display and the quirks of an IDE differ, the programming language does not. Thus, changing IDEs in Anaconda does not result in drastically changing your Python code. The learning curve is mostly related to understanding Python's syntax. Once you learn how to code in one IDE, you will be able to transfer this skill to another with ease. One IDE is not necessarily better than another, each comes with its own pros and cons and which one you choose comes down to personal preference.

Figure 4.7: Anaconda

Downloading the toolkit also provides you with an enormous selection of prebuilt functions that the Python community has coded in the past. These functions are regrouped in what are called libraries and can be downloaded easily through Anaconda. There are many different ways to install and use Python on your computer, but Anaconda is a simple, well-supported, graphical user interface (GUI) that includes the most important libraries and IDEs in its installation. Anaconda also simplifies the process of keeping all of these libraries up to date. Thus, rather than installing Python separately with different IDEs, libraries and functionalities, Anaconda can do it for you in one installation.

As mentioned on their website, Anaconda is "the easiest way to perform Python/R data science and machine learning on a single machine. Developed for solo practitioners, it is the toolkit that equips you to work with thousands of open-source packages and libraries." It is a great platform for beginners, as well as advanced programmers, to tackle different projects and is the best approach to getting started with Python.

.....

Chapter 5

Design Implementation

5.1 Computer Vision

Computer Vision, frequently referred as a CV, is described as an area of research that focuses on improving techniques that aid computers "see" and recognize digital image information, such as photographs and videos. The challenge of computer vision is basic, and humans, including very young kids, solve it relatively easily. Nonetheless, it remains essentially an unresolved issue focused on both the restricted knowledge of biological vision and the nature of interpretation of vision in a chaotic and almost endlessly changing physical environment.

Computer Vision is one of the most effective and convincing forms of AI that everyone has most definitely seen in a variety of ways without actually recognizing it. Computer vision is the computer science area which emphasizes on reproducing aspects of the complexities of the human vision system and allowing computers to recognize and interpret objects in images and videos in the same manner as humankind does. It is a multidisciplinary domain which may loosely be considered a sub-field of artificial intelligence and machine learning, and may include the use of advanced approaches to the use of general learning algorithms. This may look chaotic as an interdisciplinary area of research, with methods adapted and replicated from a number of diverse areas in engineering and computer science.

Computer vision's goal is to grasp the information contained in a digital image. This usually involves the creation of procedures which aim to replicate human vision functionality. Comprehending the content of digital images that include retrieving a definition from the image, which may be an object, a description of text, a three-dimensional model, etc. Computer vision has only operated in a minor capacity until recently. Due to developments in artificial intelligence and advancements in deep learning and neural networks, the technology has been capable of taking major strides in recent times and in certain activities related to identification and marking of items has been able to overtake even human capabilities.

Computer Vision largely intersects with the corresponding areas:

1. Image Processing: It focuses primarily on the manipulation of images.

2. Pattern Recognition: It demonstrates different pattern-classification methods.

3. Photogrammetry: It's all about getting precise measurements from the images.

The Image Processing module of Computer Vision includes numerous image processing operations such as image filtering, geometrical image transformations, color space conversion, histograms, etc. In the Java library of OpenCV, this module is included as a package with the name org.opencv.imgproc.

5.2 Python libraries, modules and GPU specific commands used

A library is also a series of behavioral implementations, written in terms of a script, which has a well-designed interface that invokes the required actions. For example, people who want to write a higher level program can use a library to make system calls, rather than repeatedly implementing those system calls. In addition, several separate systems allow for reuse of the actions as and when required with little to no effort.

Library program is structured in such a manner that many programs that have no relation to each other can use it, whereas program that is part of a program is arranged such that it can only be used within the one program. This differentiation will acquire a hierarchical notion as a system, such as a multi-million-line plan, grows big. In some cases, there are inbuilt libraries that can be used by independent sub-portions of the large program. For this algorithms we have used python libraries such as numpy, cv2, etc. The standard library for Python is very extensive and offers a wide range of facilities. The library consist of built-in modules which are written in C language. It provides access to system functionality such as I/O file that would otherwise be inaccessible to Python programmers, as well as modules written in Python that provide standardized solutions to many of the issues that occur in day-to-day programme. Some of these modules are explicitly designed by abstracting platform-specifics into platform-neutral APIs to encourage and enhance the portability of Python programme. The Windows platform Python installers typically include the entire standard library, and often include many additional components as well. For Unix-like operating systems, Python is normally provided as a collection of packages, so some or all of the optional components may need to be obtained using the packaging tools provided with the operating system.

