North South University

Department of Electrical Computer Engineering

Senior Project Design Report

Property damage detection system using Object detection through images.

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Submitted By:

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LETTER OF TRANSMITTAL

28 July, 2021

To

Dr. Mohammad Rezaul Bari

Professor and Chairman

Department of Electrical and Computer Engineering

Through

Dr. Nabeel Mohammed

Associate Professor

Department of Electrical and Computer Engineering

North South University

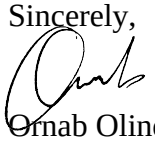
Dhaka, Bangladesh

Subject: Submission of Project Report on “Property damage detection system using object detection through images”

Dear Sir,

Conveying the utmost compliment to your position and honor that we would like to approach you with the following fact that we are very happy and grateful at this moment of submission of our Project Report on “Property damage detection system using object detection through images” In partial fulfilment of the requirement for the degree program, Bachelor of Science in Electrical and Electronics Engineering. We have used all the data and information in this report that was found most relevant and correct as per best of our judgment. It will be worthwhile to mention that this field work has immensely helped us to gather knowledge that might have been required for a long time for us to acquire. We sincerely hope this report will be the standard of our judgment. We will be always available for any inquiry or clarification regarding the report.

Sincerely,



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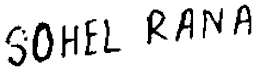

Sohel Rana
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DECLARATION

I, hereby, declare that the work presented in this report is the outcome of my four months project program performed under the supervision of Nabeel Mohammed Department of Electrical and Computer Engineering, North South University, Dhaka, Bangladesh. The work was spread over a span of one of the final year courses. Project, in accordance with the course curriculum of the Department for the Bachelor of Science in Electrical and Electronics Engineering program.

Declared By:

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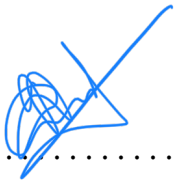
APPROVAL

The Project report on “Property damage detection system using Object detection through images.’’ has been submitted by Ornab Olindo 1320156042, student of the Department of Electrical and Computer Engineering, North South University, Bangladesh. This report partially fulfills the requirement for the degree of Bachelor of Science in Electrical and Electronics Engineering in May, 2021 and has been accepted as satisfactory.

Approved By:

Supervisor:



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Dr. Nabeel Mohammed
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ACKNOWLEDGEMENTS

I am profoundly grateful to Dr. Nabeel Mohammed for his expert guidance and continuous encouragement throughout to see that this project meets its target since its commencement to its completion.

At last, I must express my sincere heartfelt gratitude to all the staff members of the Computer Engineering Department who helped us directly or indirectly during this course of work.

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Abstract—Image processing is a method to perform various operations on an image to extract some useful information from them. It is a format of signal processing in which the input is an image and output may be data or real-world detection of objects, scenarios and information. Our goal in this project is to use image processing to detect damages in properties.

I. INTRODUCTION

Property preservation companies work with bank owned disclosed properties that need to be renovated on a regular basis. The bank owns a lot of properties which have to be kept in a conveyable state. As they are considered investments the selling value of the properties have to be above market. The banks usually delegate this responsibility to National Contracting companies as it is not in their best interest to physically visit every property and fix them. The contracting companies are the ones who are handling these properties through sub-contractors who physically go to the property, report damages and bid to fix them. The only system of quality assurance in this business is through photos. The companies and the banks have only the photos taken by the contractor to go by, and confirm the work has been done correctly. This is where the business problem is. It takes countless hours and man power to Quality check every photo from every property. And the process to survey and fix every property is exponentially lengthier. Our project aims to use advanced image processing techniques to solve this bottleneck in the flow of this business. Using object detection and image segmentation we aim to quality check each standardized photo faster. And more efficiently to reduce man power and 2 to 3 layers of human quality checks.

II. FORMALIZATION OF THE PROBLEM

The projects main focus is to eliminate the countless hours it takes to sort out every image. As the issue we are looking into is quite diverse and large we took a small-time approach to using Deep learning and artificial Intelligence to try and make the process a bit simpler. Our main

