

SCHOOL *of* BUSINESS AND TECHNOLOGY

Department of Engineering and Aviation Sciences

**Clam Activity Detection System**

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Clam Activity Detection System

By

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Submitted to the Department of Engineering and Aviation Sciences in partial fulfillment of the requirements for the degree of Bachelor of Science in Engineering at the

UNIVERSITY OF MARYLAND EASTERN SHORE

Date

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Authors Shanice Nurse, Ashley Afueh

Signature

Date

Department of Engineering and Aviation Sciences

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**List of Contents**

[**List of Contents 2**](#_30j0zll)

[**List of Figures 4**](#_1fob9te)

[**List of Tables 5**](#_3znysh7)

[**Abstract 6**](#_2et92p0)

[**1.**](#_tyjcwt) **Introduction 7**

[**1.1**](#_3dy6vkm) **Backgound/Motivation 7**

[**1.2**](#_4d34og8) **Objective 7**

[**1.3**](#_2s8eyo1) **Design Requirements 7**

[**1.4**](#_17dp8vu) **Design Constraints 7**

[**1.5**](#_3rdcrjn) **Design Methods 7**

[**2.**](#_26in1rg) **Project Description 9**

[**2.1**](#_lnxbz9) **System Description 9**

[**2.2**](#_35nkun2) **System Diagram 9**

[**2.3**](#_44sinio) **System Functions 9**

[**3.**](#_2jxsxqh) **Implementation Plan 11**

[**3.1**](#_z337ya) **Tasks 11**

[**3.2**](#_3j2qqm3) **Team Organization 12**

[3.2.1.](#_1y810tw) Responsibility of Team Member 1. 12

[3.2.2.](#_4i7ojhp) Responsibility of Team Member 2. 12

[**3.3**](#_2xcytpi) **Timeline/Milestones/Delivery Plan 12**

[**4.**](#_3whwml4) **Implementation 13**

[**4.1**](#_2bn6wsx) **Implementation of Task 1. 13**

[4.1.1.](#_qsh70q) Implementation of Subtask 1.1 13

[**4.2**](#_3as4poj) **Implementation of Task 1. 13**

[**5.**](#_1pxezwc) **Conclusion (Discussion and Future Plans) 14**

[**Acknowledgment 15**](#_2p2csry)

[**Appendix 16**](#_147n2zr)

[**A.**](#_3o7alnk) **Component Specs 16**

[1.](#_23ckvvd) Specs of Arduino Due 16

[2.](#_ihv636) Specs of Raspberry Pi 16

[**B.**](#_32hioqz) **Source Code. 16**

[1.](#_1hmsyys) Source Code of Graphic User Interface 16

[2.](#_41mghml) Source Code of Robotic Arm 16

[**REFERENCES 17**](#_2grqrue)

**List of Figures**

[Figure. 1.](#_1t3h5sf) Mussel Active Filtering (A), Voltage Output (B), and Mussel Resting (C). 6

[Figure. 2.](#_1ksv4uv) Design Methods. 7

**List of Tables**

[Table 1.](#_1ci93xb) Project Timeline and Delivery Plan 10

**Abstract**

By the end of the project, summarize the project into short text and put here (can be waived for Senior Design I). The abstract needs to be more than half page.