module allows us to organize Python code logically. Grouping associated code into a module facilitates the understanding and use of the code. A module is a Python object with attributes arbitrarily named that can bind and reference. If the python interpreter is closed and opened again the interpreter will not display previous executions and programs. So to write a lengthy code we make use of a text editor. To handle lengthy code, it is divided into multiple tiny pieces for easy maintenance. To use the definition of a function which is written in some another piece of code, there is no need of copying and pasting the same definition again and again whenever required. Instead, Python has a way to put definitions in a file and use them in a script or in an interactive instance of the interpreter. Such a file is called a module. Definitions from a module can be imported into other modules or into the main module as per our need. It may include executablestatements, as well as definitions of functions. The aim of those statements is to initialize the

module. They are only executed the first time the name of the module is found in an import declaration. Modules are imported from other modules using the 'import' command. For example, When a module named spam is imported, the interpreter first searches for a built-in module with that specified name. If not found, it then searches for a file named spam.py in a list of available directories.

5.2.1 Numpy

NumPy is the fundamental package for scientific computing with Python. Some popular and handy features of numpy among other things are:

1.a powerful N-dimensional array object

2.sophisticated (broadcasting) functions

3.tools for integrating C/C++ and Fortran code

4.useful linear algebra, Fourier transform, and random number capabilities

NumPy can also be used as an effective multi-dimensional container of generic data, in addition to its obvious scientific uses. Arbitrary data-types can also be defined. This allows NumPy to integrate with a wide variety of databases seamlessly and quickly. NumPy is basically a package of Python representing 'Numerical Python'. It is the core scientific computing library that contains a powerful n-dimensional array object, provides tools to integrate C, C++, etc.

Operations using NumPy:

A developer can use NumPy to execute the following operations:

1.Mathematical and logical operations on arrays.

2.Fourier transforms and routines for shape manipulation.

3.Operations related to linear algebra. NumPy has in-built functions for linear algebra and random number generation.

5.2.2 OpenCV

Computer vision is an increasingly growing field, partly due to cheaper as well as more powerful sensors, partly due to inexpensive computing power, and partly because of the vision algorithms are beginning to mature.Through empowering thousands of people to do more meaningful research in vision, OpenCV itself has played a major part in the growth of computer vision. OpenCV is an open source computer vision library. The library is written in C and C++ programming languages and runs under Linux, Windows

and Mac OS X. There is active development on interfaces for Python, Ruby, MATLAB, and other languages[26]. Also, interfaces based on CUDA and OpenCL are also under active development for high-speed GPU operations[29]. OpenCV has been developed for computational efficiency and focuses strongly on real-time applications. OpenCV is written in optimized C language, and can use multicore processors.

We have used Opencv module named cv2 using import cv2.The fuction we have used in cv2 moudles are imread(), imwrite(), normalize(), imshow(), waitKey(), destroyAllWindows(), merge(). Let's see the detalied syntax of these functions.

cv2.imread() is a method which loads an image from the location specified by the user. If the image cannot be read (because of missing file, improper permissions, unsupported or invalid format) then this method returns an empty matrix[27]. It's syntax is:

cv2.imread(path, flag)

Parameters:

1. window name: Represents the name of the window in which the image is going to be displayed.

2. image: Image which is to be displayed.

3. Return value: Returns nothing.

5.2.3 Matplotlib

Plotting functions for python programming languages are supported by Matplotlib. In this project, it will be used to draw the bounding boxes to display the image name and score range. The bounding box is utilized to show the object detection name with a score range of an image. The Matplotlib comes up with an object-oriented application programming interface. The Numpy is one of the mathematical numerical expansion of Matplotlib [4].

5.2.4 Data Collection

The training data was acquired mainly using the images available over the internet and few of them were taken from a normal mobile camera,the training data was obtainable which was mainly used in the classification of garbage for detection. There were around 1000 pictures with 250 images of bottle , 250 images of plastic bag, 250 images of cup, 250 images of straw,[6].But the annotation of these images were specifically needed for training the model to get the annotations that are for the labeling of the images, a tool has been used which is known as the LabelIMG tool. These divisions were made depending on the pictures contained in the separate respective folder. But the annotations of these

images were specifically needed for training the data in a Faster R-CNN model. To get the annotations that are for the labeling of the images, a tool has been used which is known as the LabelIMG tool.