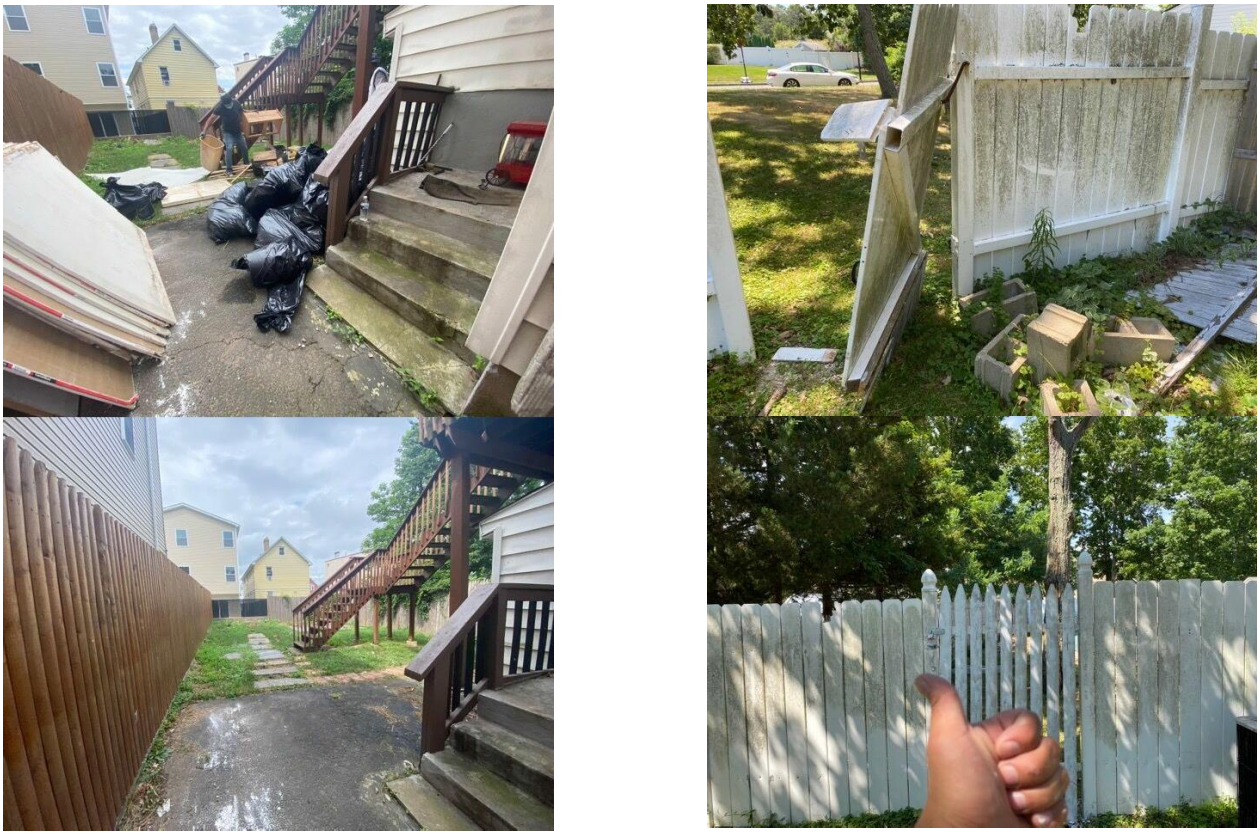
goal is to come up with a subscription-based product that goes into the market for both contractors and 3rd party processors to use. In the day on technology most of the work can be distributed to people. And Images are considered data. We are going to work with this data and make it more understandable and in turn make the whole process of more seamless.

A. DELIVERABLES

We aim to make a product that is present in all platforms. From the mobile which the contractor will use from onsite to the computer that will be used to process these images and send them to the National companies to prove of the work being completed in conveyance and with quality. We aim to use machine learning model and deep-thinking algorithms and basic front end and back-end programing to create the User interface of the software that we want to publish into the market at a later stage.

B. OVERVIEW

In this project we are going to discuss about Relevant work that has been done in this field that we have taken inspiration from. We are going to discuss about the Gaps that we found in works done before us. We are going to talk about the software and the tools that were used to accomplish this project. Our whole process from point A to Z of developing the work and the Methodology behind it. And we are also going to talk about some Results that we found accuracy wise and the future and effects of the project and what we predict it will achieve going forward. We are also going to give used guides and future updates that can be made to this software.



Sample photos to be processed

III. BACKGROUND STUDY

For this project we have used various articles and online sources to gather information on previous work done in the field. Since we had to train our own data for this project, we also had to learn annotation methods and making up a data set that we can work with. I would like to add that many of the things we researched and studied were not actually used but it gave us a good idea of what the project requires and what we are working with.

A. Image Classification:

Image classification is a technique that is used to classify or predict the class of a specific object in an image. The main goal of this technique is to accurately identify the features in an image. The main steps involved in image classification techniques are determining a suitable classification system, feature extraction, selecting good training samples, image pre- processing and selection of appropriate classification method, post-classification processing, and finally assessing the overall accuracy. In this technique, the inputs are usually an image of a specific

object, like the garbage in the above image, and the outputs are the predicted classes that define and match the input objects. Convolutional Neural Networks (CNNs) is the most popular neural network model that is used for image classification problems.

B. Object Detection:

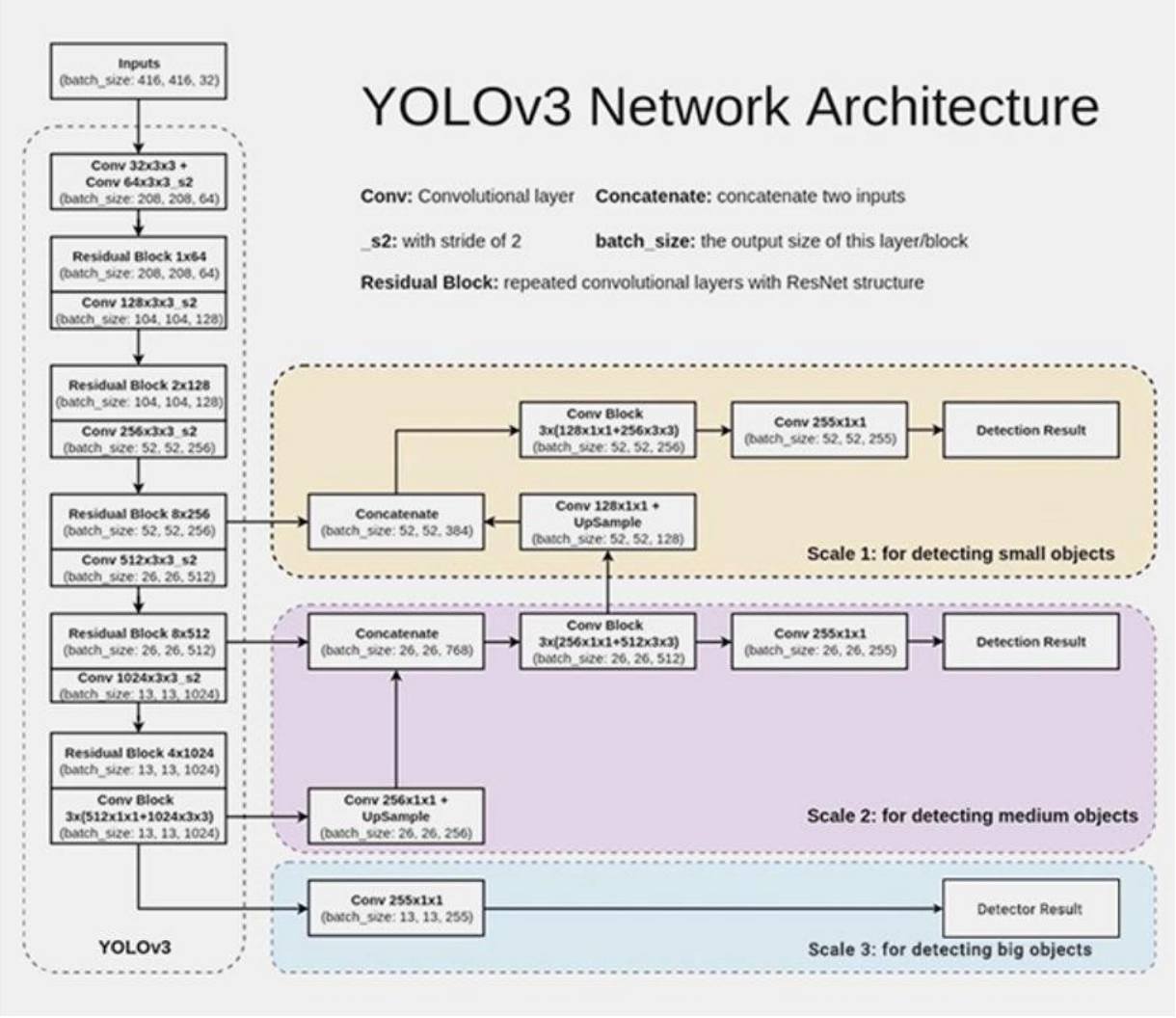
The problem definition of object detection is to determine where objects are located in a given image such as object localization and which category each object belongs to, i.e. object classification. In simple words, object detection is a type of image classification technique, and besides classifying, this technique also identifies the location of the object instances from a large number of predefined categories in natural images.