1. **Introduction**

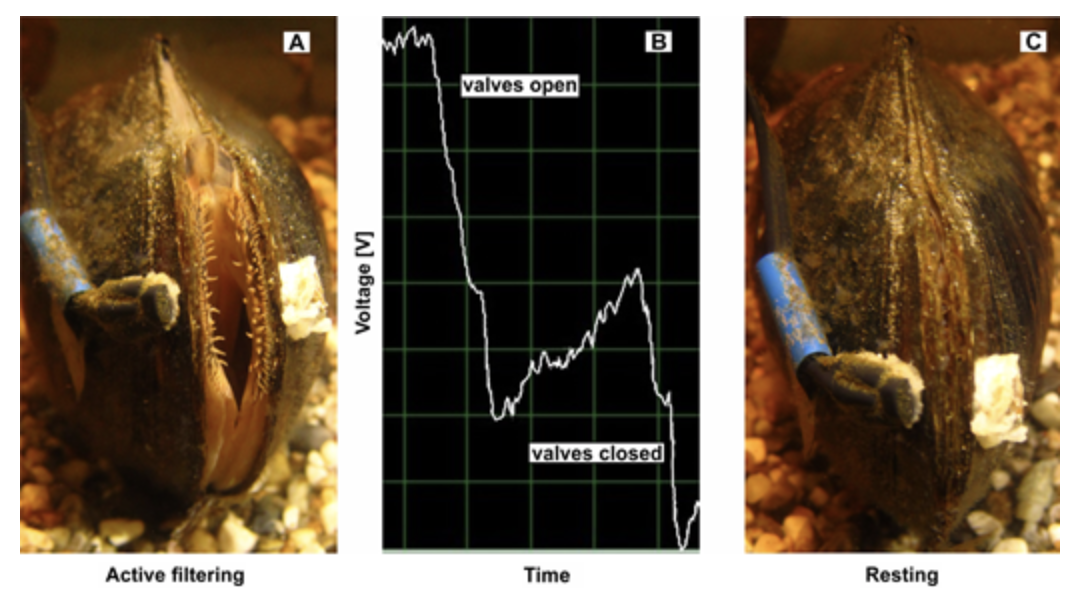
## 1.1 Background/Motivation

Clams provide a positive environment for the coastal and estuarine waters. Shellfish cultivating can give communities an assortment of environmental benefits, whose worth can be quantified. Clams have the ability to clean the water which they’ve grown in by filter feeding. By this way of feeding, clams filter phytoplankton, microorganisms, and detritus. By filtration, clams improve water quality by diminishing sediment loads and turbidity and expelling abundance supplements from inshore coastal waters. Clear water quality permits more daylight to infiltrate, which helps in the development of significant seagrasses and expands oxygen.

The capability of remotely monitoring the behavior of clams and their relationship with their habitat has restructured how ecologists conduct research. Shellfish cultivating can give nearby communities an assortment of environmental benefits, whose worth can be quantified. Freshwater mussels (Unionoida) are target species in aquatic conservation and belong to one of the fastest diminishing taxa globally (Bogan, 1993; Geist, 2010, 2015). Most recently, there has been a critical effort to put resources into improving the conception of the reasons for the decrease of Unionoida. Biologists have urged the discovery of a solution to observe the behavior, physiology, and ecological conditions experienced by creatures as they progress and communicate with their habitat. On account of the mechanical advances made in the course of the most recent 40 years, a wide range of approaches have been created to precisely comprehend the lives of creatures that go overlooked by the observation of an ecologist. Comprehensively, the strategies used to monitor clams are directly related to the "biotelemetry", which can be characterized as the remote detection of physiological, or behavioral activity information. It is effective to include biotelemetry into the study of clams in order to have a precise understanding of its preservation to the ecosystem. The standard amount of biotelemetry incorporated in research, differs enormously, from the utilization of data recorded, to transmitters that send data to either land-based receivers, or to a satellite circumnavigating the earth. For this reason, researchers and different articles suggest it useful to attach sensors to the mussels’ shell for ecological investigations and preservation ventures.

Various research projects range from, but are not limited to, mark-recapture studies to translocation and restocking programs, and mussel behavior research (Smith, Villella & Lemarié, 2003; Villella, Smith & Lemarié, 2004; Kurth *et al.*, 2007; Wilson *et al.*, 2011; Hartmann *et al.*, 2015). For instance, the controlled release of captive-reared freshwater pearl mussels (*Margaritifera margaritifera*) requires effective tools to monitor the success of such conservation projects (Gum, Lange & Geist, 2011). Adjoining sensors to a mussel may bring about strain for the mussel and increase endangerment to their vulnerability to harmful mixes from the glue. To connect an item includes the expulsion of the mussel from its condition, cleaning and drying the shell, applying the paste, squeezing the remote article against the shell and, for some paste', the procedure additionally includes keeping the mussel out of the water until the paste is dry. Currently, there are experimental studies of filtration-behavior and biological rhythm for freshwater mussels. Biologists perform their research by attaching objects to bivalve shells for conservation projects, mark-recapture studies, and behavioral analysis. The “marking” process is performed by using a magnet and a rubber-coated Hall sensor glued with cyanoacrylate adhesive attached to a mussel shell known as the “Anodontia Anatina.” These attachments were built to last for nine months after attachment. This system was designed for a filtration-behavior experiment, which identified a circadian rhythm. This experiment was performed by placing twenty-six mussels that were randomly selected were placed into two different closed recirculating aquarium systems. After allowing the mussels to adapt to their laboratory habitat for about 12 days, a Honeywell SS495A linear position Hall sensor (Honeywell, USA) and magnet were then attached for monitoring behavior. Additionally, this system allowed ecologists to observe the water quality parameters, dissolved oxygen (DO), pH and EC daily. Figure 1 depicts the measurement of a mussel’s filtration behavior using the change in proximity of a magnet (in right valve) to a Hall sensor (on left valve). In Figure 1, photograph B depicts a graph showing a measurement of the voltage output transduced by the Hall sensor when the mussel is active and resting.