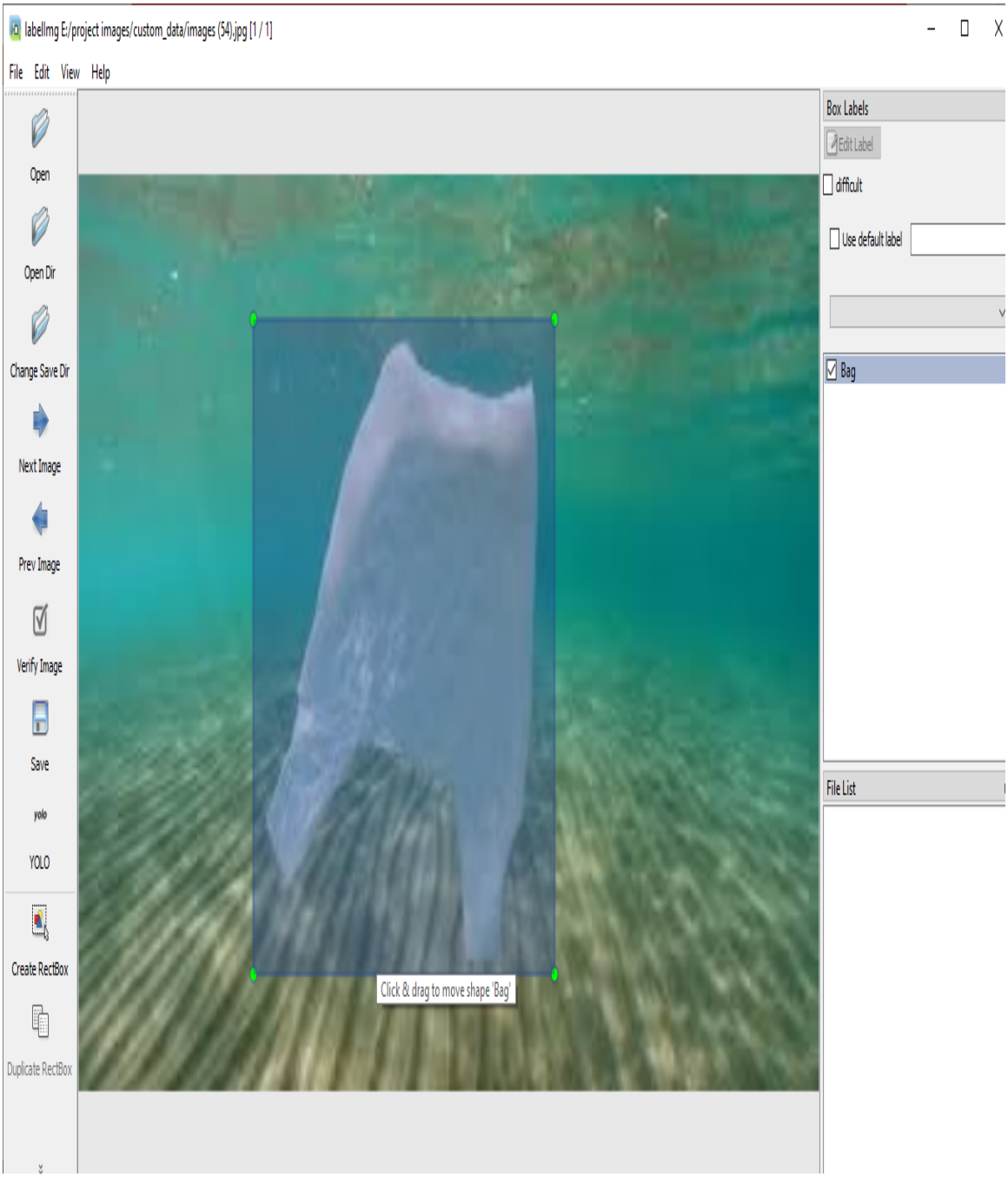

Figure 5.1: LabelIMG tool Labelling the object from an Image

In LabelImg tool, we needed to label the relevant area of the image to the class it is associated with such as plastic bag , cup, straw ,etc. This type of labeling of the image includes the strategy of creating boundaries to the waste object in the picture. 80whole dataset of waste images are used for training. The other 20phase. The whole purpose of this particular system is to make the framework figure out how to detect objects. The data of the annotations of the images made by the LabelIMG tool are saved in the XML extension format. The annotations of the picture include the size of images, location

coordinates, and also the names of marked objects that could be inspected in the file.