The pipeline of traditional object detection models can be mainly divided into three stages, that are informative region selection, feature extraction and classification. In the above image, it

doesn’t only classify that it is a fully loaded truck but also tells where the truck is located in the image.

C. YOLO (You Only Look Once) Algorithm:

YOLO V3 was implemented using a darknet framework, which originally has a 53 layer network trained on Imagenet. For the task of detection, 53 more layers are added to it, giving us a 106 layer fully convolutional underlying architecture for YOLO V3.



YOLO detects objects in an image very well unlike sliding window and region proposal-based techniques because it used to see the entire image during training and testing time so it gets

every detail about the whole image and the object and also it's appearance. The algorithm divides the image into grids and runs the image classification and localization algorithm on each of the grid cells. It predicts N bounding boxes and confidence scores in each grid. The confidence score reflects the accuracy of the bounding box of that class. As most of these boxes have low confidence scores so we can avoid unnecessary bound boxes or objects detected by setting a threshold.

D. Localization of the Objects

The first step in the object system is finding location on the objects. The object region is usually a common color on all properties. This implies that the transition between these the colors is very distinguishable. And it is very different compared to a house in perfect condition. Finding this region is done by locating the transition points. This is where we can use annotation methods such as Landmark Annotation, Semantic Segmentation, Lines and Splines, Polygons,3D Cuboids and Bounding Boxes.

E. Engineering Problem

For the project is finding the object in the image accurately. Annotation methods aren't always accurate and they need to be even more advanced than the ones we have. For now, we will be working with certain methods to detect the objects in our images.

1. Bounding Boxes: For bounding box annotation, human annotators are given an image and are tasked with drawing a box around certain objects within the image. The box should be

as close to every edge of the object as possible

2. Semantic Segmentation: Other annotation methods deal with outlining the outer edges or boundaries of an object, semantic segmentation is much more precise and specific. Semantic segmentation is the process of associating every single pixel in an entire image with a tag

3. Landmark Annotation: This type of image annotation for computer vision systems is landmark annotation, sometimes referred to as dot annotation, owing to the fact that it involves the creation of dots/points across an image. Just a few dots can be used to label objects in images containing many small objects, but it is common for many dots to be joined together to represent the outline or skeleton of an object.

F. Gap Identification

There weren't many gaps in this field to begin with that we could help identify. But the amount of work that was there specific to our dataset was very minimal. There has been other work done in the past with satellite images of using the matrices that we were using for example mold, Debris and other stuff. But overall, we had to make our own dataset to achieve this project. And that in itself is a gap that we had to fill.

Our goal is to confirm if there are objects or damages on the property and whether the work has been completed without. And also denote other damages that require thorough inspection. For this our object detection has to be on point and annotation the image must have as less error as possible.

IV. SOFTWARES AND TOOLS

Google Collab was used to train and test the model that we have created. 2. Visual studio was used to implementation of Django. 3. Android studio android studio was used for web view and web model.

A. Frameworks

1. Django

Django is a high-level Python Web framework that encour- ages rapid development and clean, pragmatic design. Built by experienced developers, it takes care of much of the hassle of Web development, so you can focus on writing your app without needing to reinvent the wheel. It's free and open source.

2.Dango rest frame work

Django REST framework is a powerful and flexible toolkit for building Web APIs.

Some reasons you might want to use REST framework:

- The Web browsable API is a huge usability win for your developers.
- Authentication policies including packages for OAuth1a and OAuth2.
- Serialization that supports both ORM and non-ORM data sources.
- Customizable all the way down - just use regular function- based views if you don't need the more powerful features.
- Extensive documentation, and great community support.

• Used and trusted by internationally recognised companies including Mozilla, Red Hat, Heroku, and Eventbrite.

