REAL-TIME BANGLADESHI CURRENCY DETECTION SYSTEM FOR VISUALLY IMPAIRED PERSON

BY
Md. Ferdousur Rahman Sarker
ID: 161-15-6783
AND
Md. Israfil Mahmud Raju
ID: 161-15-7141

This Report Presented in Partial Fulfillment of the Requirements for the Degree of Bachelor of Science in Computer Science and Engineering

Supervised By

Prof. Dr. Syed Akhter Hossain
Head
Department of CSE
Daffodil International University

Co-Supervised By

Mr. Ahmed Al Marouf
Lecturer
Department of CSE
Daffodil International University

DAFFODIL INTERNATIONAL UNIVERSITY
DHAKA, BANGLADESH
DECEMBER 2019

APPROVAL

This Project titled **"Real-time Bangladeshi Currency Detection System for Visually Impaired Person"**, submitted by Md. Ferdousur Rahman Sarker, ID No: 161-15-6783 and Md. Israfil Mahmud Raju, ID No: 161-15-7141 to the Department of Computer Science and Engineering, Daffodil International University has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of B.Sc. in Computer Science and Engineering and approved as to its style and contents. The presentation has been held on 7th December, 2019.

BOARD OF EXAMINERS

Dr. Syed Akhter Hossain — **Chairman**
Professor and Head
Department of Computer Science and Engineering
Faculty of Science & Information Technology
Daffodil International University

Abdus Sattar — **Internal Examiner**
Assistant Professor
Department of Computer Science and Engineering
Faculty of Science & Information Technology
Daffodil International University

Shaon Bhatta Shuvo — **Internal Examiner**
Senior Lecturer
Department of Computer Science and Engineering
Faculty of Science & Information Technology
Daffodil International University

Dr. Md. Saddam Hossain — **External Examiner**
Assistant Professor
Department of Computer Science and Engineering
United International University

DECLARATION

We hereby declare that, this project has been done by us under the supervision of **Prof. Dr. Syed Akhter Hossain, Head, Department of CSE**, Daffodil International University. We also declare that neither this project nor any part of this project has been submitted elsewhere for award of any degree or diploma.

Supervised by:

10.12.2019

Prof. Dr. Syed Akhter Hossain
Head
Department of CSE
Daffodil International University

Co-Supervised by:

Mr. Ahmed Al Marouf
Lecturer
Department of CSE
Daffodil International University

Submitted by:

11-12-2019

Md. Ferdousur Rahman Sarker
ID: 161-15-6783
Department of CSE
Daffodil International University

Raju
11.12.19

Md. Israfil Mahmud Raju
ID: 161-15-7141
Department of CSE
Daffodil International University

ACKNOWLEDGEMENT

First we express our heartiest thanks and gratefulness to almighty God for His divine blessing makes us possible to complete the final year research project successfully.

We really grateful and wish our profound indebtedness to **Prof. Dr. Syed Akhter Hossain**, Head, Department of CSE, Daffodil International University, Dhaka. Deep knowledge & keen interest of our supervisor in the field of "Human-Computer Interaction (HCI)" helped to carry out this project. His endless patience, scholarly guidance, continual encouragement, constant and energetic supervision, constructive criticism, valuable advice, reading many inferior draft and correcting them at all stage have made it possible to complete this research project.

We would like to express our heartiest gratitude to **Mr. Ahmed Al Marouf**, Lecturer, Department of CSE, Daffodil International University, for his kind help as our co-supervisor to finish our project. His supports and encouragements speeded up our research progress.

Also we would like to thank **Mr. Shah Md. Tanvir Siddiquee**, Assistant Professor, Department of CSE, Daffodil International University, for helping us in all aspects of our life, **Rubaiya Hafiz**, Lecturer, Department of CSE, Daffodil International University and **Munim Hossain Khandker Protik** (Rehabilitation Centre for Visually Impaired, Harivanga, Lalmonirhat) for their efforts in testing the implementation of our research project and also to other faculty member and the staff of CSE department of Daffodil International University for their help.

We would like to thank our entire course mate in Daffodil International University, who took part in this discuss while completing the course work.

Finally, we must acknowledge with due respect the constant support and patients of our parents.