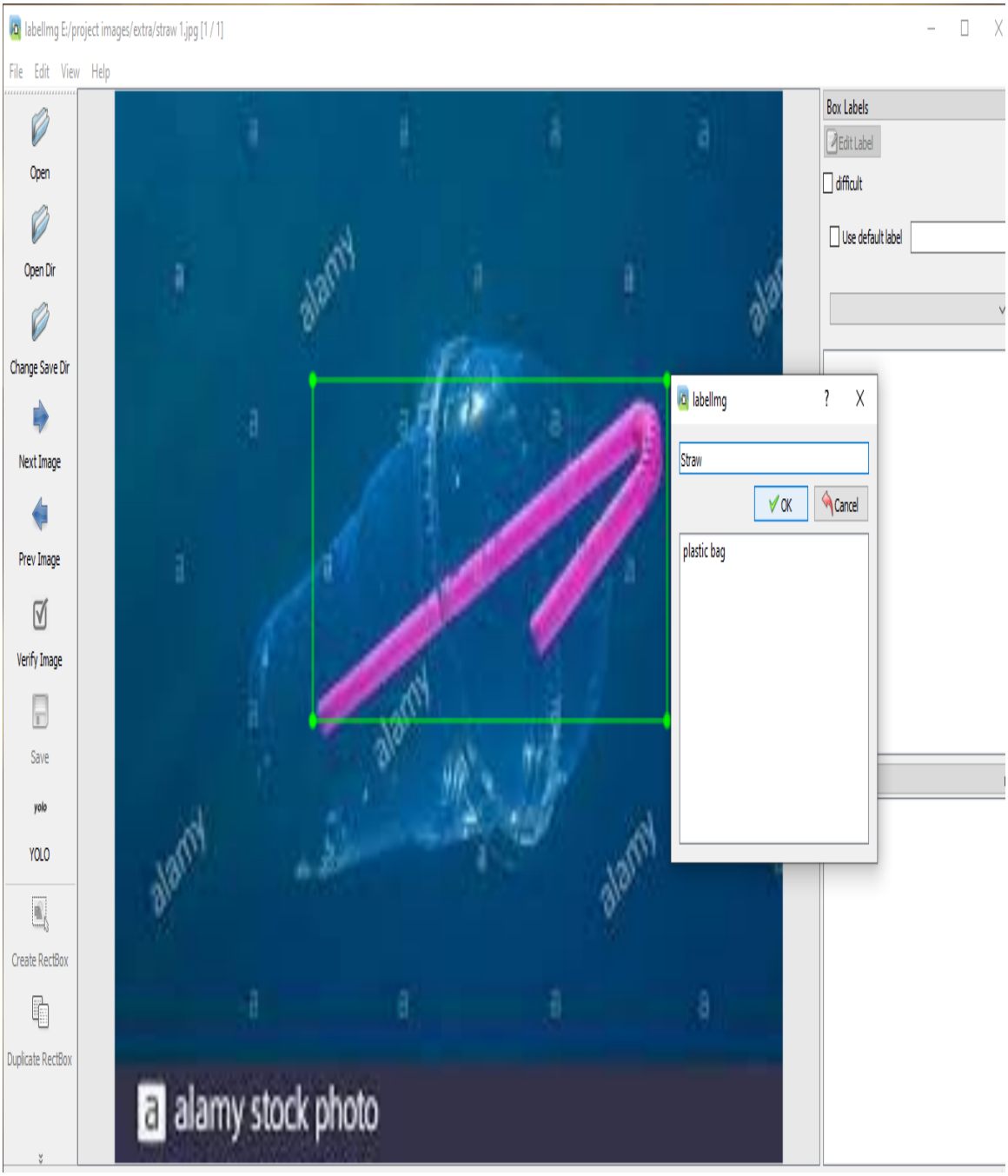

Figure 5.2: LabelIMG tool Labelling the Straw from an Image

The XML file can be then converted to the CSV file. And this CSV file contains the records of available information which includes the names of the recorded file, height and widths, and labeled classifications and coordinate positions (xmin, ymin, xmax, ymax) obtained from the images. This converted CSV file act as one of the major training inputs for the model. Figure 3 and Figure 4 show how the LabelIMG Tool labeling the single and multiple objects from an Image.

5.2.5 Model Training

After generating the training data the XML files are obtained which contain all the data for train and test images . Once the training data is generated a label map is created which notified the system about what each object is by characterizing a mapping of class ID numbers to class names. After the label map is created, finally, the object detection pipeline is configured which helped in defining what type of parameters and models is used for training. Once the training pipeline is successfully built up and configured, TensorFlow started initializing the model training.