B. Libraries

• Tensorflow object detection api TensorFlow is a free and open-source software library for machine learning. It can be used across a range of tasks but has a particular focus on training and inference of deep neural networks. Tensorflow is a symbolic math library based on dataflow and differentiable programming.

• Numpy NumPy is a library for the Python programming language, adding support for large, multi-dimensional arrays and matrices, along with a large collection of high-level mathematical functions to operate on these arrays

• Pillow Python Imaging Library is a free and open-source additional library for the Python programming language that adds support for opening, manipulating, and saving many different image file formats.

• Opencv

OpenCV features GPU acceleration for real-time operations.

• pycoco tool

pycoco is a script that can be used to generate code coverage info for the Python source code.The script downloads the Python source code, builds the interpreter with code coverage options, runs the test suite and generates an HTML report how often each source code line in each C or Python file has been executed by the test suite.

• ipython Python is a command shell for interactive comput- ing in multiple programming languages, originally developed for the Python programming language, that offers introspec- tion, rich media, shell syntax, tab completion, and history.

• pandas matplotlib pandas is a package commonly used to deal with data analysis. It simplifies the loading of data from external sources such as text files and databases, as well as providing ways of analyzing and manipulating data once it is loaded into your computer.
Matplotlib is a Python package used for data plotting and visualization. It is a useful complement to Pandas, and like Pandas, is a very feature-rich library which can produce a large variety of plots, charts, maps, and other visualizations.

C. *Languages*

Languages

- Python- Used to code machine learning algorithms and train our model.
- Angular- Used to create the application for the user interface.
- Html css- Used for the front end of our application.
- Javascript- Used for the front end of our application.
- Bootstrap- Used for the back end of our application.

For this project we first use Google Collab to implement the Deep Learning Libraries in training and testing of our data. We created a model that was accurate in detection various images that we created a fresh data set for.

We then converted that model to a website using Django framework and we used Visual studio to work on those. Where you can upload the photos and run the classifier and then download the photos.

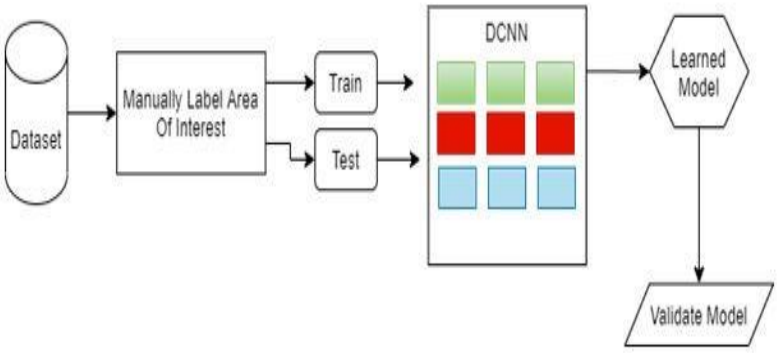
The application was made with Android studio where one can upload the photos and the photos will be transferred to the server and the website we created.

Due to price restriction, we could now get a server as it is too expensive to maintain so we did it locally. But as a domain is purchased for our application and website the sync between them will me seamless.

Most of the tools we used are the best in the business and easily accessible and also easy to learn. As they are all open sources tools there is vast libraries and utilizations that we thought were useful to our project.

V. METHODOLOGY

Methodology of our project is to specify damages and if the damage was fixed thorough processing the images that the contractors have sent us after they have done the work. In the introduction our main project is to solve the problem of extra human effort. For this we used object detection as it was pretty obvious. After doing the literature review, we came up with a strategy to continue the project. For our specific project, we had to source images from the contractors and annote them. We had to process about 5000 images to get a subsequent data-set from which we could build our model. The images were annotated by classes we created for every damage and the respective damage being fixed. For example, if there was mold we used Mold as a class an annotated that area using a bounding box. And use the photos of the damage being fixed to annote no mold. We did the same with different types of damages. Like wall damage, door damage, debris etc. Once we had a workable database with enough variations and information, we went onto out next process which is training the model. We decided to use SSD mobleNET v2 which is a deep neural network. We used that with a deep learning framework called TensorFlow. We used the XML data from the images and split the date into test and train segments. 30 percent test and 70 percemt train. then we converted the train and test XML files into CSV. further, test and train CSV is converted into TFrecord data which is a TensorFlow record file having all the images and labels. The language we used for all the data processing is Python. This was the initial image processing and object detection tasks we did. We mean to further improve the model by adding in more classes and more images to get better data. For the object detection part, we selected the DCNN using tenserflow object detection api. We can choose any DCNN for example SSD mobilenet v2 faster rcnn resnet squeeze net after selection we provide the prepared data to selected model and start training after the training completion, we export the model as frozen graph. Pb which is our output file and final model.



Here is the pipeline that we created.

VI. COLLECTING DATA

The data was collected from photos of inside the property and outside. Of both the damage being there and after being fixed. So we have a consistent flow of data for True Positive, False Positive (FP),False Negative (FN) and True Negative (TN):