Figure 1.



1. Mussel Active Filtering (A), Voltage Output(B), Mussel Resting(C).

This project is intended to assist in research for the Food & Science Department at the University of Maryland Eastern Shore. By developing a Clam Activity Detection System, a dataset from the activity of the clams will be derived from the activity observed without putting addition strain on the clams. This would be extremely beneficial to ecologist and researchers as they can remotely monitor precise data from their experiments. The dataset will be the basis for the development, evaluation, and use of the neural network developed. During this project, there will be models developed for photograph classification, and object detection to further investigate the activity of clams. By creating this development, the department will have a better insight of the clams’ behavioral activity with its environment. The Deep learning Convolutional Neural Network will be trained with an image classification model to observe each clam individually. This neural network is intended to monitor the clams’ amount of interaction, length of interaction, growth, and its overall adaptivity to its surroundings. This deep learning model will have the ability to integrate the feature extraction and classification process into a whole to record when the clam is most comfortable.

The purpose of this project is to develop a SMART system that will precisely monitor the activity and interaction of clams without the tedious strain imposed on their shell. By using deep learning approach to monitor the clam’s activity the data will be recorded with increased accuracy. As previously stated, there methods on the market that will accomplish similar tasks as our system. However, the methods do not offer the precision and comfortability our system can guarantee.

## Objective

The objective of this project is to create an automatic system that can precisely monitor and record activity of clams with 95% accuracy using a SMART design system.

## Design Requirements

1. The system will identify activity of each clam using a SMART system.
2. A time-lapse recording log will be implemented for visual data recording.
3. Access to a 24-hour data log will be offered with hourly updates.
4. Controlled parameters of the water quality along with the clam’s interaction to the environment will be accessed through a local network.

## Design Constraints

1. $200 budget
2. Light system is required for 24-hour monitoring

## Design Method

A system diagram for the design method can be seen in figure 2.

1. Design Method.

## Standards

List in this section all (industry) standards the project complied with.

1. **Project Description**

## System Description

This system intended to remotely monitor activity is controlled by a Deep Learning Convolutional Neural Network. For the project, the neural network is trained to identify various activities. A dataset will need to be prioritized with photographs of active clams and resting clams provided as a subset of photographs from a larger dataset. Using Keras the photos will be loaded to pre-process into standard directories. Python will then be used to create directories and subdirectories for both the “train” and “test” directories. After testing the dataset, a baseline Convolutional Neural Network will need to be developed. Different convolutional layers within the baseline model will be tested for accuracy. About three different VGG-based architecture models will be implemented to improve the performance by increasing the model capacity. This technique will alter the performance by allowing the model to learn features that will maximize the training dataset. After the process of model improvements, a final model configuration is selected and adopted. A final model normally includes all available data; the combination of train and test datasets. Through a web application, researchers will be able to view recorded datasets.

## System Diagram (or Flow Chart)

A screenshot of a cell phone

Description automatically generated

1. System Flow Chart

## System Functions

This system uses a camera which will monitor the clam’s various activity; either resting or active. This information is then communicated to the Raspberry Pi. In the microcomputer, there is a system design which utilizes Artificial Intelligence and a Convolution Neural Network to process the data extracted from the images recorded. The data is then transmitted to a local network for visual recordings.

1. **Implementation Plan**

## Tasks

## Team Organization

## Tasks

* Task 1: Lab Setup
* Subtask 1.1: Mound Cameras to tank
* Subtask 1.2: Mound Sensors to tank
* Subtask 1.3. Setup Raspberry pi for experiment
* Subtask 1.4: Setup any more other configurations
* Task 2: Design software for practice image identification
  + Subtask 2.1: Import required library
  + Subtask 2.2: Import image
  + Subtask 2.3: Find object
  + Subtask 2.4: Validate if object was captured correctly
* Task 3: Design CNN (convolutional neural network)
  + Subtask 3.1: Preprocess design
  + Subtask 3.2: Feed neural network
  + Subtask 3.3: Obtain intrinsic dataset of picture
  + Subtask 3.4: Save pictures and results in database
* Task 4: Design software for clam identification
* Subtask 4.1: Photo dataset preparation
* Subtask 4.2: Develop a baseline CNN (convolutional neural network) model
* Subtask 4.3: Improvement on CNN model
* Subtask 4.4 Develop Transfer learning
* Subtask 4.5: Finalize CNN model