Lot of computational power is required for training the network.For training a network we used a DELL laptop outfitted with intel i5 processor with windows 10. Along with this googlecolab was used which provides a free gpu to work on .

5.2.6 Model Testing

Testing the trained model is a last part of the process after training gets completed it is used for identifying and classifying the objects given in a input feed eg. images ,etc. In this the trained or created model is tested using the test dataset the framework processes the test dataset like the training dataset . At last , by utilizing the OpenCV python library , python scripts are written to test the newly trained object detection model on the image finally it classifies the waste in 4 categories.

Chapter 6

Result and Analysis

In this segment of the paper, the outcomes of the created model will be examined. The created model works reasonably on the test data. predicted by the model accurately which concludes that the accuracy rate of the model is near about 91The model precisely classifies the type of waste by detecting the type of objects. The images of the testing data were utilized for testing the result of the created model. For the detection of the waste materials, the images of the test data have been specifically included in the testing code. The total detection time took by the model to predict a single object from an image is near about 7.05 seconds. To find the actual accuracy of the model, the names of the images were physically given to observe how exact the functions of the model have performed in those images. At first, during testing, multiple boundaries have been observed getting created in the region of the detection of the objects and by changing the threshold for the prediction of the images this error was eliminated. The accurate prediction done by the developed model is shown in figure .

Images of a similar item yet taken in various directions were also considered for the testing result. The model could predict the objects correctly with greater accuracy fulfilling the expectation of the object detection effectively correct. These images also don't belong to testing data and were taken by a mobile camera. .