A. Matrices

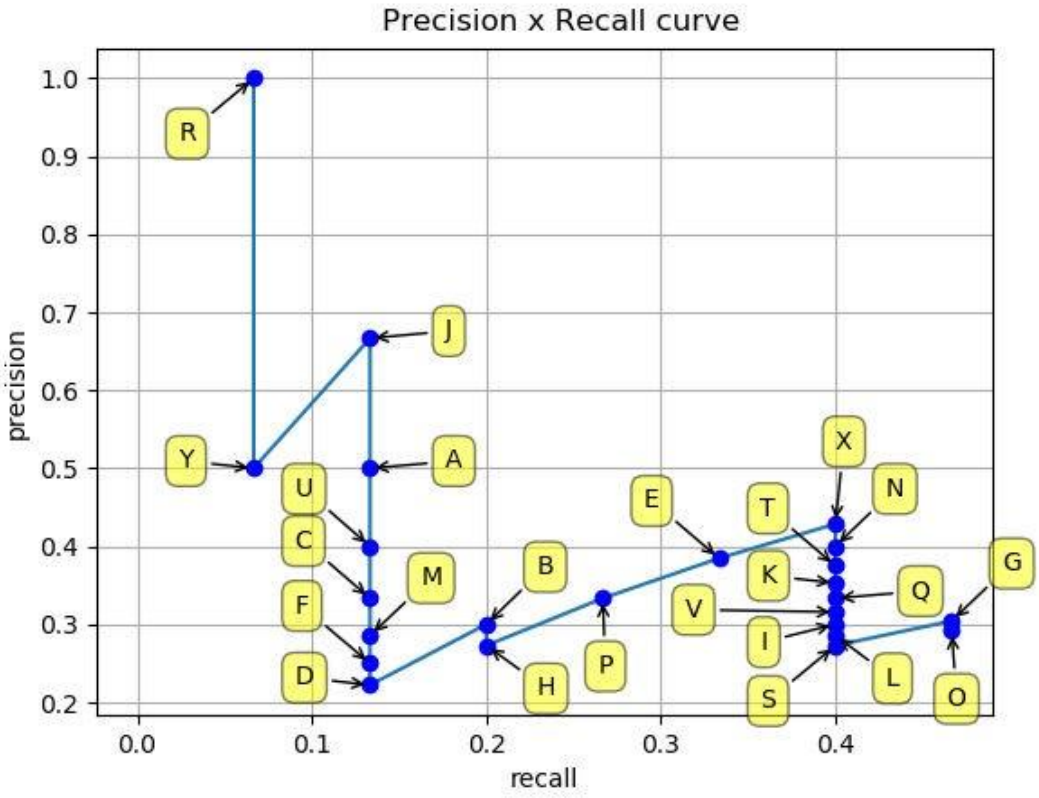
Matrices evaluate the performance of our object detecting algorithms.

Object Detection Matrices:

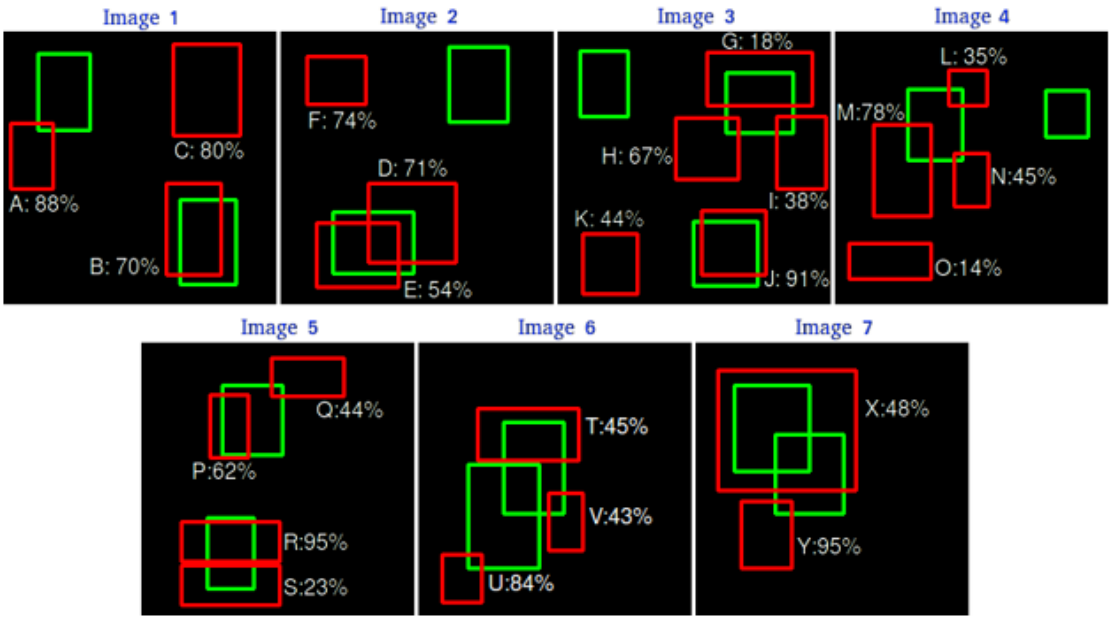
1. Precision x Recall Curve (PR Curve)
2. Average Precision (AP)

3. Mean Average Precision (mAP)

1. Precision x Recall Curve (PR Curve) The Precision x Recall curve is a good way to evaluate the performance of an object detector as the confidence is changed by plotting a curve for each object class. An object detector of a particular class is considered good if its precision stays high as recall increases, which means that if you vary the confidence threshold, the precision and recall will still be high. Another way to identify a good object detector is to look for a detector that can identify only relevant objects (0 False Positives = high precision), finding all ground truth objects (0 False Negatives = high recall). [1]



2. Average Precision (AP) Another way to compare the performance of object detectors is to calculate the area under the curve (AUC) of the Precision x Recall curve. As AP curves are often zigzag curves going up and down, comparing different curves (different detectors) in the same plot usually is not an easy task - because the curves tend to cross each other much frequently. That's why Average Precision (AP), a numerical metric, can also help us compare different detectors. In practice AP is the precision averaged across all recall values between 0 and 1. [1]