* Task 5: Design software for clam activity level
* Subtask 5.1: Photo dataset preparation
* Subtask 5.2: Develop a baseline CNN (convolutional neural network) model
* Subtask 5.3: Improvement on CNN model
* Subtask 5.4 Develop Transfer learning
* Subtask 5.5: Finalize CNN model
* Task 6: Data Organization for Database
* Subtask 6.1: Sorting data files
* Subtask 6.2: Writing data to a file
* Subtask 6.3: Modeling Data for database
* Subtask 6.4: Work with data constructed
* Subtask 6.5: Ensuring all cameras are synchronizing with little to no error
  + Subtask 6.6: Create code to send pics from Camera to raspberry pi
  + Subtask 6.7: Create code to send sensor data to raspberry pi
* Task 7: Send Obtained Data to Cloud
* Subtask 7.1: Create channel for data
* Subtask 7.2: Create API key
* Subtask 7.3: Create python code for data
* Task 8: Generate Website Database
* Subtask 8.1: Organize layout for website
* Subtask 8.2: Sort data for general clam activity and activity level
* Subtask 8.3: Sort data for individual clam activity and activity level
* Subtask 8.4: Create figures for data
* Subtask 8.5: Run website, fix errors
* Task 9: System evaluation
* Subtask 9.1: Determine accuracy levels of 4 cameras and of each sensor.
* Subtask 9.2: Test entire system
* Subtask 9.3: Fix any errors
* Subtask 9.4: Evaluate system
* Subtask 9.5: Refine system (if necessary)

**3.2: Team Organization**

Team Member 1: Shanice Nurse

Team Member 2: Ashley Afueh

***3.2.1: Responsibility of Team Member 1:***

Task 1: Lab Setup (half)

Task 3: Design CNN (convolutional neural network)

Task 5: Design software for clam activity level

Task 7: Send obtained data to cloud

Task 8: Generate website database (half)

Task 9: System Evaluation (half)

***3.2.2: Responsibility of Team Member 2:***

Task 1: Lab Setup (half)

Task 2: Design software for practice image identification of stars

Task 4: Design software for clam identification

Task 6: Data organization for database

Task 8: Generate website database (half)

Task 9: System Evaluation (half)

1. **Project Timeline and Delivery Plan**

|  |  |  |  |
| --- | --- | --- | --- |
| 1. Time | Task | Comment | Responsible Personnel |
| Week 1 | Begin Subtask 1.1, 1.2 | Task 1: Lab Setup | Shanice Nurse, Ashley Afueh |
| Week 2 | Finish Subtask 1.1, 1.2 | Shanice Nurse, Ashley Afueh |
| Week 3 | Begin Subtask 1.3, 1.4 | Shanice Nurse, Ashley Afueh |
| Week 4 | Finish Subtask 1.3 | Shanice Nurse, Ashley Afueh |
| Week 5 | Finish Subtask 1.4 | Shanice Nurse, Ashley Afueh |
| Week 6 | Begin Subtask 2.1 | Task 2: Design software for practice image identification | Ashley Afueh |
| Week 7 | Finish Subtask 2.1 | Ashley Afueh |
| Week 8 | Begin Subtask 2.2, | Ashley Afueh |
| Week 9 | Finish Subtask 2.2 | Ashley Afueh |
| Week 10 | Begin Subtask 2.3, 2.4 | Ashley Afueh |
| Week 11 | Finish Subtask 2.3, 2.4 | Ashley Afueh |
| Week 12 | Finish subtask 3.1 | Task 3: Design CNN | Shanice Nurse |
| Finish subtask 3.2 | Shanice Nurse |
| Finish subtask 3.3 | Shanice Nurse |
| Finish subtask 3.4 | Shanice Nurse |
| Week 13 | Finish Subtask 4.1-4.2 | Task 4: Design software for clam identification | Ashley Afueh |
| Finish Subtask 4.3 | Ashley Afueh |
| Finish Subtask 4.4 | Ashley Afueh |
| Finish Subtask 4.5 | Ashley Afueh |
| Week 14 | Finish subtask 5.1-5.3 | Task 5: Design software for clam activity level | Shanice Nurse |
| Week 15 | Finish Subtask 5.4-5.5 | Shanice Nurse |
| Week 16 | Finish Subtask 6.1 – 6.2 | Task 6: Data organization for Database | Ashley Afueh |
| Finish Subtask 6.3 – 6.4 | Ashley Afueh |
| Week 17 | Finish Subtask 7.1 – 7.3 | Task 7: Send obtained data to Cloud | Shanice Nurse |
| Week 18 | Finish Subtask 7.4 – 7.5 | Shanice Nurse |
| Week 19 | Finish Subtask 8.1 – 8.3 | Task 8: Create Website Database | Ashley Afueh, Shanice Nurse |
| Week 20 | Finish Subtask 8.4 – 8.5 | Ashley Afueh, Shanice Nurse |
| Week 21 | Finish Subtask 9.1 – 9.2 | Task 9: System Evaluation | Ashley Afueh, Shanice Nurse |
| Finish Subtask 9.3 – 9.4 | Ashley Afueh, Shanice Nurse |