Figure 6.1: Input image of a waste

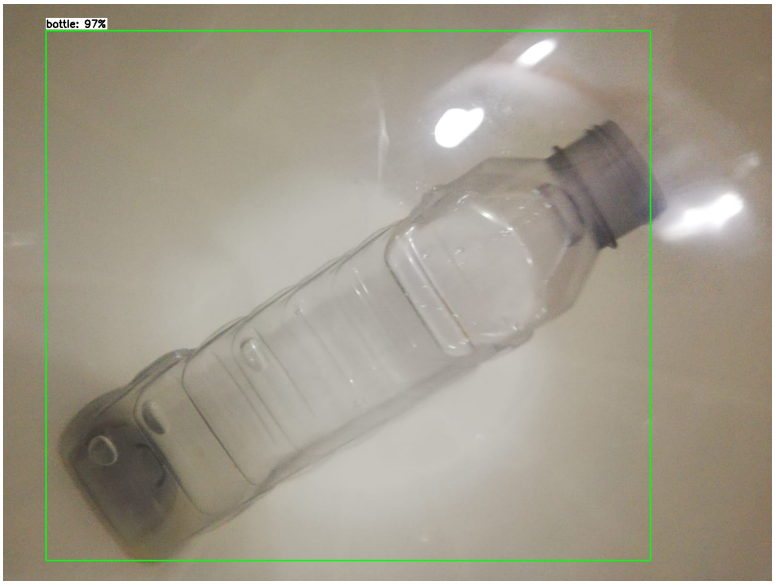

Figure 6.2: Bottle detected with an accuracy of 96 percent in output

Figure 6.3: Input Image of a waste

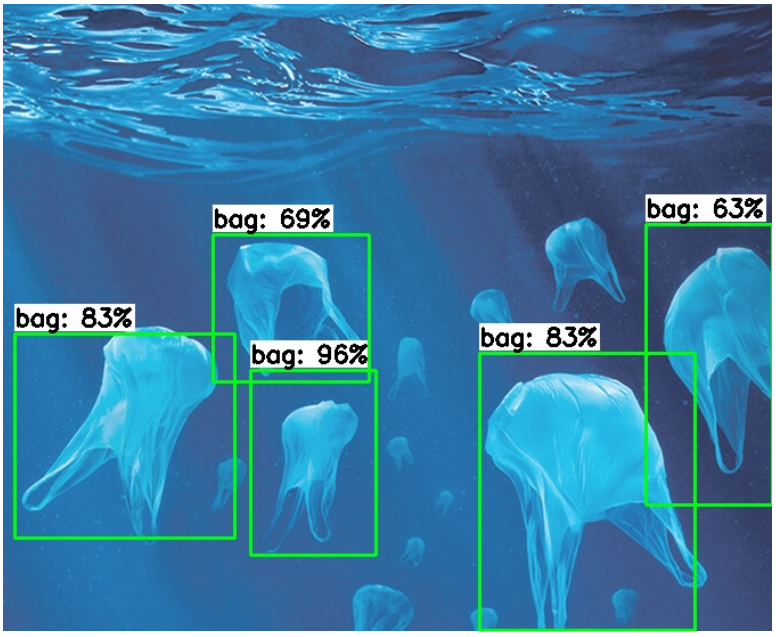

Figure 6.4: Plastic Bags detected with a accuracy of 63-95percent in Output

Figure 6.5: Input Image of a waste

Figure 6.6: Straw in the cup detected with an accuracy of 91 percent in output

Chapter 7

Conclusion

To limit the impact caused by incorrect disposal of trash, this project introduced an automated waste detection framework using deep learning algorithms and image processing techniques. Thus, for implementation, the framework worked with a large dataset of images, training algorithms, and predictive patterns for object detection and classification. In this paper, we have demonstrated that how the classification of waste in four categories.

The detection of waste materials is done correctly maintaining a higher accuracy level. The methodology used in this paper will help in lessening the contamination levels and in the long run, it will focus on the advancement of the universal waste management system. Hence, it can be concluded that this project is a significant asset to society.

Bibliography

[1] "Indian Coast Guard removes 500 kg of marine waste during underwater clean-up drive off Kovalam Beach," Mirror Now Digital, 6 June 2019. [Online]. Available: https://www.timesnownews.com/mirror-now/society/article/indian-coastguard-removes500-kg-of-marine-waste-during-underwater-clean-up-drive-off-kovalambeach/431936. [Accessed 20 August 2019].

[2] "FLOATING TRASH SKIMMERS," Cleantec Infra, [Online]. Available: https://www.cleantecinfra.com/trash-skimming. [Accessed 20 August 2019].

[3] S. RAMESH, "These giant machines are removing all the plastic choking India's water bodies,"The Print, 14 September 2018. [Online]. Available: https://theprint.in/science/these-giantmachines-are-removing-all-the-plasticchoking-our-water-bodies/113022/. [Accessed 20 August 2019].

[4] A. Klein, "Ocean-cleaning sea bins will gobble up plastic waste to recycle," New Scientist, 29 July 2016. [Online]. Available: https://www.newscientist.com/article/2099339-oceancleaning-sea-bins-will-gobbleup-plastic-waste-to-recycle/. [Accessed 20 August 2019].

[5]] "Seabin Project," The Seabin Project, 2019. [Online]. Available: https://seabinproject.com. [Accessed 2019 August 2019].

[6] C. Weller, "This floating garbage collector is longer than a football field — and it could get 1,000 times bigger," Tech Insider, 5 July 2016. [Online]. Available: https://www.businessinsider.com/ocean-cleanup-floating-garbagecollector-2016-7?IR=T. [Accessed 20 August 2019].

[7] "The Ocean Cleanup," 2019. [Online]. Available: https://theoceancleanup.com. [Accessed 20 August 2019].

[8] William H. Carter San Diego "Evaluation of Peak Location Algorithms With Subpixel Accuracy For Mosaic Focal Planes" Processing of Images and Data from Optical Sensors, Conference Volume 0292, 1981.

[9]] K. P. Indulekha, R. and C. Kumar A., "Novel method of detecting moving object in video," International Conference on Emerging Trends in Engineering, Science and Technology, pp. 1055-1060, 2015.

[10] M. Prabowo, N. Hudayani, S. Purwiyanti, S. Sulistiyanti and F. Setyawan, "A moving objects detection in underwater video using subtraction of the background model," EECSI, pp. 19-21, 2017.

[11] Donovan, J. Auto-trash sorts garbage automatically at the techcrunch disrupt hackathon. Techcrunch Disrupt Hackaton, San Francisco, CA, USA, Tech. Rep. Disrupt SF 2016, 2016.

[12] Yang, M.; Thung, G. Classification of trash for recyclability status. CS229 Project Report 2016, 2016.

[13] Lowe, D.G. Distinctive image features from scale-invariant keypoints. International journal of computer vision 2004, 60, 91–110.

[14] Krizhevsky, A.; Sutskever, I.; Hinton, G.E. Imagenet classification with deep convolutional neural networks. Communications of the ACM 2017, 60, 84–90.

[15] Sunpyo Hong and Hyesoon Kim, "An Analytical Model for a GPU Architecture with Memory-level and Thread-level Parallelism Awareness", ISCA'09, Texas, USA, June 2009.