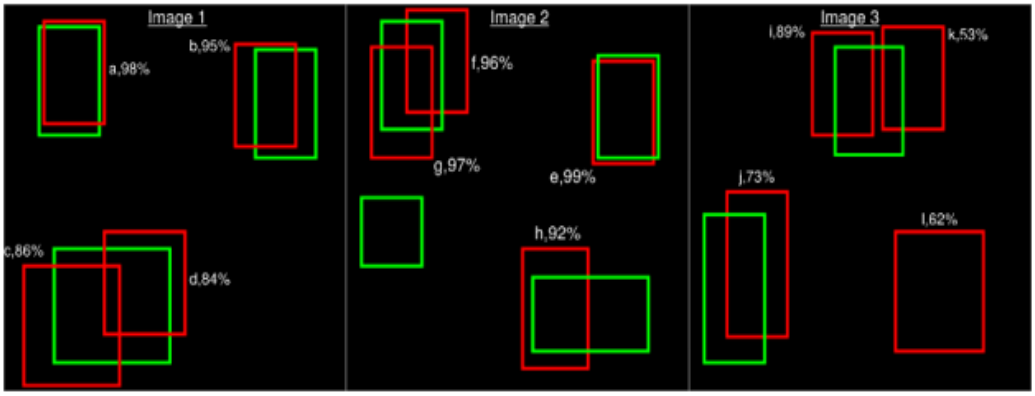


11-point interpolation method A 11-point AP is a plot of interpolated precision scores for a model results at 11 equally spaced standard recall levels, namely, 0.0, 0.1, 0.2, . . . 1.0. It is defined as

$$\text{AP@}\alpha_{11} = \frac{1}{11} \sum_{r \in R} p_{interp}(r),$$

3. mean Average Precision (mAP) Remark (AP and the number of classes): AP is calculated individually for each class. This means that there are as many AP values as the number of classes (loosely). These AP values are averaged to obtain the metric: mean Average Precision (mAP). Precisely, mean Average Precision (mAP) is the average of AP values over all classes. [2]

$$\text{mAP@}\alpha = \frac{1}{n}\sum_{i=1}^{n} \text{AP}_i \quad \text{for n classes.}$$



VII. ANALYSIS

We have also used confusion matrix which is a error matric to analyze the performance of the algorithm. From the work we did so far, we have analyzed that the project is doable within the amount of time given and the resources we have. But for the model to be more efficient we need to put in more data and training hours to get an even accurate program. The issue we are facing is when there are a lot of damage in one photo. This is due to the images in all honesty. As we get more images the model will be trained better. For example, if there is mold, wall damage and debris in the same photos then everything is recognized as mold. This can only be fixed with increasing the dataset which is time consuming and needs a lot of resources. There is a low precision issue that is caused due to the lack of data with more than one issue in a single photo. The images are also not clear and basically the efficient of our project is based on time and more input of data.

VIII. EXPERIMENTAL DETAILS

It took us about 40-45 hours to train the date and about 250k steps. We had a few issues with these as the results were not consistent but however it was promising. The model was working with simple images where there weren't as many variations as shown in the images below.

IX. RESULTS


Debris 97.1%


No mold 92.7%
07/22/2020


Empty Truckload 99.1%


Full truckload 99.0%


Mold 56.1%
07/22/2020

X. POST DEVELOPMENT CONCERNS.

A. Sustainability

Property Preservation is a field that is here to stay. Banks are always going to give out profitable loans to home owners and in tern invest in properties. With that our business that the project is revolving around is here to sustain. And mentioned the need for a software like this is also very crucial in ensuring the efficiency of the functionality of the business. In USA as loans increase the chance of them defaulting and the property being ceased by the bank will increase too. And with that the need to maintain these properties. Hence there will always be businesses that will have a need to process images and do the preservation work that is necessary. Specially in 3rd world countries that solely focus on just processing the image. Any software that can cut the execution time of a processor who processes and quality checks the image is welcomed in the businesses. And our product is in high demand according to market research and surveys.

B. Environmental Impacts

This is solely a business issue. We don't mean to improve, solve or help out on any social issue. Nor is there a health or safety issue with this software. Our project is aimed for the market where we provide solution to a specific type of business know as property preservation. The impact is completely economical and is inspired by making a profit in the future.

C. Economic issues

Currently in property preservation the damages are reported to the National Companies in USA. The companies that handle the properties for the banks that own them. Once the property is for closed the bank delegates the duties of maintaining the property to these nationals that then in turn give smaller companies to handle the work. As the contractor goes to the property and uploads the damages and the work being made through photos; human processors have to then manually look at thousands of photos each day. This is extremely time consuming. Out project will take those photos in bulk 3000- 5000 photos at once and find the damages out automatically. This will save time, resources and most importantly money. But however, the issue is that it might make a lot of human jobs redundant. Our project will impact this business of property preservation immensely and chance the way the system is built. It is completely ethical but

from a humanitarian point it making a lot of jobs redundant. There is a lot of money to be made in this business and our project will make the whole process more efficient and cost a lot less money to operate. We plan to use this project to develop a software in the future that will take bulk photos and not different types of damages in properties.

D. Ethical Consideration

The relevant ethical issue we might face is the mere extinction of man power. For example, the office I work for employees 20 people just to analyze the photos and process them. There is a vendor website where all the work that needs to be done and all the damages at the property have to be noted. The contractors don't do this. It needs to be analyzed from the photos and put in manually. If what we are aiming is achieved it might mean the extinction of manual labor. And companies can just pay for my software to get the work done. All they need are photos of the house and the software will note everything. So one can say I'm ensuring that my colleges' carriers become obsolete.