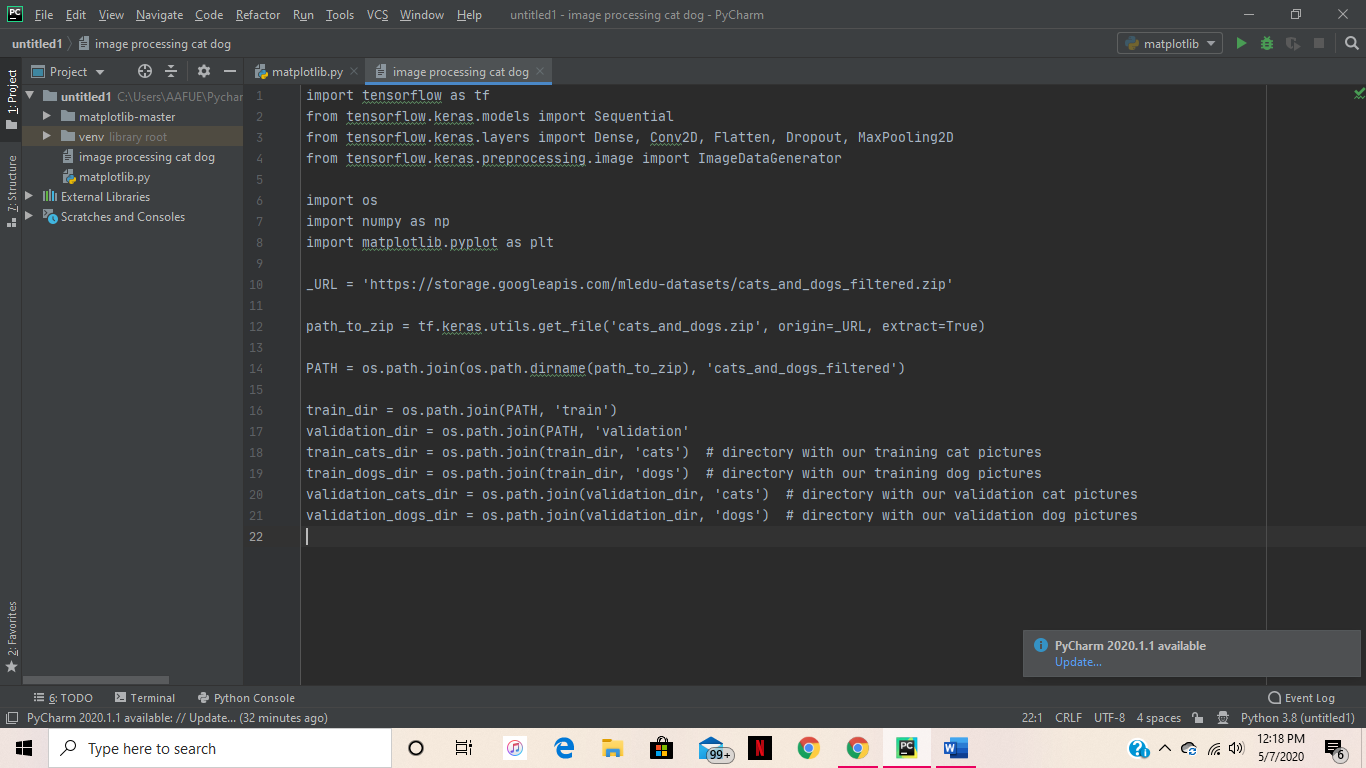
1. **Implementation**

Task 2: Design Software for practice image identification:

2.1: Implementation of Subtask 2.1: Import required library

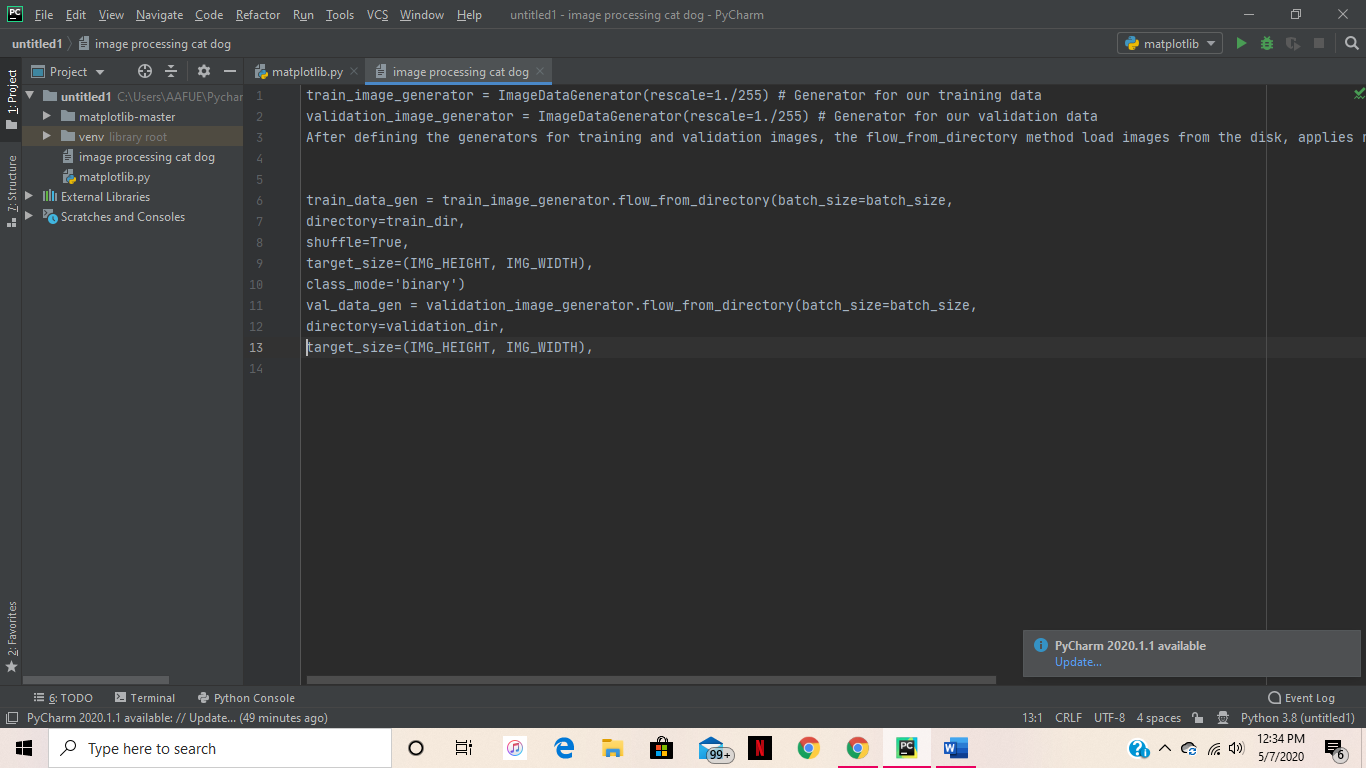
The os package is used to read files and directory structure, NumPy is used to convert python list to numpy array and to perform required matrix operations and matplotlib.pyplot to plot the graph and display images in the training and validation data.

Import Tensorflow and the Keras classes needed to construct our model.