[16] Patil, Parag Singhaniya, Navin Jage, Chaitanya Vyawahare, Vishwesh Patil, Mukesh Paluri, Nataraj. (2018). GPU Computing of Special Mathematical Functions used in Fractional Calculus.

[17] Minichino, Joe, and Joseph Howse. Learning OpenCV 3 Computer Vision with Python - Second Edition. Packt Publishing, 201

[18] "Python OpenCV: cv2.Imread() Method." GeeksforGeeks, August 2, 2019. https://www.geeksforgeeks.org/python-opencv-cv2-imread-method/.

[19] "Python OpenCV: cv2.Imwrite() Method." GeeksforGeeks, August 7, 2019. https://www.geeksforgeeks.org/python-opencv-cv2-imwrite-method/.

[20] "Introduction to OpenCV-Python Tutorials." Accessed April 5, 2020. https://opencv-python-tutrials.readthedocs.io

[21] "User Interface." User Interface - OpenCV 2.4.13.7 documentation. Accessed April 5, 2020. https://docs.opencv.org/2.4/modules/highgui/doc/user interface.html

[22] "Operations on Arrays." Operations on Arrays - OpenCV 2.4.13.7 documentation. Accessed April 5, 2020. https://docs.opencv.org/2.4/modules/core/doc/operations on arrays.html.

[23] Gonzales and Woods, "Digital Image Processing," 3rd ed., Prentice Hall

[24] Pant A, Arora A, Kumar S, Arora RP. "Sophisticated Image Encryption Using OpenCV," International Journal of Advances Research in Computer Science and Software Engineering, 2012, 2(1).

[25] Devi, R.S.; Vijaykumar, V.; Muthumeena, M. Waste Segregation using Deep Learning Algorithm

[26] Yang, M.; Thung, G. Classification of trash for recyclability status. CS229 Project Report 2016, 2016.

[27] Thomas Gamauf, TensorFlow Records? What they are and how to use them? Blog (https://medium.com/mostly-ai/tensorflow-records-what-they-are-and-how-to-use-themc46bc4bbb564), March 20, 2018

[28] Singh, S.; Mamatha, K.; Ragothaman, S.; Raj, K.D.; Anusha, N.; SusmiZacharia. Waste Segregation System Using Artificial Neural Networks. HELIX 2017, 7, 2053–2058.

[29] Ranada, P. Why PH is the world's 3rd biggest dumper of plastics in the ocean. Rappler Blog. Retrieved October 6, 2015, 2015.

[30] https://books.google.com/books/about/Detection-of-Waste-Materials-Using-Deep.html?id=Zpd5zgEACAAJ

[31] Dabholkar, A.; Muthiyan, B.; Srinivasan, S.; Ravi, S.; Jeon, H.; Gao, J. Smart illegal dumping detection. 2017 IEEE Third International Conference on Big Data Computing Service and Applications (BigDataService). IEEE, 2017, pp. 255–260.

[32] Zhao, Z.Q.; Zheng, P.; Xu, S.t.; Wu, X. Object detection with deep learning: A review. IEEE transactions on neural networks and learning systems 2019, 30, 3212–3232

[33] Çevik, E.; Zengin, K. Classification of Skin Lesions in Dermatoscopic Images with Deep Convolution Network. Avrupa Bilim ve Teknoloji Dergisi 2019, pp. 309–318.

[34] John, N.E.; Sreelakshmi, R.; Menon, S.R.; Santhosh, V. Artificial Neural Network based Intelligent Waste Segregator.

[35] Singh, S.; Mamatha, K.; Ragothaman, S.; Raj, K.D.; Anusha, N.; SusmiZacharia. Waste Segregation System Using Artificial Neural Networks. HELIX 2017, 7, 2053–2058.

[36] Albeahdili, H.M.; Han, T.; Islam, N.E. Hybrid algorithm for the optimization of training convolutional neural network. International Journal of Advanced Computer Science Applications 2015, 1, 79–85.

[37] Rosebrock, A. Histogram of Oriented Gradients and Object Detection. línea]. Disponible en:Blog(http://www.pyimagesearch.com/2014/11/10/histogram-oriented-gradients- objectdetection) 2014

[38] Bobulski, J.; Kubanek, M. Waste classification system using image processing and convolutional neural networks. International Work-Conference on Artificial Neural Networks. Springer, 2019, pp. 350–361.