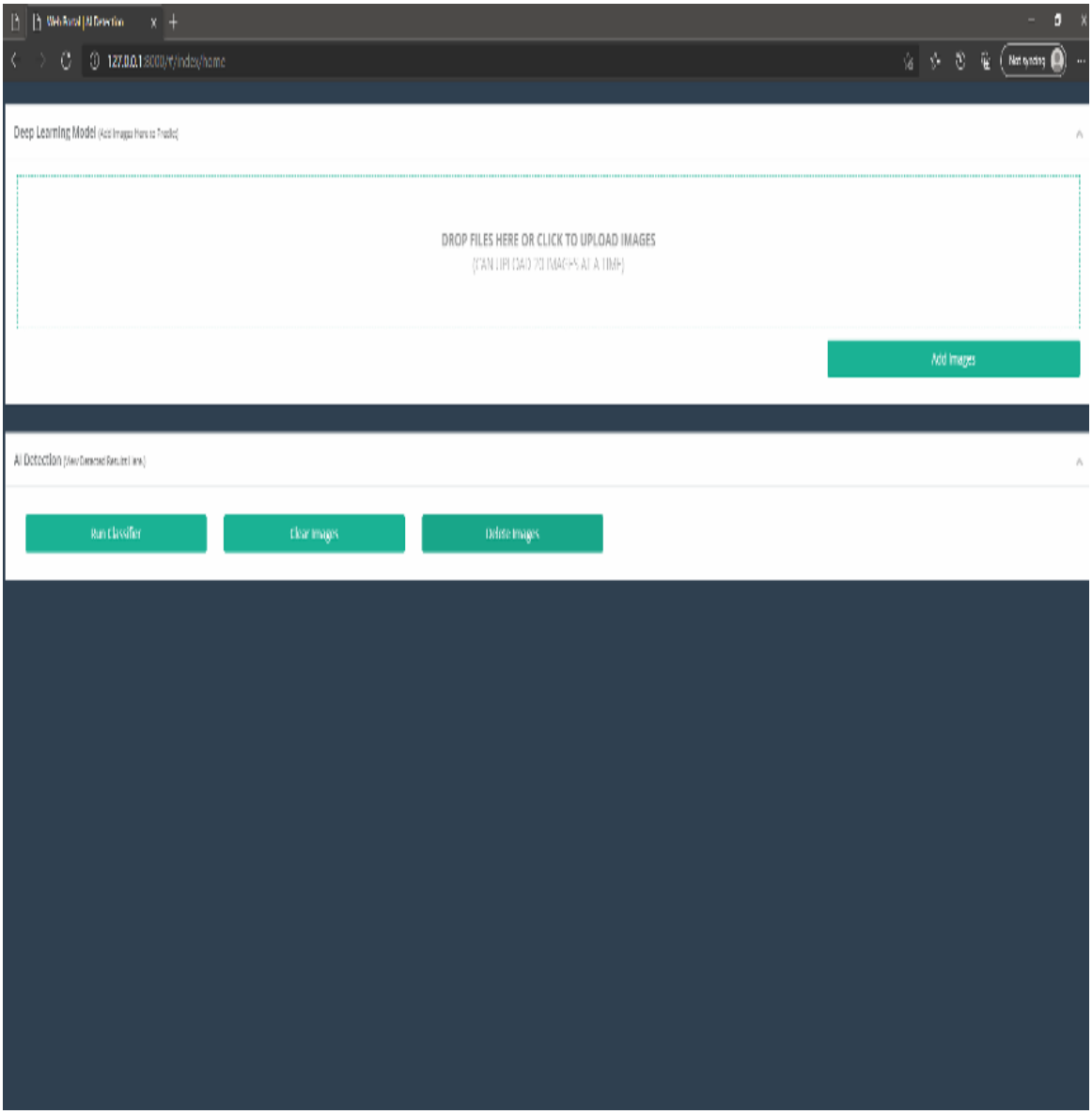
E. Usability

Our application is very user friendly. You just need to login in to the website and the application and access with it with your own unique credentials. The rest of the process is very easy for the average target audience of this application. You just upload the photos and they are segmented. The real work goes out at our end and the user doesn't need to worry about it. There is a process however of developing the accuracy of the application over time which can only be achieved with the increasing about of total users and more photos and various cases.

