

A Deep-Learning Based Approach to Bangla Currency Recognition in Real Time

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A Deep-Learning Based Approach to Bangla Currency Recognition in Real Time

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**A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree
of Bachelor of Science in Computer Science and Engineering of the University
of Asia Pacific**

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DECLARATION

We hereby proclaim that the work presented in this project is the result of the analysis conducted by us under the observation of Md. Hasan Murad, Lecturer, Department of CSE, University of Asia Pacific. We also declare that no part of this project has been or is being submitted elsewhere for award of any degree or diploma.

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Finally, we would like to thank our all-honorable faculty members, family and friends for their support and being always with us.

Abstract

Nowadays, researchers are trying to provide working solutions to the day-to-day problems faced by visually impaired people. Currency recognition using android phones can be a promising solution for visually impaired people for the safety and security during financial transactions. In this research work, we are going to implement a camera-based system that can detect Bangladeshi currency automatically. Our goal is to use 2500 images to make the dataset. To design our model architecture, we are deploying the state-of-the-art object detector model named YOLOv4. We will train our model using our Bangla currency dataset. Finally, we will deploy our trained model by developing an android application which will be user-friendly for the visually impaired people.

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Chapter 1 : Introduction

This system works with real time currency detection. Basically, it's for visually impaired people who have been deprived from society. According to ³ World Health Organization (WHO) reports that 253 million people are visually impaired globally and among them 36 million are blind and 217 million have moderate to severe vision impairment. From the recent statistics Bangladesh has 650,000 blind adults aged 30 and over in Bangladesh. This system can recognize, identify and show real time results of the currency note of People's Republic of Bangladesh (TAKA). As nowadays transactions of Currency is increased to a large quantity and most of them happen face to face, it is difficult for visually impaired people to know how much currency they are transiting.

³³ This system is based on deep learning methodology. we develop a system that will be able to recognize currency with great accuracy. For this YoLo-v4 will be the best solution. It is faster than any other object detection algorithm.

1.1 Motivation

Our primary motivation was visually impaired people. There are so many people in our country who are totally blind or partially sighted. Some of them are blind by birth, some of them lost their sight due to accidents or injuries. According to research [1] 50–80% of blindness in this region are due to cataracts. Latest research ³⁸ of the ³ World Health Organization (WHO) [2] reports that 253 million people are visually impaired globally and among them 36 million are blind and 217 million have moderate to severe vision impairment. From current estimation, Bangladesh has 6,50,000 blind adults aged with 30 years or more in Bangladesh, the majority of them are agonized from operable cataract [3].

While leading their daily life in society, visually challenged people face a terrible amount of challenges. This is because so much information is expressed visually. Among so many problems one of the major problems is knowing the value of the currency that they are currently holding in their hand. As nowadays transactions of currency are increased to a large quantity and most of them happen face to face, it is difficult for visually impaired people to know how much currency they are transiting.

They may get fraud by dishonest people. Another problem agonized by a visually impaired person to recognize paper currencies. This is because of nearly similar paper size and texture between banknotes. As credits are the commonly used material in day-to-day life, recognizing the value of the banknotes is a very essential task for them. Therefore, we have put forward a real-time system that will help them to recognize the banknotes and resolve this issue to make visually impaired people feel confidence in the financial dealings, not depending on others.²

Only country in the world that prints all denominations of Banknotes in the same size is the USA. Only two countries that use the same colors for all of their various bills are The US and Switzerland. It is safe to say that similar size and colors make it hard for a blind person to recognize the correct bills to make a purchase without any assistance [4]. A sightless person can identify paper currency by folding each denomination in different ways. Although the idea of folding the currency seems a good step, it needs others' help to serialize the bills. The recent banknotes of Bangladesh have three dots for blind humans, which can be effective to check the value of the bill by touching. As the embossing fades away in the banknotes that are in circulation for a long time, It is hard to identify the bank note after several uses [5]. Moreover, in a developing country like Bangladesh, visually impaired people fall victim to deception on a regular basis while transacting money. Therefore, to ensure safety and confidence during financial transactions conducted by visually impaired people, they need assistance from technology to recognize Bangla currency. The main argument in this project is realization of deep-learning based currency recognition software. According to the procedure in this project and perform currency recognition step by step, it includes identifying the bank-note.

1.2 Social and Ethical Issues

The term “visual impairment” is employed to explain a large number of conditions that have an effect on clarity of sight and field of sight. Visually impaired people have been deprived from society. Day to day life is not that easy for them. One of the daily matters they have to deal with is acknowledging the currency they are using. Though there are some ways imprinted in every Bangladeshi note to recognize the value just using our touch senses. But not everyone knows about it and it is hard to remember. Also, the note can be damaged in a certain way, it can't be acknowledged. Another Ethical issue sightless people have to face is getting defrauded by some ill-intentioned people. It is a matter of mortification for our society. So, our approach on this issue using deep-learning algorithms can have a huge impact on society.

1.3 Sustainability Issues

At this moment there are so many systems or applications to detect and identify different types of currency. Several research happens to resolve this problem. The USA Department of Treasury invented a device that can detect currency. There are also some other apps available and these systems are able to give output in real time. But for Bangladeshi currency there is no well-known, easy to use system. This is an opportunity for us to do something for our people. A large number of visually impaired humans face hassle in their daily lives during currency transactions.

Our project can save their money from falling into the wrong hands. This project can be well accepted by society and beneficial for the visually impaired. Day to day transactions can be easily done by this system. This type of system has side effects on the environment and the society. As we know coronavirus can spread through Bank Note. If visually impaired people use our app, then they don't have to touch the Note to identify the value of that currency. This can help them prevent contamination of coronavirus. As Bangladeshi banknotes have blind spots, visually impaired people have to rub the note to understand it. If they don't have to do it then they can keep themselves away from lots of germs and bacteria.

1.4 Related Work and Limitation

For this project, this report will read many research papers on currency recognition, object detection, image processing and edge detection(ORB). We tried to refer them into the reference section of this report. But we evaluate some projects and research papers on our own.