ABSTRACT

This report presents a real-time Bangladeshi currency detection system for visually impaired person. The proposed system exploits the image processing algorithms to facilitate the visually impaired people to prosperously recognize banknotes. The recent banknotes of Bangladesh have blind embossing or blind dots, which could be effective to recognize the value of the bill by touching. As the embossing fades away in the long-term used notes, detecting right value of the banknote using image processing algorithms could be considered as a challenging task. Particularly in Bangladesh, each banknote seems similar using the direct exertion of simplified image processing algorithms. In this paper, a recognition system was implemented that can detect Bangladeshi banknote in different viewpoints and scales. The detection system is also able to detect currency those are rumpled, decrepit or even worn. The detection system includes image preprocessing, image analysis and image recognition. To enhance the determination of the currency recognition, the descriptor of an individual input scene is matched with various training images of same category. After that by analyzing their matching result it recognizes the currency with higher confidence. For real time recognition, we have deployed the system into a mobile application.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

Introduction

1.1 Introduction:

Globally, it is estimated that approximately 1.3 billion people live with some form of distance or near vision problems [1]. In Bangladesh there are about 40,000 visually impaired people. Among them, 80% of the visually impaired persons live in rural areas. With this statistics, it is to be mentioned that the increase number of visually impaired employees in the government and private job sectors is highly impressive. But one of the main problems suffered by visually impaired person is to identify paper currencies because of the similarity of paper size and texture between different banknotes. As currencies are the commonly used stuff in everyday life, understanding the value of the banknotes is very important task for them. Therefore, we have proposed a real-time system that will help them to recognize the currencies and resolve this crisis to make visually impaired people feel confidence in the financial dealings, not depending on others.

There are two trends in currency recognition: scanner-based and camera-based. Scanner-based systems are quite hard to carry and the recognition rate is not up to the mark. While camera-based systems can be developed with the help of modern image processing techniques and each Smartphone has camera features, which makes it available to the visually impaired persons. Therefore, the camera-based systems will be much easier to use and feasible for the target users.

1.2 Motivation

Huge numbers of people are suffering from different form of distance or near vision problems. The motivation behind this research is to find out an approach to implement an image recognition system to recognize Bangladeshi banknotes for visually disabled

people. As recognizing a banknote is quite tough for them because of similarity of Bangladeshi paper currencies. If such a system can be developed, visually impaired people can have confidence on recognizing currencies. Also they can create their own microfinance company and have belief on financial dealings. It is highly impressive to see an increase in the number of visually impaired workers in government and private jobs.

1.3 Rationale of the Study

The major problem faced by visually impaired people is to recognize paper currencies. Especially in Bangladesh, not enough research and development has done to solve the issue. Also a system that will be less costly and easily usable for people who are not well enough in financial condition. But if such a system can be developed, it will help the visually impaired people in different ways.

i. **Recognize Banknotes:** Due to the similarity of paper size and texture between different Bangladeshi banknotes it is quite hard to identify for people who are visually impaired. A system should be developed that will help them to recognize banknotes easily.
ii. **Financial Dealings:** Visually impaired people don't want to a burden to the society. They also want to contribute to their family. They need confidence in the financial dealings, not depending on others.
iii. **Participation in Microfinance:** Our Government is creating different micro-jobs where people who are disabled can work and contribute to their family.

1.4 Research Questions

Various questions came on our mind before starting the research. The research is based on creating an Image Detection system to recognize Bangladeshi paper currencies for visually impaired people. Most important questions regarding this research were:

i. How a visually impaired person can operate an Android Smartphone?
ii. Which image detection approach to be followed as the system will be implemented on an Android Application?
iii. How we'll reduce the problems of low resolution camera and lower processor based low budget Smartphone?
iv. How we'll achieve higher accuracy as the system will be used in financial dealings.

1.5 Expected Outcomes

The primary outcome of the research is to recognize Bangladeshi paper currencies for visually impaired people. Also implement the system as an Android Application that will be able to run on low budget Smartphone. Some important outcomes that we expect from the system are given below:

- Recognizing Bangladeshi paper currencies from different perspective views.
- Reducing the banknote recognition time.
- Increasing the recognition accuracy.
- Providing detection result through spoken feedback.

1.6 Report Layout

In the rest of the report, Chapter 2 presents the background study, related works, research summary, scope of the problem and challenges. In Chapter 3, we'll briefly discuss our research methodology, data collection and banknote database setup, statistical analysis and implementation requirements. Experimental results and analysis will be discussed in Chapter 4. In Chapter 5, conclusion will be done by summarizing the experimental results and scopes of future study. References and appendices will be given later on under the title of Appendix A: Research Reflection, Appendix B: Related Issues.

CHAPTER 2

Background

2.1 Introduction

In this chapter, we have discussed on numerous research work accomplished by researchers on the problem statement of this report. Various works have been done in this field to recognize objects. But most of the recognitions were done between objects of different shapes as our research is on Bangladeshi paper currencies and most of the banknotes are of same size and texture, it was quite tough to solve. As well as we had to study different real-time object recognition based mobile application.