[39] Rad, M.S.; von Kaenel, A.; Droux, A.; Tieche, F.; Ouerhani, N.; Ekenel, H.K.; Thiran, J.P. A computer vision system to localize and classify wastes on the streets. International Conference on computer vision systems. Springer, 2017, pp. 195–204. Springer, 2019, pp. 350–361.

[40] Zailah, W.; Hannan, M.; Al Mamun, A. Feed forward neural network for solid waste image classification. Research Journal of Applied Sciences, Engineering and Technology 2013, pp. 1466–1470.

[41] Albeahdili, H.M.; Alwzwazy, H.A.; Islam, N.E.; others. Robust convolutional neural networks for image recognition. International Journal of Advanced Computer Science and Applications 2015, 6, 105–111.

[42] Dewangan, S.K. Importance Applications of Digital Image Processing. International Journal of Computer Science Engineering Technology (IJCSET) 2016, 7, 316–320.

[43] Nyaga, G.M. A Mobile-based image recognition system for identifying bird species in Kenya. PhD thesis, Strathmore University, 2019.

[44] Aleid, H.; Alkhalaf, A.A.; Taemees, A.H.; Almurished, H.S.; Alharbi, K.A.; Alanazi, N.H.; others. Framework to classify and analyze social media content. Social Networking 2018, 7, 79

[45] Gonzalez, R.C.; Woods, R.E.; Eddins, S.L. Digital image processing using MATLAB; Pearson Education India, 2004.

[46] Silver, B. An introduction to digital image processing. Technology Officer Cognex Corporation, Modular Vision Systems Divisio, Natick 2000, pp. 1–9.

[47] Al-Azzoa, F.; Taqia, A.M.; Milanovab, M. Human Related-Health Actions Detection using Android Camera based on TensorFlow Object Detection API. INTERNATIONAL JOURNAL OF ADVANCED COMPUTER SCIENCE AND APPLICATIONS 2018, 9, 9–23.

[48] Arcos-Garcia, A.; Alvarez-Garcia, J.A.; Soria-Morillo, L.M. Evaluation of deep neural networks for traffic sign detection systems. Neurocomputing 2018, 316, 332–344.

[49] A. Klein, "Ocean-cleaning sea bins will gobble up plastic waste to recycle," New Scientist, 29 July 2016. [Online]. Available: https://www.newscientist.com/article/2099339-oceancleaning-sea-bins-will-gobbleup-plastic-waste-to-recycle/. [Accessed 20 August 2019].

[50] "Seabin Project," The Seabin Project, 2019. [Online]. Available: https://seabinproject.com. [Accessed 2019 August 2019].

[51]] C. Weller, "This floating garbage collector is longer than a football field — and it could get 1,000 times bigger," Tech Insider, 5 July 2016. [Online]. Available: https://www.businessinsider.com/ocean-cleanup-floating-garbagecollector-2016-7?IR=T. [Accessed 20 August 2019].

[52] "The Ocean Cleanup," 2019. [Online]. Available: https://theoceancleanup.com. [Accessed 20 August 2019].

[53] Abubakar Yamin, Faisal Imran, Usman Akbar, Syed Hassan Tanvir, "Image Processing Based Detection Classification of Blood Group Using Color Images", IEEE - International Conference on Communication, Computing and Digital Systems (C-CODE), 978-1-5090-4448-1, 2017.

[54] Choubeila Maaoui, Christophe Rosenberger, Bruno Emile, "Robust Color Object Detection Recognition", Eusipco2005. Corporation, Modular Vision Systems Divisio, Natick 2000, pp. 1–9. Corporation, Modular Vision Systems Divisio, Natick 2000, pp.

1–9. Corporation, Modular Vision Systems Divisio, Natick 2000, pp. 1–9. Corporation, Modular Vision Systems Divisio, Natick 2000, pp. 1–9. Corporation, Modular Vision Systems Divisio, Natick 2000, pp. 1–9. Corporation, Modular Vision Systems Divisio, Natick 2000, pp. 1–9.

Acknowledgments

My first and sincere appreciation goes to our Principal Dr. Mukesh D. Patil, H.O.D. Dr. Vishwesh Vyawahare,Project cordinator Mrs. Sharmila Petkar, Project Co-cordinator Mrs. Shweta Ashtekar and Project guide Mr Chaitanya Jage . l for all I have learned from him and for his continuous help and support in all stages of this dissertation. I would also like to thank him for being an open person to ideas, and for encouraging me to shape my interest and ideas.

Date

Signature