The papers we are trying to uphold here are :- Prof. Sagar S.Rajebhosale [7], Sandeep Kumar Chaubey [8] and Md. Ferdousur Rahman Sarker [9]. All of these systems are well proposed and designed. But we found some relative issues that we are going to explain in a later segment of this report. And the project we are developing will overcome all these problems.

1.5 Problem Statement

An approach based on deep learning methodology to solve the currency recognition problem for the people suffering from visual impairment. A system that can recognize, identify and show real time results of the currency note of People's Republic of Bangladesh (TAKA). In this project we are also developing skills on image annotation, image processing, object detection model training.

1.6 Contribution

Here we have created a model to recognize Bangladeshi currency. Our model can identify all running banknotes that exist in Bangladesh. Here we are going to summarize our contribution.

In the past, no perfect dataset has worked on recognizing Bangladeshi currency. We worked on the dataset to label it correctly for training purposes. Training purpose was not 100% accurate. We tried to train it to achieve more accuracy.

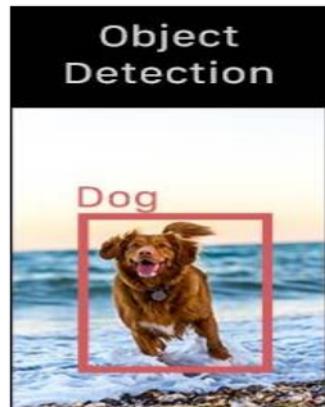
We used YoLo v4 to train our dataset. Currently it is the best option for object recognition in machine learning. We have done training, testing, validation for our dataset and model. Finally, we write this paper based on our project.

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Chapter 2 : Background Study

In background study we will talk about the knowledge we had to gather to complete this project. We will discuss object detection, machine learning, deep learning etc.

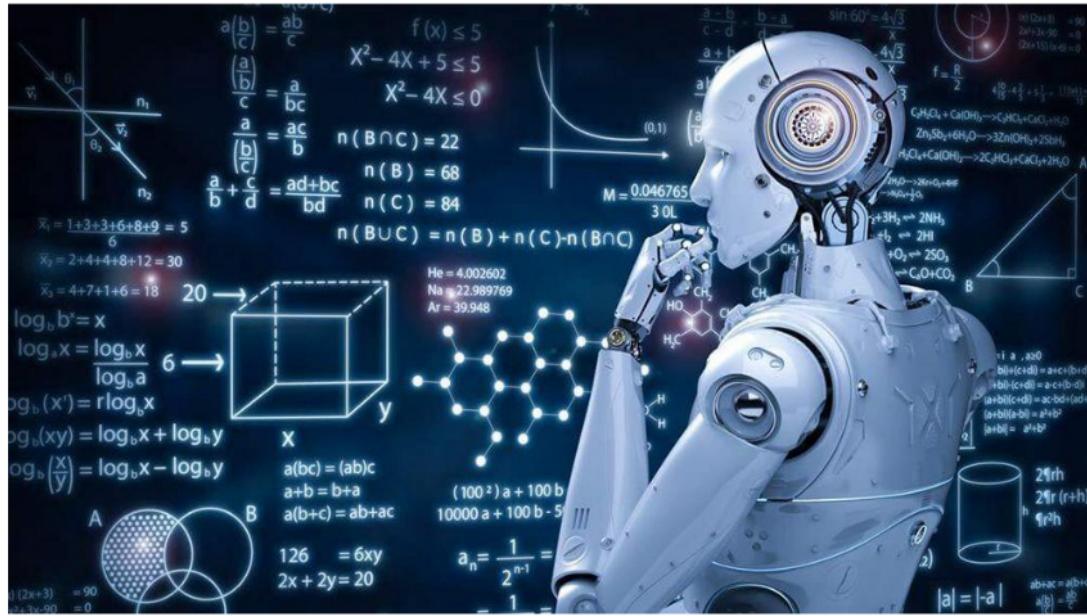
2.1 Object Detection



Object detection allows us to identify and locate an object from an image. This technology is related to computer vision and image processing which work with semantic object class. In short, if we want to define what object detection is then we can say this technique is to draw a box around the object and label the particular object. The model decides which object is and which label is to apply.

2.2 Machine Learning

Machine learning is a study of algorithms. It can improve by itself by experience and use of data. Basically, machine learning is a process of data analysis which helps us to build analytical models in an automated system. In this technology a computer can learn by itself by using data.



2.2.1 Machine learning Approach

Supervised Learning

Supervised machine learning is a subclass of machine learning. Basically, it uses a labeled dataset to train algorithms that we use for determining objects. As input data is provided into the model. This model is being continuously adjusted until the weight of the model is well fitted, which occurs as part of the go through validation process.

Unsupervised Learning

Unsupervised learning algorithm use for unlabeled and non-classified data sets. This algorithm couldn't find out target output but draw inference from datasets that people aren't explicitly looking for. Example of unsupervised learning clustering algorithm, dimensionality reduction.

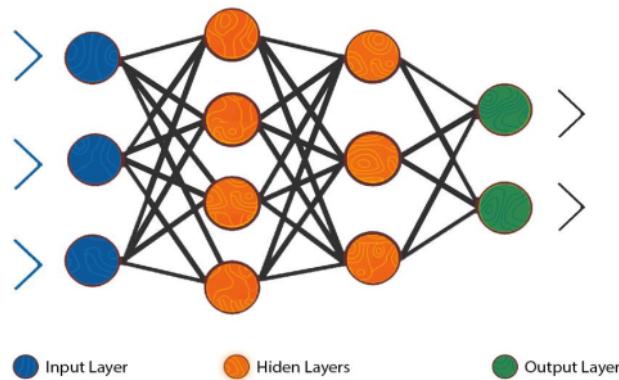
Reinforcement Learning

Reinforcement learning (RL) may be an important sector of machine learning. It deals with how an intelligent agent takes action to support the thing. It doesn't like any input or output labels. It abides by the Andrei Markov call method. The purpose of reinforcement learning is to show a man-made agent to require action by gazing at object or associate surroundings. Here the bogus agent is trained o.k. in order that the agent will take the correct steps at the correct time.