Considering a real-time system to detect the Bangladeshi currency accurately, we'll be focusing two things in this chapter: related works in currency detection using image processing and related works on real-time mobile application for the same problem.

2.2 Related Works

Several methods have been adopted by the researchers for solving this problem. L. J. Feng et al. [2] proposed an algorithm for real-time detection of Chinese currencies. A modified Kohonen Network is developed for recognizing Chinese paper currencies for the experiments by them. The method applied could be used for practical currency sorting system. A hardware implementation is performed in [3] for paper currency number recognition utilizing the CIS scanning circuits and ARM.

An edge-based defect detection algorithm is proposed in [4] for paper currency by J. Ye. The method divides the currency image into several overlapping subzones and within each subzones, the defect feature is calculated to estimate the stage of contamination. The method proved to be robust while applied to low quality paper currency.

K. Fanhui et al. [5] proposed a Gaussian Mixture Model (GMM) based paper currency recognition. The applied method in [5] based upon the structural risk minimization (SRM) to develop a faster system. The experimentation shows that GMM exploiting the SRM provides more flexibility and lead to an improved result on Chinese paper currency recognition.

Y. Weiqi et al. [6] proposed a fast recognition system for paper currency numbers. The method captures the 24-bits color images using CCD camera, then outputs number clusters through process of segmentation by gray ridge-vale algorithm. The orientation by projection and character recognition by structure-analyzing algorithm is implemented as data processing. The experimental analysis shows satisfactory results as the system recognizes the paper currency with high rate and fast recognition speed.

An image processing based fake banknotes detection system is proposed in [7] which only works on denomination of 1000 BDT. The got 63.34% accuracy for the experimental analysis presented using edge detection methods. Focusing on the fake or counterfeit Bangladeshi currency in [8], presented by Z. Ahmed et al., and presented a feasibility analysis. Similar Bangladeshi currency detection system proposed in [9] by M. M. Rahman, utilizing similar approach, but with 89.40% accuracy on white paper background and 78.40% accuracy tested on complex background. Similar machine vision based approaches [10, 11], hardware implementation using PIC or ATMega88 devices [12] are presented.

Though all the above mentioned algorithms and methods were presented for Chinese paper currency and developed system using machine learning. The idea of developing these sort of systems of visually impaired persons is missing in the literature. Therefore, the need of a real-time system for visually impaired persons is quite high and in this paper, we try to mitigate the gap in the literature.

2.3 Research Summary

In our background study, we are intended to find a feasible solution for creating a android based image recognition system to recognize Bangladeshi banknotes in real-time. As the system needs to recognize paper currencies in real-time, to we need to reduce the time complexity for recognition. Different approaches were done, some were feature based detection and some were Convolutional Neural Network (CNN) based detection. As implementing CNN directly on Android Application isn't flexible enough right now, we'll need to focus to feature based detection as well as reducing time complexity.

In this report, we have exploited the ORB method for keypoint detection and feature descriptions. The method experimentally shows better accuracy in recognition with faster processing time.

2.4 Scope of the Problem

This study focuses on finding a way to develop a real-time Bangladeshi currency detection system for visually impaired people. If such a system can be developed, then visually impaired people can:

i. **Recognize Banknotes:** They will be able to recognize paper currencies with a handy tool as the system will be implemented as an Android Application that will run on lower budget Smartphone.
ii. **Financial Dealings:** Confidence on recognizing currencies will help them to participate on financial dealings and contribute something for their family.
iii. **Participation in Microfinance:** Visually impaired people will be able to create their small microfinance business or join some jobs created by our Government for disabled people.

2.5 Challenges

To develop such a system for visually impaired people we need to create a reliable system with higher accuracy and usability. Some of the challenges may come in the development of this research based system:

i. **Smartphone Usability:** As visually impaired people face difficulties on seeing, then operating a Smartphone will be impossible for them. To overcome these difficulties we need to create such an approach or use a pre-built system that will help them to control a Smartphone.

ii. **Time Complexity:** As the intended system is a real-time detection system, so, we need to focus with highest priority to reduce the processing time of the detection.

iii. **Lower Camera Resolution:** 80% of visually impaired people in our country live in rural areas as well as their financial conditions are not well enough to buy a Smartphone that has good camera. So the system should be developed in such a way where the camera resolution may be moderate.

iv. **Offline System:** Detection needs to be done offline, as in rural areas internet connectivity isn't well enough still also costly. If we could use internet then we would be able to use machine learning for the solution. Android App doesn't support python programming language directly so the system needs to be created using JAVA or Kotlin programming language, where there are not enough resources available in this area.