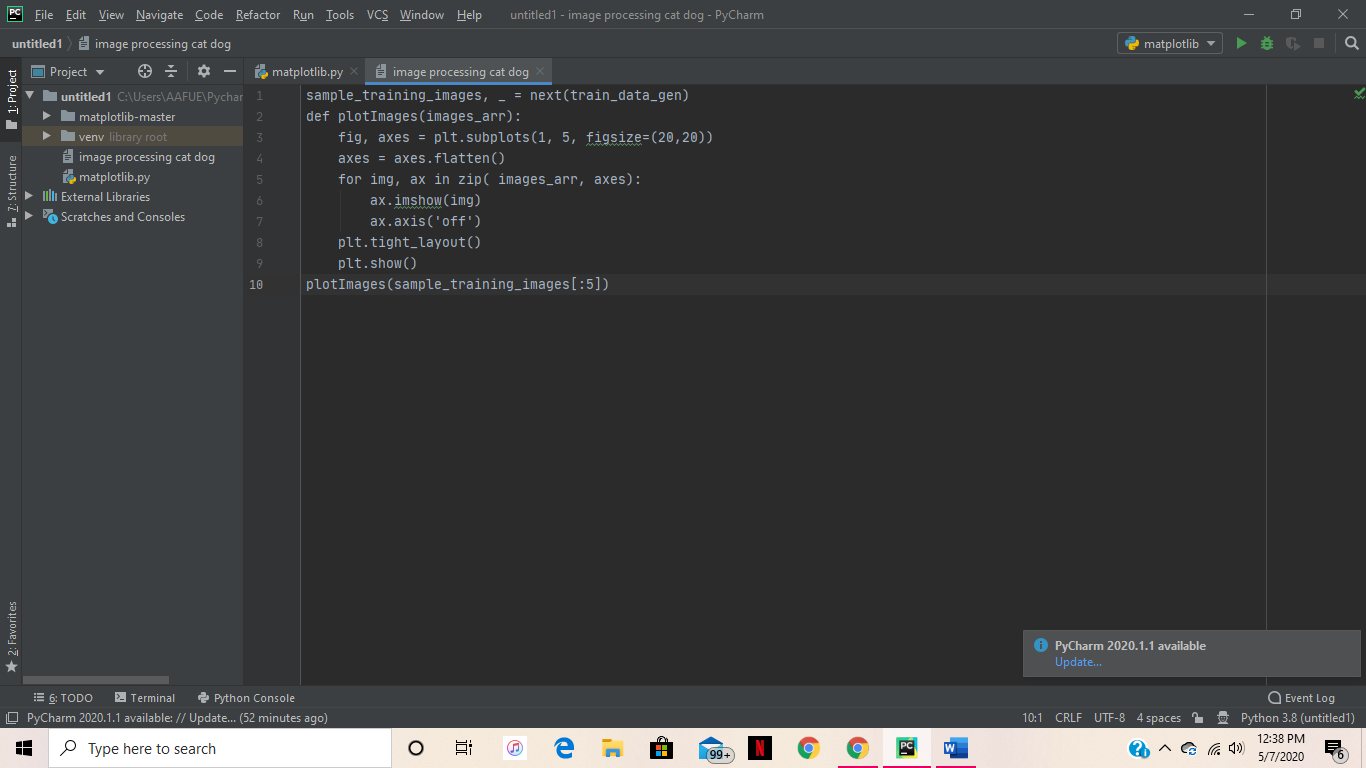
2.2: Implementation of Subtask 2.2: Import image

Read images from the disk. Decode contents of these images and convert it into proper grid format as per their RGB content. Convert them into floating point tensors. Rescale the tensors from values between 0 and 255 to values between 0 and 1, as neural networks prefer to deal with small input values. Fortunately, all these tasks can be done with the ImageDataGenerator class provided by tf.keras. It can read images from disk and preprocess them into proper tensors. It will also set up generators that convert these images into batches of tensors—helpful when training the network.



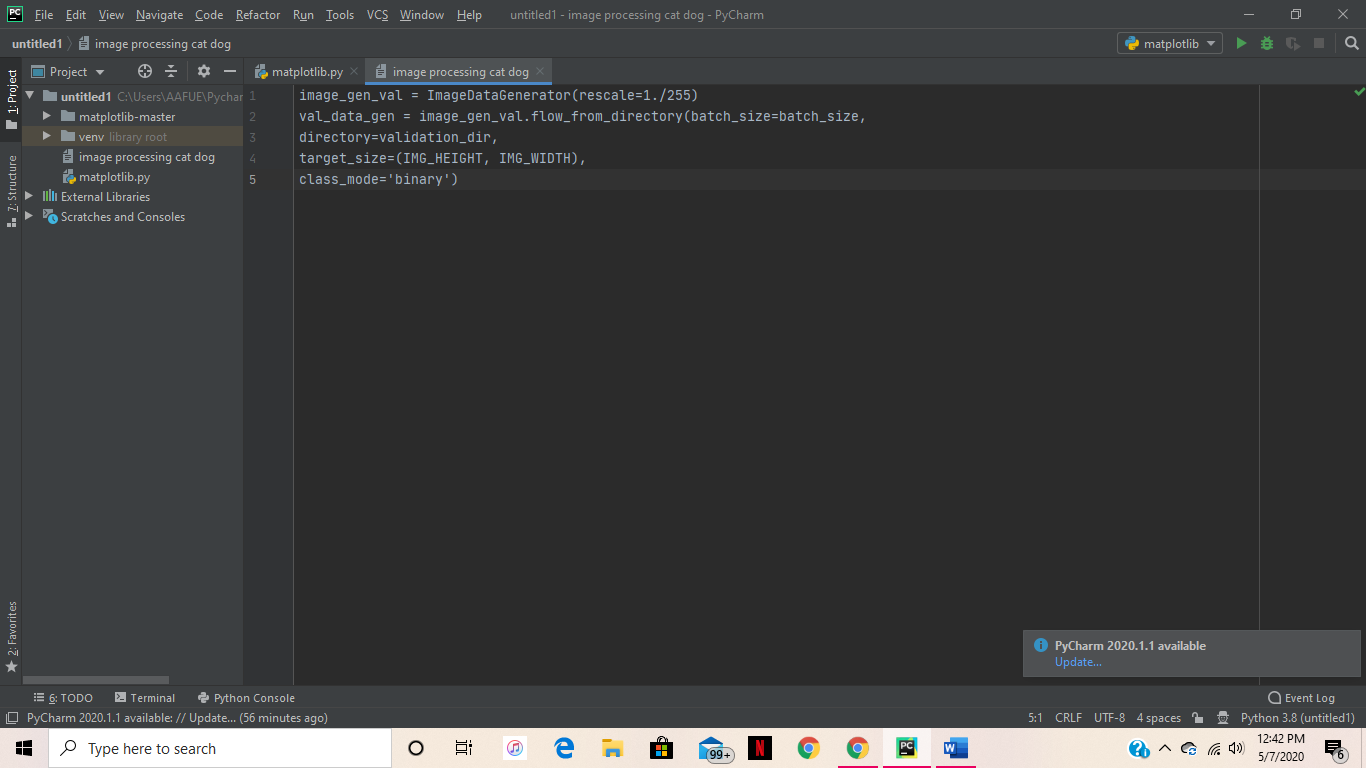
2.3: Implementation of Task 2.3: Finding object