2.3 Deep Learning

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Deep Learning is a subclass of machine learning apprehensive with algorithms inspired by the structure and performance of the brain called AI. Deep learning AI is in a position to find out without human interval or supervision, drawing from a dataset that's both structured and unmarked. Deep learning uses multiple layers to extract complex high-level information. Here we discuss deep convoluted neural networks and deep recurrent neural networks.



2.4 Model Architecture

Different model architectures are used in machine learning for different purposes. One is used to classify images, one is good for predicting the next item in a sequence, and one is good for sorting data into groups. Some are good for multiple purposes, and some are good for just one.

2.5 Computer Vision

Computer vision is a subject where a computer discusses how to acquire a high level of knowledge from a picture or video. It can do a whole job quickly and very easily. Moreover, it can repeat a task very easily. Computer vision always tries to give very perfect results. It always plays an important role for face recognition. Here are some of the important sub-area of computer vision, Image classification, Object recognition, Object tracking.

2.6 Image Classification

Image Classification is a central assignment that endeavors to appreciate a whole picture overall. The objective is to arrange the picture by doling it out to a particular mark. Regularly, Image Classification alludes to images in which just one item shows up and is dissected. Conversely, object discovery includes both characterization and confinement errands, and is utilized to break down more sensible cases in which different items may exist in an image.

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2.7 Object Recognition

Object Recognition is a sub-area of computer vision. Object Recognition is a technique to identify objects in images or videos. There are a large number of practical applications of Object Recognition. Face Recognition, Face Detection, Image Annotation, Activity Recognition, Video object co-segmentation are some examples of object recognition.

2.8 Object Trucking

Object Tracking algorithms detect moving objects in videos. Traffic controlling, medical imaging, sports analysis, autonomous driving, security and surveillance are most common object tracking work.

Chapter 3 : Related Work

We search for research papers, projects and live software on the internet. We got so many results and trying to uphold few of them here ,

3.1 Related Paper and Limitation :

A research paper called “Currency Recognition System Using Image Processing” was published by Prof. Sagar S.Rajebhosale [7]. In this paper the researchers proposed a system based on image processing. In this method input Image will be converted into digital form and then compared with the previously setup template. They propose to use a different system than the user. Users have to upload the image to a server, then the server will process it and return the result to the user.

This system is not fast enough, like, the total time for returning the result might take a while depending on the multiple variables. For example, users have to upload the image to the server then the server will process the image with various operations, compare with the database in the server and return the result to the user. In our observation, this is the main limitation of this system. It's not reliable because the main processing is not happening on the user's device.

3.2 Related Paper and Limitation :

Sandeep Kumar Chaubey [8] submitted a report on “Currency Recognition System using image processing”. In this paper the researcher uses image analysis , image processing and edge detection. Image analysis tasks such as reading bar-code tags or as sophisticated as identifying a person from their face. Edge detection is used in image analysis for recognizing region boundaries. Researchers are using the MATLAB environment. MATLAB is considered as a high level advanced Computing language. It has a variety of API for image processing.

After analyzing their research paper we found some limitations: they use image processing, image analysis and edge detection which don't get a high percentage of accurate results. They use the MATLAB environment. Matlab is very complicated to use. Matlab is a confusing mixture of multiple programming languages like c, c++ and java. So manipulating this system is quite complicated in our observation.

3.2 Related Paper and Limitation :

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"Real-Time Bangladeshi Currency Detection System for visually impaired persons" named research paper was published by Md. Ferdousur Rahman Sarker [9]. In this paper, the researchers propose an image processing based system that will use Keypoints Detection. Their approach to the system is very impressive. The proposed system can be reliable and process time for each image will be fast because of ORB Keypoint detection.

After reading about their paper and researching their approach, we have found some slight limitations on this method. Though they train the neural network with ideal and distorted images, it still might have some issues. Though they used Keypoint Detection to make it fast ,but when the bank-note is folded Artificial Intelligence won't be able to find all the Keypoints. Hence, the result accuracy will decrease. Similar problems also can occur when the bank-note is stained.

Chapter4 : Proposed Solution

In this phase, we discussed about the model architecture of YoLo-V4 model and details about our model training: -

4.1 Model Architecture: YoLo V4

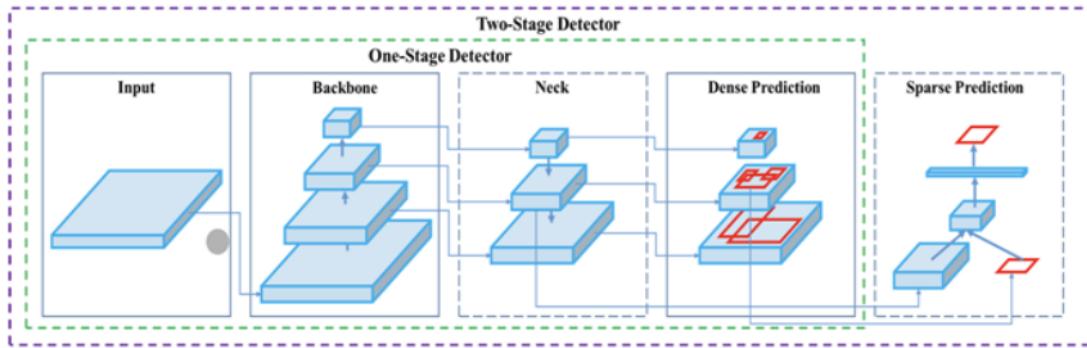
YoLo was originally authored by Joseph Redmon to detect objects. The full meaning of YoLo is “ You Only Look Once”. YoLo is a sophisticated Neural Network for object detection in real time. In YoLo, a single neural network predicts multiple boundary boxes simultaneously and class probabilities for those boxes. YoLo works on complete images and directly optimizes detection performance and speed.