CHAPTER 3

Research Methodology

3.1 Introduction

To implement the detection system as an Android Application for visually impaired people we need to find how the recognition process will execute. In this chapter we will discuss our implementation steps. To speed up the development, the Open Source Computer Vision (OpenCV) library was used. Using OpenCV, we can do the feature based matching by different approaches. Throughout this chapter we'll determine which approach is appropriate for our system. Figure 3.1 shows the overview of our detection stages.

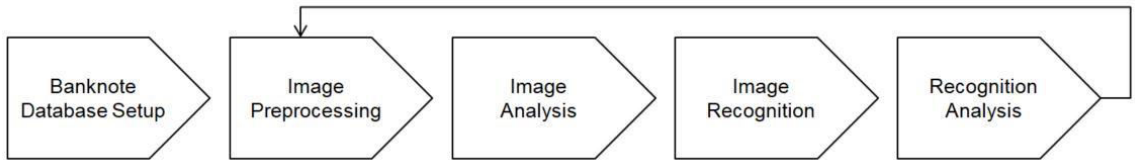

Figure 3.1: Overview of the main processing stages.

As the detection system needs to be reliable when it’s come to accuracy, after the first detection, the system will again detect taking another image from the real-time camera for the validation of the result. Thus it will generate much reliable results.

3.2 Research Subject and Instrumentation

3.2.1 Reference Image Database Setup

In order to recognize the banknotes, a database of valid instances must be computed. This database contains the descriptors associated with the keypoints generated by OpenCV. To improve the detection we used Five training images of each banknotes. In each folder, there are different images of a currency to get matching results for different variations. Figure 3.2.1 illustrates each banknote folder containing five training images.

Figure 3.2.1: Training images stored by category of different notes.

3.2.2 Image Preprocessing

In Bangladeshi currency, one side of each notes are quite similar. Processing that tough side has the chance to get inaccurate results. Therefore, the first step is to exclude that side if found. It will ask to place another side of the note. The whole things start after the conversion of the input image to Grayscale. By gray-scaling the image will reduce inappropriate results due to lighting variations. Also we keep only the high intensity pixels from the image by removing the lower intensity pixels below 80. System will automatically explore all the training folders and for each folder it will detect the keypoints of the training image using ORB Keypoint Detection and also extract the descriptors using ORB Descriptor Extractor. Descriptors of training images will be alive until the system is terminated. This descriptors will be used later to match with the descriptor of input images.

ORB is based on BRIEF. However, ORB addresses the detection, the orientation assignment and the descriptor extraction phases rather than only the descriptor (i.e. BRIEF). ORB adopts a multi-scale approach. Figure 3.2.2 shows how the input image is preprocessed.

Figure 3.2.2: Impact of preprocessing stage.

3.2.3 Image Analysis

After preprocessing, we detect the keypoints of input image for future recognition using ORB Keypoint Detection. As the system runs in real-time detection so ORB is the fastest. Also the Descriptor Extractor extracts its description using ORB.

In this stage we find out the Scale invariant keypoints of the processed image. Keypoints are the interesting points. Scale invariant means that no matter how you scale the image, you should still be able to find those points.

For finding the keypoints we took the help of ORB Keypoint Detection. Though ORB analysis on small amount of keypoints, but for our currency recognition system the detected keypoints are enough to start matching as there are five images for each banknote. Detected descriptor of input image will be stored and the system will start matching in Image Recognition part. Figure 3.2.3 shows the Keypoints detection on an input image for future feature matching.

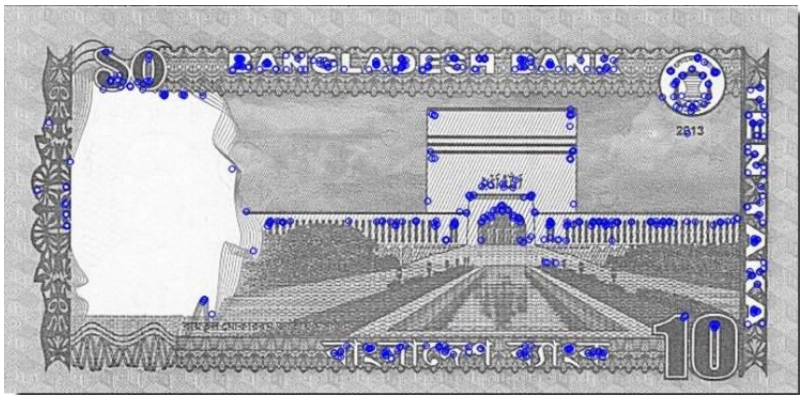

Figure 3.2.3: Keypoints detection on an input image for future feature matching.