XI. DEMONSTRATION

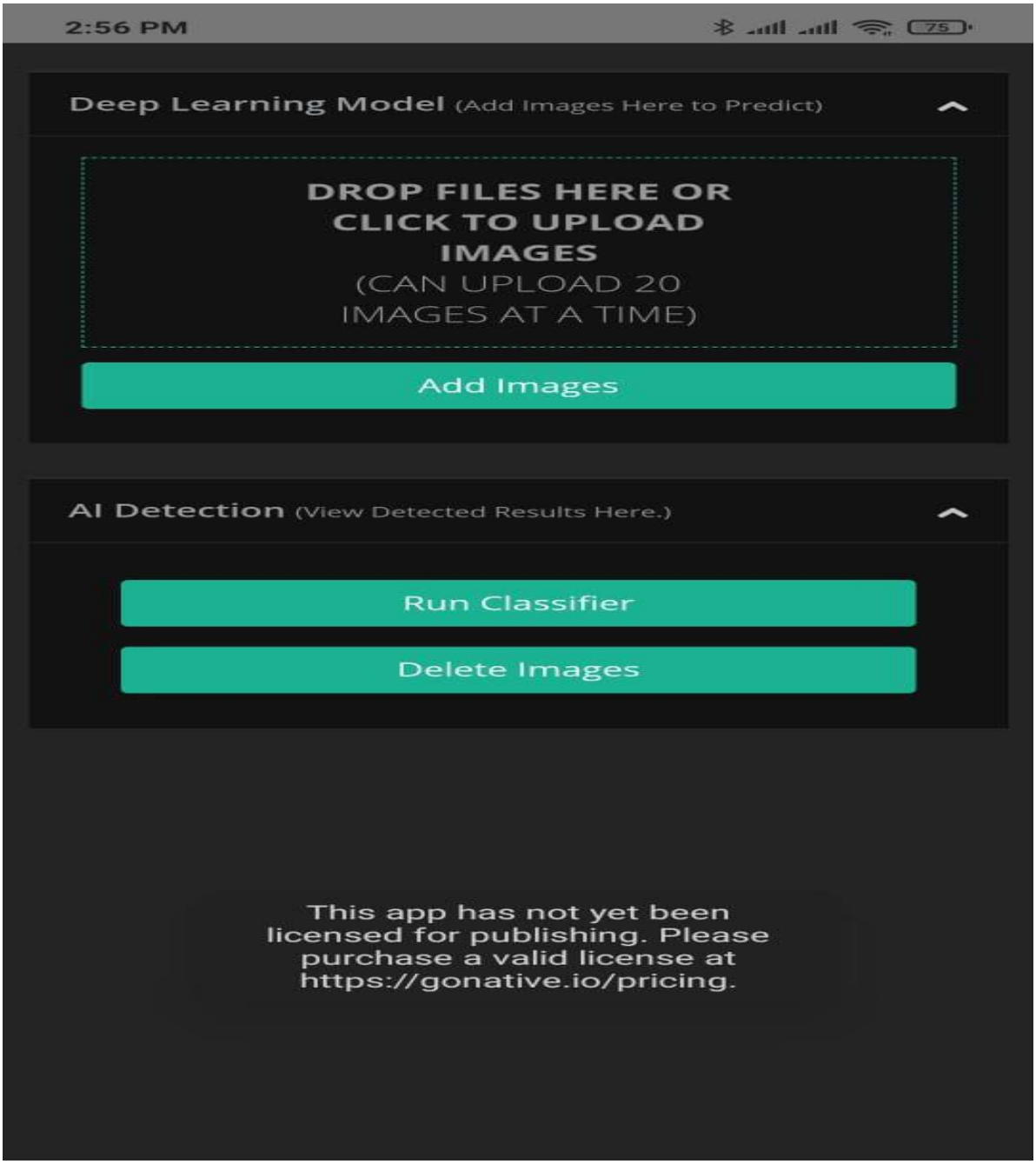
For our demonstration we have segmented the demo into two parts. Firstly, we have given a small intro to what property preservation is and the value of photos in the business and how it is sorted and figured out. The images are download through various management software that are used in the business and photos are used to give bids for work that is need. For example, if there is drywall damage or grass overgrowth at the property, we will bid to fix those issues with a set amount.

A. Website Interface



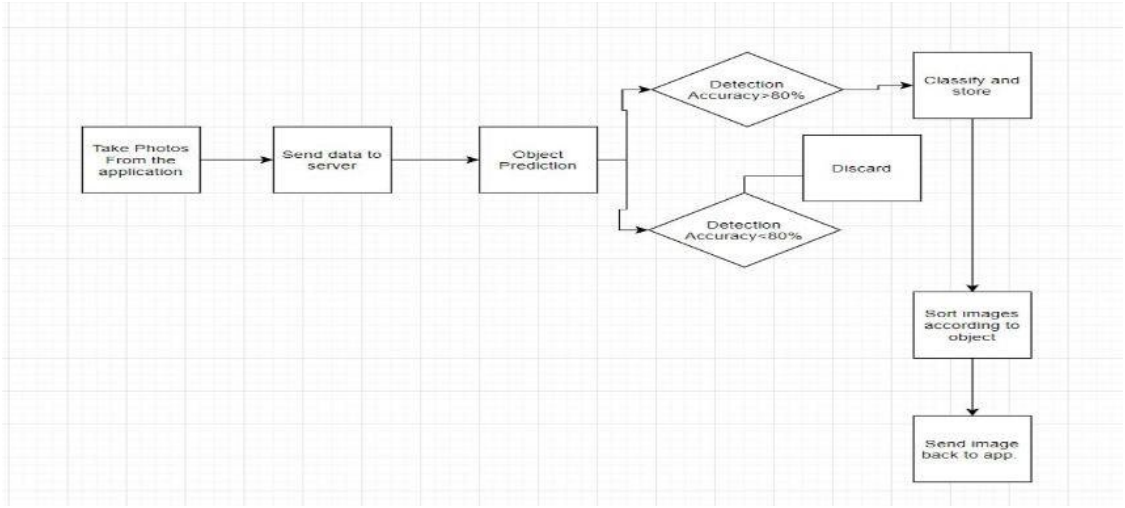
This is our website interface where you can upload the photos and the results will show accordingly.

B. Application



The web application is used to upload the photos through the camera. And will be directly linked to the server and show on the website portal. Thought this process is not actually necessary as the contractors on the field dont really process the photos themselves. But its an added bonus that we have implemented.

C. *Website Interface*



Our main objective is to optimize the business through this flow chart.

XII. FUTURE EXTENSIONS

For future work we want to improve the algorithm and more matrices to improve the precision. We will need to annote more images and add it to the dataset and invest more time into training the data. We also hope to implement the ML algorithm to the app we have planned where a contractor will upload photos and a summary of the damages and if they are fixed or not are noted. Our main goal is to eliminate the need for human processing. But on realistic terms we aim to reduce human error and increase the efficiency in this field of analyzing damages through pictures. In the future we intend to release this software with more patches that include other fields of property preservation. We intend to apply more machine learning technology where the software will automatically detect the damage and predict the price that is needed to fix it and give bids. This even further decrease the time needed to process work orders. And each task can now be completed smoothly with lower man power.

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[2] rafaelpadilla, Object-Detection-Metrics, 11-point-interpolation.

[3] K. E. Koech, Object Detection Metrics With Worked Example

[4] https://en.wikipedia.org/wiki/Kernel(imageprocessing)

[5] www.google.com

For this project Ornab Olindo has handled the data collection, Data annotation and the main coding and training part and report writing, website and the mobile application. Sohel Rana has contributed to annotating the data, collecting resources and writing parts of the literature review and the final paper.