YoLo-v4 model published in April 2020 and achieved state of the art performance in COCO dataset. The object detection task broken into two steps :

- Regression to identify object positioning through bonding boxes
- Classification to identify the object classes

Yolo-v4 outran all existing methods significantly in both terms detection performance and superior speed. The main objective is to optimize neural network detectors for parallel computation. Yolo-v4 consists of :

1. Backbone (CSPDarknet53)
2. Neck (Spatial Pyramid Pooling, PANet path aggregation)
3. Head (YoLo-v3)



4.2 Model Training

Model is one of the most crucial parts of this project. A Neural Network Model is a technique for approximation of an unknown function using a dataset or observation. In another construct, a neural network model resembles the way a human brain works. Yolo-V4 model training has some different steps than all other Neural network training methods. To train our model we had to create our own dataset including 9 classes. Using Label-Img software, we add annotation in Yolo format. We used a pretrained weight (yolov4-tiny.conv.29) to train our model weights. In this project we used several tools :-

1. Label-Img Master
2. Anaconda
3. Notepad++
4. GitHub Desktop
5. Google Co-lab
6. Window Photo Editor

Chapter 5 : Result

We configured our model to train up to 7000 iterations. Here is the corresponding loss vs iteration and mAP vs iteration graph. In the Loss vs Iteration graph, we can see that with increment of iterations, reduction of loss. At 7000 iteration loss becomes 0.0206.



Figure : Model loss graph

On the other hand, mAP vs iteration graph, with the iteration increases , mean average precision (mAP) increases. At the maximum iteration our mAP was 22%. There is room for improvement in this attribute, but it demands more resources.

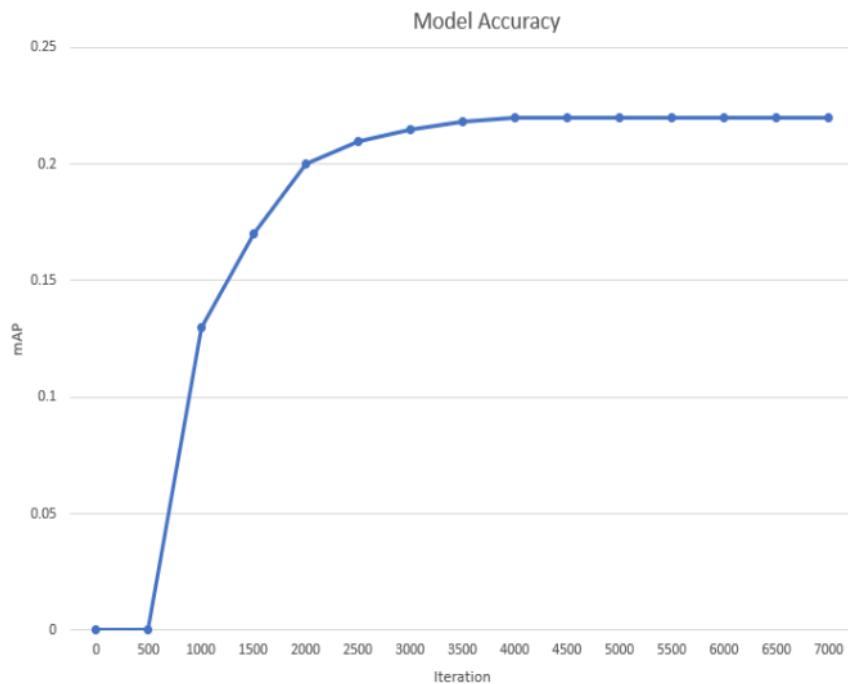


Figure : Model Accuracy graph

5.1 Dataset

Dataset helps the YoloV4 model to generate the approximate function to detect previously unknown objects. In this project we used 9 classes, containing all the currency printed on paper that is currently in use. Name of those class are :-

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- | | |
|----------------|---------------------|
| 1. Two_taka | 6. One_hundred_taka |
| 2. Five_taka | 7.Two_hundred_taka |
| 3. Ten_taka | 8.Five_hundred_taka |
| 4. Twenty_Taka | 9.Thousand_taka |
| 5. Fifty_taka | |

This type of project is not very common, especially the currency we are working on. We didn't find any open dataset that can fulfill our project outcome. So, we create our own dataset, collecting different types of credits. For all nine classes, we primarily collected 200 individual data for each corresponding class. The initial dataset was 1800 data. Unfortunately for limited resources, we had to size down the dataset to 900 (100 data for each class).

Example of dataset: -



5.2 Training Graph

This graph was automatically generated by the framework called darknet. It resembles the whole training process. mAP, initial loss, last loss, current average loss, iteration, time to complete and max_batch, all of these data is shown in the graph below.

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In this 2-axis graph, x-axis represents the loss of every iteration and y-axis represents the value of iterations. We can see the initial loss of this model was really high. This initial loss drastically drops between 0 to 100 iterations. After 700 iterations the loss is already below 1. From 2100 iterations loss drops very small amounts at a time. At this point loss might be very low still the accuracy of this model is not good at all. So, we need to complete all 7000 thousand iterations to improve accuracy. After completing the training our average loss was 0.0206.

This graph represents another important attribute called Mean Average Precision also known as mAP. In object detection, mAP is an evaluation matrix. Using mAP in a deep learning model, we can determine the percentage of successful detection for every thousand iterations. mAP increases proportionally with iteration increases.