3.2.4 Image Recognition

After input image analysis the system will now match the descriptors of training images that we generated from Preprocessing with the descriptor of input image. The descriptor of input image will be matched one by one with the training descriptors and calculate the matching results. For matching the descriptors we will be using OpenCV Descriptor Matcher. Between different types of descriptor method, we will be using Brute force Hamming algorithm for the matching phase. Each matching results will be stored for the analysis part, where the system will analysis between the results to return the most accurate matching banknote. Figure 3.2.4 shows the descriptor matching graphically.

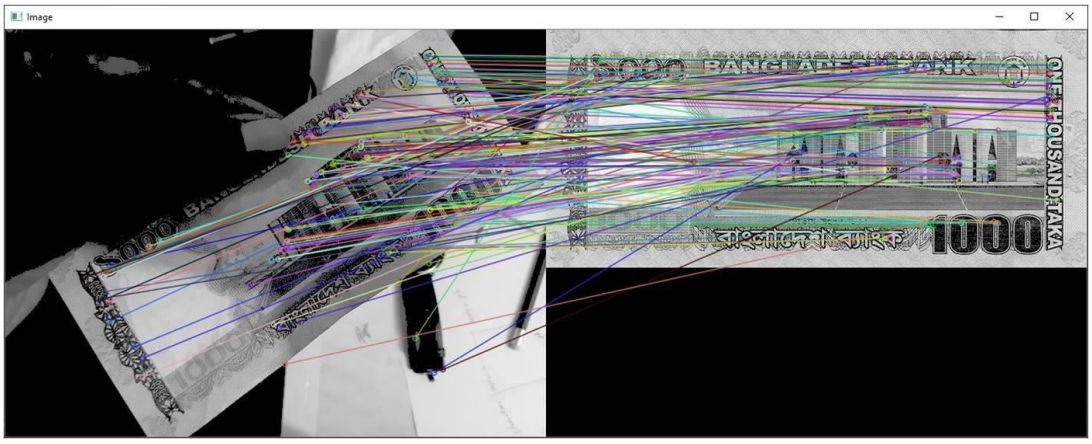

Figure 3.2.4: Descriptor matching between input image descriptor and training image descriptor.

3.2.5 Recognition Analysis

Here we find the maximum results between the addition of each set of banknotes. First we calculate the sum of matching points of all training images of each category of banknotes. If a, b, c, ..., h are different training folders of 2 Taka, 5 Taka, 10 Taka, ..., 1000 Taka banknotes respectively containg 5 training images each then $\boldsymbol{x_a, x_b, x_c, .., x_h}$ are the summations of matching points of their set of training images.

$$\sum_{\boldsymbol{a=1}}^{\boldsymbol{5}} \boldsymbol{x_a} = \boldsymbol{a}_1 + \boldsymbol{a}_2 + \boldsymbol{a}_3 + \boldsymbol{a}_4 + \boldsymbol{a}_5$$

$$\sum_{\boldsymbol{b=1}}^{\boldsymbol{5}} \boldsymbol{x_b} = \boldsymbol{b}_1 + \boldsymbol{b}_2 + \boldsymbol{b}_3 + \boldsymbol{b}_4 + \boldsymbol{b}_5$$

- - - - - - - - - - - - - - - -

$$\sum_{\boldsymbol{h=1}}^{\boldsymbol{5}} \boldsymbol{x_h} = \boldsymbol{h}_1 + \boldsymbol{h}_2 + \boldsymbol{h}_3 + \boldsymbol{h}_4 + \boldsymbol{h}_5 \quad (1)$$

Finally, the system will measure the banknote category containing the maximum matching points.

$$\text{Result} = \text{Max}(\boldsymbol{x_a, x_b, x_c, x_d, x_e, x_f, x_g, x_h}) \quad (2)$$

As the system will measure the maximum matching set, chances of inaccuracy will reduce dramatically.

3.3 Data Collection Procedure

For the research purpose different banknote images were collected from internet sources and captured in different lighting conditions. The raw images are different in size, shape and category with variation of color combination and textures. All the images are preprocessed to get them all in a suitable form of data.

3.4 Statistical Analysis

The system contains total 40 training images and was tested in two different perspective views, Ideal and Distortion.

While testing, we used 87 images of Ideal perspective and 97 images of Distortion perspective. Table 3.4.1 and Table 3.4.2 illustrate the True Positive (TP), True Negative (TN), False Positive (FP) and False Negative (FN) values for ideal and distortion perspective, respectively, applying the ORB detector, descriptors and brute force hamming matcher. The training time (1.12s) and average matching time for the ideal case is very minimal as it shows 100% accuracy.