Visualize the training images by extracting a batch of images from the training generator—which is 32 images in this example—then plot five of them with matplotlib. The next function returns a batch from the dataset. The return value of next function is in form of (x\_train, y\_train) where x\_train is training features and y\_train, its labels. Discard the labels to only visualize the training images.



2.4: Implementation of Subtask 2.4: Validate of Object was captured correctly:

Generally, only apply data augmentation to the training examples. In this case, only rescale the validation images and convert them into batches using ImageDataGenerator.



3.1: Implementation of Task 1: Convolutional Neural Network Design

The code in Figure “” demonstrates training a simple (CNN) to classify CIFAR images using Kera Essential API. A picture containing drawing

Description automatically generated

The CIFAR10 dataset contains 60,000 color images in 10 classes, with 6,000 images in each class. The dataset is divided into 50,000 training images and 10,000 testing images. The classes are mutually exclusive and there is no overlap between them. ​​  A picture containing drawing

Description automatically generated

After preparing the CIFAR10 dataset the data was then verified in order to create a convolutional base which is shown in Figure “” and Figure “”. To verify that the dataset looks correct, the first 25 images from the training set needed to be plotted and displayed by the class name below each image. The code to verify the data is shown in Figure “”.

A screenshot of a cell phone

Description automatically generated

The 6 lines of code in Figure “” define the convolutional base using a common pattern: a stack of CONVI D and MAXPOOLING 2D layers. ​ As input, a CNN takes tensors of shape (image\_height, image\_width, color\_channels), ignoring the batch size. In this example, the CNN will be configured to process inputs of shape (32, 32, 3), which is the format of CIFAR images. This is done by passing the argument input shape to the first layer.

A screenshot of a cell phone

Description automatically generated

To complete the model, was fed the last output tensor from the convolutional base (of shape (4, 4, 64)) into one or more Dense layers to perform classification shown in Figure “”. Dense layers take vectors as input (which are 1D), while the current output is a 3D tensor. First, flatten (or unroll) the 3D output to 1D, then add one or more Dense layers on top. CIFAR has 10 output classes, so you use a final Dense layer with 10 outputs and a SoftMax activation. ​

A picture containing bird, drawing

Description automatically generated

This CNN model has achieved a test accuracy of over 70%. ​Next the model will have to be overfitted in order to increase accuracy.

1. A screenshot of a cell phone

   Description automatically generated
2. **Project evaluation**

In this chapter, please evaluate the performance of the solution completed in the project with the considerations of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors. And please consider improvement suggestion for the future on the aspect.

1. Public health
2. Safety
3. Welfare
4. Global factor
5. Cultural factor
6. Social factor
7. Environmental factor
8. Economic factor
9. **Conclusion**

By the end of the project, conclude the project and your learning experience.

Please make sure you include the overall evaluation of the project and the **future plan** about how the project can be improved.

* Project summary

…

* Learning and practice experience

…

* Future plan (how to improve)

…

**Acknowledgment**

If you get help or support from someone else (besides the team member and the advisor) and want to show your appreciation, put here (**do not include the advisor**).

**Appendix**

You can put reference info here, including i) specs of components used in the system, ii) source code (must be here but not in the body text), iii) CAD figures, etc.

1. **Component Specs**
2. ***Specs of Arduino Due***

...

1. ***Specs of Raspberry Pi***

…

1. **Source Code.**
2. ***Source Code of Graphic User Interface***

…

1. ***Source Code of Robotic Arm***

…

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