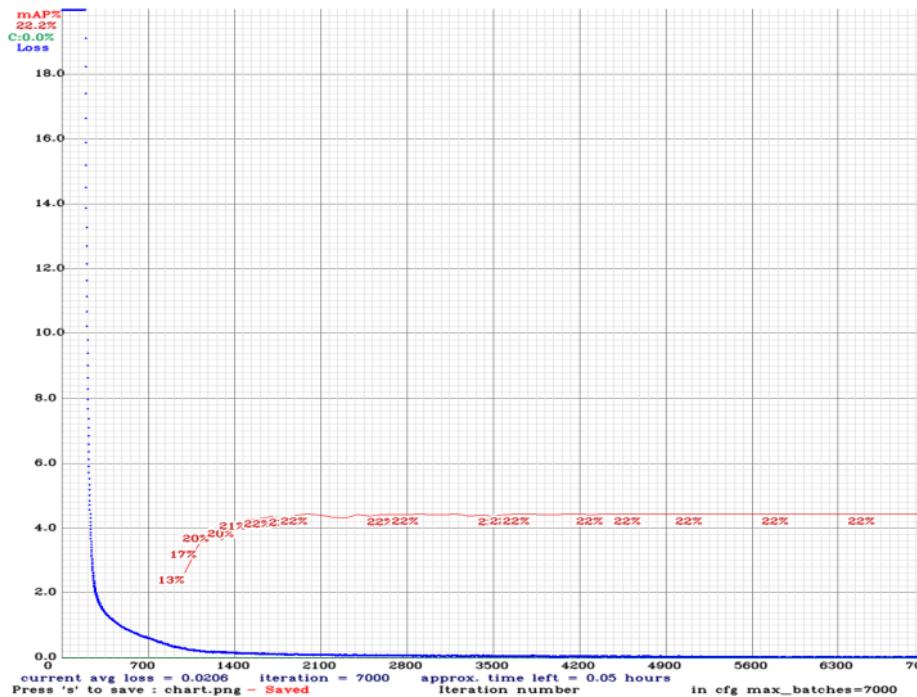


Figure: Training Chart

5.3 Evaluation

Here is the result of our custom trained model of Bangla currency detection. All the 9 classes of objects are presented below: -

Two taka result



Five taka result



Ten taka result





Twenty taka result



Fifty taka result



One hundred taka result





Two hundred taka result



Five hundred taka result



One thousand taka result



5.4 Summary of Finding

In this part of this report we like to discuss our findings and the problems we faced during all the steps of our project.

Image Difference : In the data collection process, we (all 3 members) individually collect pictures of different bank notes and also ask some of our friends to help us with this matter. But we faced issues in our model training phase. The problem was, not all capture devices are the same , they have different sensors , different image processing algorithms. So, output from all these devices were different like resolution, size, color accuracy, lighting condition. We were able to fix the resolution and size, but because of different color accuracy our model had a hard time detecting different bank notes. Also different bank notes have nearly the same color(Example: the newly released 50 taka and 200 taka bank notes).

Bank Notes Design : Bank notes design deferred for different values but all of them have something in common. Now a days nearly all bank notes of Bangladesh has a portrait of our Father of Nation Bongo Bondhu Sheikh Mujibur Rahman alone with the printed text “Bangladesh Bank” , “বাংলাদেশ ব্যাংক”. This type of similarity causes some confusion in the trained model.

Another issue was the condition of the bank notes. For staying in circulation some notes condition becomes very poor because of dirt and some cases because of abuse. These poor condition notes are hard to detect or even make conflict when trained in a model.

Resource Limitation : Some of the limitations we discussed earlier could be resolved (like the similarity and poor condition) with larger and accurate image dataset. For argument sake, let's pretend we have a larger dataset with multiple types of bank note models. But we could utilize larger data because of hard resource limitations. Larger data set for this many classes, needs more graphics memory to train as well as take a lot of time to train a model. We have done all of our training, test and demo in Google Co-lab. Google Co-lab doesn't allow run-time more than 12 hours for free users. This was a major setback for this project. Double the amount of dataset was available then we used in training.

Chapter 6

In this chapter, we are discussing the final outcome of this project and our future plan and vast possibility of this project.

6.1 Conclusion

Our paper advanced a project for recognizing currency using object detection from YoLo V4. as YoLo means “you only look once”, so we have a very good theory about this system faster than any other currency recognition software that has been released to the public until now.

We collect Bangladeshi bank notes as data . We collected 2 taka, 5 taka, 10 taka, 20 taka, 50 taka, 100 taka, 200 taka, 500 taka and 1000 taka notes to train our model. We labeled our data using Label-Img Master. We ran it using anaconda. After data labeling we train our dataset using YoLo v4 tiny and test it using a sample image. Though we looked for top most accuracy but couldn't achieve 100% accuracy. In the future we will make our project more accurate.

After implementing all our codes and labeled datasets we insert some sample video. This shows us that our system can identify Bangladeshi banknotes without facing any issue. This is a great achievement for our team and this project is going to help a large number of people who cannot see properly. Our initial goal was to help visually impaired people. People who cannot see properly or lost partial visualisation, can get help to recognise bank notes by using our system. We will work further on our project to make it usable for mass people.

6.2 Future Work

We have plans to work on this project in future. We will try to develop android and iOS applications for android and apple users. This will reach our initiative to the people who are visually challenged. We know android has google assistant and iOS has Siri as voice assistant. Visually challenged people as well as blind people can use those voice assistants to open the money recognition app and can identify the banknotes, he/she holds.

So far this is our future plan. Hopefully we can work on this and produce a beneficial output for our society.

³²
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Appendix A (CEP Mapping)

How Ks is addressed through the project and mapping among Ps, COs, and Pos

Ks	Attribute	How Ks is addressed through the project	COs	POs
K3	Engineering Fundamental	Knowledge of Deep-Learning and good understanding of Darknet Framework is required for this project. Programming language knowledge (python, anaconda) is also needed.	CO4	PO-f
K4	Engineering Specialist Knowledge	On this proposed solution, there will be YoLo-v4 model training and testing. This can be a great engineering practice	CO5	PO-h
K5	Engineering design	This project shows how we solving modern society engineering problem with an effective approach.	CO8	PO-i
K7	The roles of Engineering in society	This project can help a vast amount of people all around the globe. That can have a huge impact on society. Visually Impaired people can be more self-reliant with their day-to-day life.	CO10	PO-a
K8	Research Literature	To complete this project properly, we had to conduct research on existing paper or nearly relevant paper on object detection and image processing. We also identify how they solve or proposed to solve the problem. We also analyze limitations of their system.	CO1	PO-b