Table 3.4.1: Confusion Matrix in Ideal perspective, ORB Detector, Bruteforce Hamming Matcher

N = 87	Predicted **YES**	Predicted **NO**
Actual **YES**	TP 53	FN 0
Actual **NO**	FP 0	TN 34

Table 3.4.2: Confusion Matrix in Distortion perspective, ORB Detector, Bruteforce Hamming Matcher

N = 97	Predicted **YES**	Predicted **NO**
Actual **YES**	TP 62	FN 1
Actual **NO**	FP 3	TN 31

3.5 Implementation Requirements

Implementation of the system is very linear as we implemented the recognition system as an Android Application. For running the application, the application file APK needs to be installed in the device. The application will be able to run in devices with Android API Level 16 (Android 4.1) or greater. The device must have a working camera as Image Processing is the main part of this system and it collects image real-time using the camera. The device's processor speed may be moderate as we are targeting to run the app in low budget Smartphone.

CHAPTER 4

Experimental Results and Discussion

4.1 Introduction

As the system is for visually impaired people, huge testing is necessary. Piloting with real people those face difficulties on seeing is also very important. The system will be used by people who may not place the camera properly above the paper notes; as a result recognition may fail in some cases. That's why we tested the implemented system with images of different perspective such as Ideal and Distortion. We took 87 images of banknotes in Ideal perspective and 97 images in Distortion perspective. All the images were captured using low budget Smartphone with medium range camera in different lighting condition. Figure 4.1 shows some of the images of both perspective views we used for our testing.

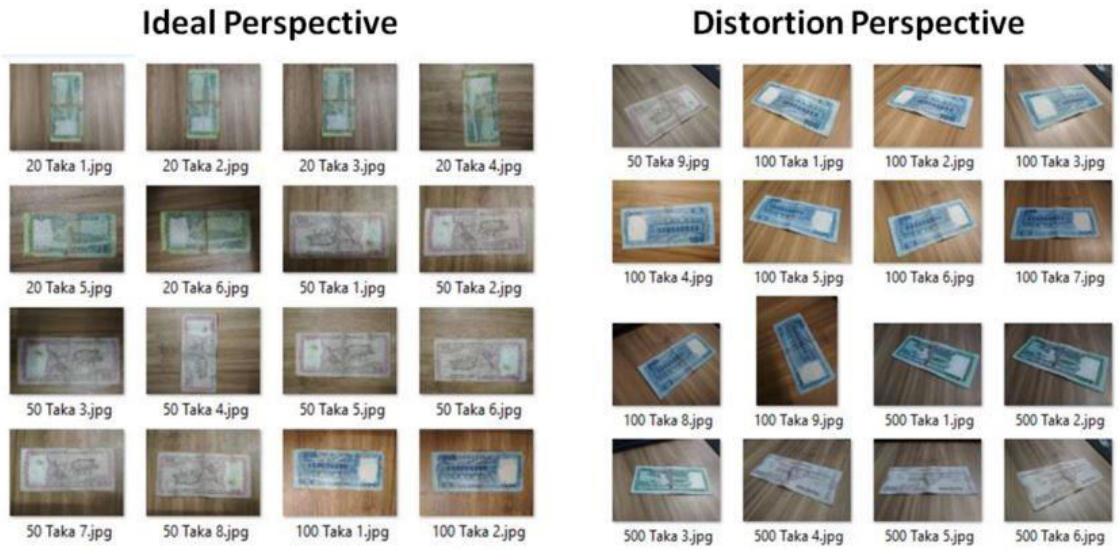

Figure 4.1: Some testing banknote images of ideal & distortion perspective.

4.2 Experimental Results

To find out the best and appropriate approach of feature based detection in real-time, we used different methods while testing. Also took various numbers of images as testing images of banknotes. Different methods we used were:

- ORB Detector, ORB Descriptors and BRUTEFORCE HAMMING Matcher
- SURF Detector, SURF Descriptors and BRUTEFORCE Matcher
- SIFT Detector, SIFT Descriptors and BRUTEFORCE Matcher
- BRISK Detector, BRISK Descriptors and BRUTEFORCE Matcher

Total 87 images were taken in ideal perspective view using mid budget Smartphone for the testing. Table 4.2.1 shows the confusing matrix in ideal perspective view using ORB Detector, ORB Descriptors and BRUTEFORCE HAMMING Matcher, Table 4.2.2 using SURF Detector, SURF Descriptors and BRUTEFORCE Matcher, Table 4.2.3 using SIFT Detector, SIFT Descriptors and BRUTEFORCE Matcher and Table 4.2.4 using BRISK Detector, BRISK Descriptors and BRUTEFORCE Matcher respectively.

Table 4.2.1: Confusion Matrix in Ideal perspective, ORB Detector, ORB Descriptors and BRUTEFORCE HAMMING Matcher

N = 87	Predicted **YES**	Predicted **NO**
Actual **YES**	TP 53	FN 0
Actual **NO**	FP 0	TN 34

Accuracy: (TP+TN)/N = (53+34)/87 = 1.00
Total Training Time: 1.12s
Avg. Matching Time: 0.17s

Table 4.2.2: Confusion Matrix in Ideal perspective, SURF Detector, SURF Descriptors and BRUTEFORCE Matcher

N = 87	Predicted **YES**	Predicted **NO**
Actual **YES**	TP 53	FN 0
Actual **NO**	FP 0	TN 34

Accuracy: (TP+TN)/N = (53+34)/87 = 1.00

Total Training Time: 41.7s

Avg. Matching Time: 15.1s

Table 4.2.3: Confusion Matrix in Ideal perspective, SIFT Detector, SIFT Descriptors and BRUTEFORCE Matcher

N = 87	Predicted **YES**	Predicted **NO**
Actual **YES**	TP 53	FN 0
Actual **NO**	FP 0	TN 34

Accuracy: (TP+TN)/N = (53+34)/87 = 1.00

Total Training Time: 37.4s

Avg. Matching Time: 10.9s

Table 4.2.4: Confusion Matrix in Ideal perspective, BRISK Detector, BRISK Descriptors and BRUTEFORCE Matcher

N = 87	Predicted **YES**	Predicted **NO**
Actual **YES**	TP 36	FN 17
Actual **NO**	FP 10	TN 24

Accuracy: (TP+TN)/N = (36+24)/87 = 0.69

Total Training Time: 3.30s

Avg. Matching Time: 0.96s

And total 97 images were taken in distortion perspective view for the testing. Table 4.2.5 shows the confusing matrix in distortion perspective view using ORB Detector, ORB Descriptors and BRUTEFORCE HAMMING Matcher, Table 4.2.6 using SURF Detector, SURF Descriptors and BRUTEFORCE Matcher, Table 4.2.7 using SIFT Detector, SIFT Descriptors and BRUTEFORCE Matcher and Table 4.2.8 using BRISK Detector, BRISK Descriptors and BRUTEFORCE Matcher respectively.

Table 4.2.5: Confusion Matrix in Distortion perspective, ORB Detector, ORB Descriptors and BRUTEFORCE HAMMING Matcher

N = 97	Predicted **YES**	Predicted **NO**
Actual **YES**	TP 62	FN 1
Actual **NO**	FP 3	TN 31

Accuracy: (TP+TN)/N = (62+31)/97 = 0.96
Total Training Time: 1.13s
Avg. Matching Time: 0.19s

Table 4.2.6: Confusion Matrix in Distortion perspective, SURF Detector, SURF Descriptors and BRUTEFORCE Matcher

N = 97	Predicted **YES**	Predicted **NO**
Actual **YES**	TP 54	FN 9
Actual **NO**	FP 5	TN 29

Accuracy: (TP+TN)/N = (54+29)/97 = 0.86
Total Training Time: 46.2s
Avg. Matching Time: 17.1s

Table 4.2.7: Confusion Matrix in Distortion perspective, SIFT Detector, SIFT Descriptors and BRUTEFORCE Matcher

N = 97	Predicted **YES**	Predicted **NO**
Actual **YES**	TP 53	FN 10
Actual **NO**	FP 4	TN 30

Accuracy: (TP+TN)/N = (53+30)/97 = 0.86
Total Training Time: 39.3s
Avg. Matching Time: 12.4s

Table 4.2.8: Confusion Matrix in Distortion perspective, BRISK Detector, BRISK Descriptors and BRUTEFORCE Matcher

N = 97	Predicted **YES**	Predicted **NO**
Actual **YES**	TP 29	FN 34
Actual **NO**	FP 19	TN 15

Accuracy: (TP+TN)/N = (29+15)/97 = 0.45
Total Training Time: 4.69s
Avg. Matching Time: 1.15s

4.3 Descriptive Analysis

The implemented Android Application for visually impaired people was tested on different perspective views. Also the testing was done using different methods to find out the best possible approach. As the system needs to work in real-time so we need to focus on time required to recognize banknotes. The less the time required, the better the system. The higher correctly recognition accuracy is also important in this case. The testing was done in two step recognition for a single image to make the recognition more trust worthy. Table 4.3.1 and Table 4.3.2 show the analyzed results of our experimental testing.