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How Ps are addressed through the project and mapping

ps	Attribute	How Ps are addressed through the project	CO	PO
P1	Depth of Knowledge Requirement	In this project we studied deep-learning system using Yolo-v4 model architecture for object detection (K8) Multi-layer of Engineering model design (K5) Data collection from user meetings, special lectures (K7) Knowledge of software engineering and app developing (K3), (K4)	CO1, CO2, CO4, CO7, CO8	10 PO-c, PO-d, PO-e, PO-h, PO-i, PO-j,
P2	Range of Conflicting Requirement	Design an appropriate deep-learning model to detect objects from images of currency in different qualities. Including low and high resolution images.	CO1, CO2	PO-b, PO-c, PO-i
P3	Depth of Analysis Required	Use Yolo-v4, a deep-learning system instead of image processing.	CO1, CO7	10 PO-c, PO-d, PO-e, PO-i,
P4	Familiarity of Issues	Based on object direction, training images have to be clear and in good quality	CO5	PO-f
P5	Extent of applicable codes	Generate proper solution of deep-learning model after designing and validation	CO5, CO6, CO7	10 PO-c, PO-d, PO-e, PO-i
P7	Interdependence	Creating deep learning model, classify image characteristic	CO3, CO5, CO6	PO-f, PO-h, PO-i

How As are addressed through the project

As	Attribute	How As are addressed through the project
A1	Range of Resources	In the development stage, the project requires are : Data : Image of all Bank-notes Technology : Yolo-v4, Darknet Framework People : Developers
A2	Level of Interaction	A better understanding is needed between the researchers and developers (Undergrads) .
A3	Innovation	A level of creativity is needed to develop the deep-learning based software using the available data and resources.
A4	Consequences for society and the environment	Will be very beneficial for visually impaired people and can be used in many types of applications for society.
A5	Familiarity	This project will help the empowerment of visually impaired people and give them the chance to be more independent.

1

CO-PO mapping for this project

CO No.	CO Statements	Corresponding POs
CO1	Identify a real-life problem (Bangla Currency Detection) that can be translated to engineering and/or computing solutions by going through design, development, and validation.	PO1, PO2
CO2	Identify results and functional requirements of the proposed solution (Object detection based on banknotes) considering software or hardware specification and standards.	PO2, PO3
CO3	Identify sub-components of a complex problem, prepare a timetable and proper budget using the project management skills.	PO11
CO4	Identify and validate the impact of environmental considerations and the sustainability of a system of a complete project .	PO7
CO5	Assess professional, ethical, and social impacts and responsibilities of the design project .	PO6, PO8
CO6	Function effectively in a multidisciplinary team.	PO9
CO7	Analyze, design, build, and verify engineering systems with given specifications and requirements .	PO3, PO4, PO5
CO8	Present design project results through verbal presentations.	PO10

Appendix B

Data Processing

```
1 import os
2 count = 0
3
4 for i in os.listdir():
5     os.rename(i,str(count)+ '.'+ i.split('.')[ -1])
6     count+=1
```

Image processing

```
[ ] 1 conda install pyqt=5
2 pip install pyqt5

[ ] 1 C:\Users\ashik\Documents\GitHub\Money-Detection\Data_Collection\LabelImg
2 conda install -c anaconda lxml
3 pyrcc5 -o libs/resources.py resources.qrc
4 python labelImg.py C:\Users\ashik\Documents\GitHub\Money-Detection\Data_Collection\custom_data
5     C:\Users\ashik\Documents\GitHub\Money-Detection\Data_Collection\custom_data\classes.txt
```

Model Training

```
1 from google.colab import drive
2 drive.mount("/content/drive")
```

Mounted at /content/drive

```

[ ] 1 !unrar x '/content/drive/My Drive/Cu_Detect/custom_data.rar' '/content/drive/My Drive/Cu_Detect/'

[ ] 1 !git clone "https://github.com/AlexeyAB/darknet.git" "/content/drive/MyDrive/cu_Detect/darknet"
  ↳ Cloning into '/content/drive/MyDrive/Cu_Detect/darknet'...
    remote: Enumerating objects: 15376, done.
    remote: Total 15376 (delta 0), reused 0 (delta 0), pack-reused 15376
    Receiving objects: 100% (15376/15376), 14.01 MiB | 6.62 MiB/s, done.
    Resolving deltas: 100% (10339/10339), done.
    Checking out files: 100% (2050/2050), done.

[ ] 1 %cd "/content/drive/MyDrive/Cu_Detect/darknet"
  /content/drive/MyDrive/Cu_Detect/darknet

[ ] 1 !make clean
  rm -rf ./obj/image_opencv.o ./obj/http_stream.o ./obj/gemm.o ./obj/utils.o ./obj/dark_cuda.o ./obj/convolutional_layer.o ./obj/list.o ./obj/image.o
  ↳ [REDACTED]

[ ] 1 !make
  chmod +x *.sh
  g++ -std=c++11 -std=c++11 -Iinclude/ -I3rdparty/stb/include -DOPENCV `pkg-config --cflags opencv4 2> /dev/null || pkg-config --cflags opencv` -DGPU
  ./src/image_opencv.cpp: In function 'void draw_detections_cv_v3(void*', detection*, int, float, char**, image**, int, int)':
  ./src/image_opencv.cpp:946:23: warning: variable 'rgb' set but not used [-Wunused-but-set-variable]
    float rgb[3];
    ^
  ./src/image_opencv.cpp: In function 'void draw_train_loss(char*, void**, int, float, float, int, int, float, int, char*, float, int, int, double)':
  ./src/image_opencv.cpp:1147:13: warning: this 'if' clause does not guard... [-Wmisleading-indentation]
    if (iteration_old == 0)
    ^
  ./src/image_opencv.cpp:1150:10: note: ...this statement, but the latter is misleadingly indented as if it were guarded by the 'if'
    if (iteration_old != 0){
    ^
  ./src/image_opencv.cpp: In function 'void cv_draw_object(image, float*, int, int, int*, float*, int*, int, char**)':
  ./src/image_opencv.cpp:1444:14: warning: unused variable 'buff' [-Wunused-variable]
    char buff[100];
    ^
  ./src/image_opencv.cpp:1420:9: warning: unused variable 'it_tb_res' [-Wunused-variable]
    int it_tb_res = cv::createTrackbar(it_trackbar_name, window_name, &it_trackbar_value, 1000);
    ^
  ./src/image_opencv.cpp:1424:9: warning: unused variable 'lr_tb_res' [-Wunused-variable]
    int lr_tb_res = cv::createTrackbar(lr_trackbar_name, window_name, &lr_trackbar_value, 20);
    ^
  ./src/image_opencv.cpp:1428:9: warning: unused variable 'cl_tb_res' [-Wunused-variable]
    int cl_tb_res = cv::createTrackbar(cl_trackbar_name, window_name, &cl_trackbar_value, classes-1);
    ^
  ./src/image_opencv.cpp:1431:9: warning: unused variable 'bo tb res' [-Wunused-variable]

[ ] 1 %cd "/content/drive/MyDrive/Cu_Detect/"

  /content/drive/MyDrive/Cu_Detect

[ ] 1 !ls darknet/cfg/
  ↳ [REDACTED]

[ ] 1 !darknet/darknet
  usage: darknet/darknet <function>

[ ] 1 !python custom_data/creating-files-data-and-name.py
  ↳ [REDACTED]

[ ] 1 !python custom_data/creating-train-and-test-txt-files.py
  ↳ [REDACTED]

```

```

1 |darknet/darknet detector train custom_data/labelled_data.data darknet/cfg/yolov4-tiny_custom.cfg custom-weight/yolov4-tiny.conv.29 -dont_show -map
total_bbox = 446843, rewritten_bbox = 0.000000 %
v3 (iou loss, Normalizer: (iou: 0.07, obj: 1.00, cls: 1.00) Region 30 Avg (IOU: 0.911932), count: 16, class_loss = 0.002935, iou_loss = 0.344748, total_loss = 0.347683
v3 (iou loss, Normalizer: (iou: 0.07, obj: 1.00, cls: 1.00) Region 37 Avg (IOU: 0.800000), count: 1, class_loss = 0.000000, iou_loss = 0.000000, total_loss = 0.000000
total_bbox = 446859, rewritten_bbox = 0.000000 %

(next mAP calculation at 7000 iterations)
Last accuracy mAP@0.50 = 22.19 % best = 22.21 %
6999: 0.011723, 0.022527 avg loss, 0.000010 rate, 1.672547 seconds, 447936 images, 0.048285 hours left
Loaded: 0.000060 seconds

v3 (iou loss, Normalizer: (iou: 0.07, obj: 1.00, cls: 1.00) Region 30 Avg (IOU: 0.913560), count: 16, class_loss = 0.024074, iou_loss = 0.258387, total_loss = 0.282461
v3 (iou loss, Normalizer: (iou: 0.07, obj: 1.00, cls: 1.00) Region 37 Avg (IOU: 0.800000), count: 1, class_loss = 0.000000, iou_loss = 0.000000, total_loss = 0.000000
total_bbox = 446875, rewritten_bbox = 0.000000 %

v3 (iou loss, Normalizer: (iou: 0.07, obj: 1.00, cls: 1.00) Region 30 Avg (IOU: 0.895543), count: 16, class_loss = 0.000815, iou_loss = 0.410283, total_loss = 0.411098
v3 (iou loss, Normalizer: (iou: 0.07, obj: 1.00, cls: 1.00) Region 37 Avg (IOU: 0.800000), count: 1, class_loss = 0.000000, iou_loss = 0.000000, total_loss = 0.000000
total_bbox = 446891, rewritten_bbox = 0.000000 %

v3 (iou loss, Normalizer: (iou: 0.07, obj: 1.00, cls: 1.00) Region 30 Avg (IOU: 0.896744), count: 16, class_loss = 0.001159, iou_loss = 0.338067, total_loss = 0.339226
v3 (iou loss, Normalizer: (iou: 0.07, obj: 1.00, cls: 1.00) Region 37 Avg (IOU: 0.800000), count: 1, class_loss = 0.000000, iou_loss = 0.000000, total_loss = 0.000000
total_bbox = 446907, rewritten_bbox = 0.000000 %

v3 (iou loss, Normalizer: (iou: 0.07, obj: 1.00, cls: 1.00) Region 30 Avg (IOU: 0.925841), count: 16, class_loss = 0.000440, iou_loss = 0.363838, total_loss = 0.364279
v3 (iou loss, Normalizer: (iou: 0.07, obj: 1.00, cls: 1.00) Region 37 Avg (IOU: 0.800000), count: 1, class_loss = 0.000545, iou_loss = 0.000000, total_loss = 0.000545
total_bbox = 446923, rewritten_bbox = 0.000000 %

(next mAP calculation at 7000 iterations)
Last accuracy mAP@0.50 = 22.19 % best = 22.21 %
7000: 0.003581, 0.026633 avg loss, 0.000010 rate, 1.516401 seconds, 448000 images, 0.047807 hours left

calculation mAP (mean average precision)...
Detection layer: 30 - type = 28
Detection layer: 37 - type = 28
136
detections_count = 383, unique_truth_count = 133
class_id = 0, name = two_taka, ap = 0.000000 (TP = 0, FP = 0)
class_id = 1, name = five_taka, ap = 99.71% (TP = 51, FP = 9)
class_id = 2, name = ten_taka, ap = 0.000000 (TP = 0, FP = 2)
class_id = 3, name = twenty_taka, ap = 0.00% (TP = 0, FP = 0)
class_id = 4, name = fifty_taka, ap = 0.000000 (TP = 0, FP = 4)

```

Model Map

```

1 |darknet/darknet detector map custom_data/labelled_data.data darknet/cfg/yolov4-tiny_custom.cfg "backup/yolov4-tiny_custom_last.weights" -points 0

17 max      2x 2/ 2      52 x 52 x 256 -> 26 x 26 x 256 0.001 BF
18 conv     256      3 x 3/ 1      26 x 26 x 256 -> 26 x 26 x 256 0.797 BF
19 route    18          1/2 -> 26 x 26 x 128
20 conv     128      3 x 3/ 1      26 x 26 x 128 -> 26 x 26 x 128 0.199 BF
21 conv     128      3 x 3/ 1      26 x 26 x 128 -> 26 x 26 x 128 0.199 BF
22 route    21 20          -> 26 x 26 x 256
23 conv     256      1 x 1/ 1      26 x 26 x 256 -> 26 x 26 x 256 0.089 BF
24 route    18 23          -> 26 x 26 x 512
25 max      2x 2/ 2      26 x 26 x 512 -> 13 x 13 x 512 0.000 BF
26 conv     512      3 x 3/ 1      13 x 13 x 512 -> 13 x 13 x 512 0.797 BF
27 conv     256      1 x 1/ 1      13 x 13 x 512 -> 13 x 13 x 256 0.044 BF
28 conv     512      3 x 3/ 1      13 x 13 x 256 -> 13 x 13 x 512 0.399 BF
29 conv     42       1 x 1/ 1      13 x 13 x 512 -> 13 x 13 x 42 0.007 BF
30 yolo

[yolo] params: iou loss: ciou (4), iou_norm: 0.07, obj_norm: 1.00, cls_norm: 1.00, delta_norm: 1.00, scale_x_y: 1.05
nms_kind: greendynms (1), beta = 0.600000
31 route    27          -> 13 x 13 x 256
32 conv     128      1 x 1/ 1      13 x 13 x 256 -> 13 x 13 x 128 0.011 BF
33 upsample           2x 13 x 13 x 128 -> 26 x 26 x 128
34 route    33 23          -> 26 x 26 x 384
35 conv     256      3 x 3/ 1      26 x 26 x 384 -> 26 x 26 x 256 1.196 BF
36 conv     42       1 x 1/ 1      26 x 26 x 256 -> 26 x 26 x 42 0.015 BF
37 yolo

[yolo] params: iou loss: ciou (4), iou_norm: 0.07, obj_norm: 1.00, cls_norm: 1.00, delta_norm: 1.00, scale_x_y: 1.05
nms_kind: greendynms (1), beta = 0.600000
Total BFLOPS 6.800
avg_outputs = 300731
Allocate additional workspace_size = 12.46 MB
Loading weights from backup/yolov4-tiny_custom_last.weights...
seen 64, trained: 448 K-Images (7 Kilo-batches_64)
Done! Loaded 38 layers from weights-file

```

Model testing

```
[ ] 1 #utility function
2 def imshow(path):
3     import cv2
4     import matplotlib.pyplot as plt
5     %matplotlib inline
6
7     image = cv2.imread(path)
8     height, width = image.shape[:2]
9     resized_image = cv2.resize(image,(3*width, 3*height), interpolation = cv2.INTER_CUBIC)
10
11    fig = plt.gcf()
12    fig.set_size_inches(18, 10)
13    plt.axis("off")
14    #plt.rcParams['figure.figsize'] = [10, 5]
15    plt.imshow(cv2.cvtColor(resized_image, cv2.COLOR_BGR2RGB))
16    plt.show()

❶ 1 !darknet/darknet detector test custom_data/labelled_data.data darknet/cfg/yolov4-tiny_testing.cfg "backup/yolov4-tiny_custom_last.weights" all_note.jpg -ext_output
2 imshow('predictions.jpg')

 34 route 33 23          -> 2b x 2b x 384
 35 conv  256   3 x 3/ 1   26 x 26 x 384 -> 26 x 26 x 256 1.196 BF
 36 conv  42    1 x 1/ 1   26 x 26 x 256 -> 26 x 26 x 42 0.015 BF
 37 yolo
[yolo] params: iou loss: ciou (4), iou_norm: 0.07, obj_norm: 1.00, cls_norm: 1.00, delta_norm: 1.00, scale_x_y: 1.05
nms_kind: greendynnn (1), beta = 0.600000
Total BFLOPS 6.800
avg_outputs = 300731
Allocate additional workspace_size = 12.46 MB
Loading weights from backup/yolov4-tiny_custom_last.weights...
seen 64, trained: 448 K-imager (7 Kilo-batches_64)
Done! Loaded 38 layers from weights-file
Detection layer: 30 - type = 28
Detection layer: 37 - type = 28
all_note.jpg: Predicted in 15.693000 milli-seconds.
five_taka: 98% (left_x: 396 top_y: 451 width: 672 height: 1298)
fifty_taka: 44% (left_x: 405 top_y: 1685 width: 650 height: 1080)
one_hundred_taka: 68% (left_x: 1083 top_y: 496 width: 1402 height: 608)
thousand_taka: 50% (left_x: 2457 top_y: 1139 width: 1536 height: 710)
two_hundred_taka: 99% (left_x: 2550 top_y: 1893 width: 1440 height: 668)
fifty_taka: 100% (left_x: 2598 top_y: 496 width: 1289 height: 677)
Unable to init server: Could not connect: Connection refused
```

(predictions:1444): Gtk-WARNING **: 09:53:25.504: cannot open display:



Result Generate

```
[ ] 1 |darknet/darknet detector demo custom_data/labelled_data.data darknet/cfg/yolov4-tiny_testing.cfg "backup/yolov4-tiny_custom_last.weights" -dont_show 200.mp4 -1 0 -out_filename results_200_taka.mp4

two_hundred_taka: 100%
FPS:16.1      AVG_FPS:15.2
cvWriteFrame
Objects:
two_hundred_taka: 100%
FPS:15.4      AVG_FPS:15.2
cvWriteFrame
Objects:
two_hundred_taka: 100%
FPS:16.5      AVG_FPS:15.2
cvWriteFrame
Objects:
two_hundred_taka: 100%
FPS:16.3      AVG_FPS:15.2
cvWriteFrame
Objects:
two_hundred_taka: 100%
```

A Deep-Learning Based Approach to Bangla Currency Recognition in Real Time

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