Table 4.3.1: Results using different methods in Ideal Perspective

Detector	Descriptors	Matcher	Accuracy	Avg. Time
ORB	ORB	BRUTEFORCE HAMMING	1	0.17s
SURF	SURF	BRUTEFORCE	1	15.1s
SIFT	SIFT	BRUTEFORCE	1	10.9s
BRISK	BRISK	BRUTEFORCE	0.69	0.96s

Table 4.3.2: Results using different methods in Distortion Perspective

Detector	Descriptors	Matcher	Accuracy	Avg. Time
ORB	ORB	BRUTEFORCE HAMMING	0.96	0.19s
SURF	SURF	BRUTEFORCE	0.86	17.1s
SIFT	SIFT	BRUTEFORCE	0.86	12.4s
BRISK	BRISK	BRUTEFORCE	0.45	1.15s

4.4 Summary

The real-time implementation of the system is demonstrated in [13] while using the mobile application practically. The exploited method has been implemented using OpenCV package of Android. The mobile application need to use the camera features available in the device. Applying the ORB detector, descriptors and brute force hamming matcher, the training time (1.12s) and average matching time for the ideal case is very minimal as it shows 100% accuracy. The accuracy and Average matching time for other methods, which provides a clear perception that our implemented ORB based methods, are significantly faster (0.17s). The same experimentation is performed over the distortion perspective using noisy images having training time (1.13s). Hence, in this case, the matching time is also significantly faster (0.19s) than the other methods.

CHAPTER 5

Summary, Conclusion, Recommendation and Implication for Future Research

5.1 Summary of the Study

It is needless to tell that we are living in a world of technology. Technologies are improving day by day, but using the technologies in appropriate field that will help human beings is necessary. In this research based work, we tried to use image recognition system to detect Bangladeshi banknotes for people who face difficulties in seeing. The problem they face in this area is huge that they don't feel confidence in participation in small financial dealings. Thus they start to feel themselves a burden in the society. If such a system can be built then it will help them in many aspects of life. It was our intension to make the system as real-time image recognition Android App. For this, we tried with various feature based methods to determine which method is more suitable with minimum time complexity and maximum accuracy.

5.2 Conclusions

In this report, we try to formalize a real-time Bangladeshi currency detection system implemented over mobile application. We have applied the widely used ORB based feature descriptor for recognizing the traditional Bangladeshi paper currencies. The average recognition rate for each of the different types of banknotes is documented in the experimental results. The recognition rate is higher than any other methods applied for experimentation and the average matching rate is also quite satisfactory considering a real-time system. The presented system could be very helpful for the visually impaired personals, who can use the mobile application to recognize the banknotes very accurately.

5.3 Recommendations

There are some recommendations that should be followed if this research is to be conducted again in the future.

- More numbers of training images to be used for betterment of results.
- More preprocessing techniques to be used to clear the image before starting the recognition.
- For the Application Development, Koltin programming language should be used to get faster processing speed.

5.4 Implication for Further Study

Due to the advancement of technologies our day to day life are getting easier. Using these technologies in appropriate fields is also necessary. There are many people in the world who are not normal; they face difficulties in their life. We must use technologies for them. Like in this report we used image recognition for visually impaired people to recognize Bangladeshi paper currencies. There are other people who may have difficulties in listening, walking, taking and so on. Technologies should be use for their betterment. There are many researches are being conducted all over the world. But we should also use those researches to make a complete solution that will help people directly. Researchers conduct research, but if the research cannot be implemented in real-life then it will be just a piece of paper.

REFERENCES

[1] R. R. A. Bourne, S. R. Flaxman, T. Braithwaite, M. V. Cicinelli, A. Das, J. B. Jonas, "Vision Loss Expert Group. Magnitude, temporal trends, and projections of the global prevalence of blindness and distance and near vision impairment: a systematic review and meta-analysis", Lancet Glob Health. 2017 Sep; 5(9):e888–97.

[2] L. Jia Feng, L. Song Bo, T. Xiang Long, "An Algorithm of Real-Time Paper Currency Recongnition", Journal of Computer Research and Development, 2003.

[3] Li Liang Ding Wanshan, "Paper currency number recognition system based on ARM", Electronic Measurement Technology;2008-10.

[4] Jin Ye, Liu Songbo, Liu Jiafeng, Song Ling, and Tang Xianglong, "An Edge-Based Defect Detection Algorithm for Paper Currency", Journal of Computer Research and Development, 2007-02.

[5] K. Fanhui, M. Jiquan, G. Xin, Y. Liping, "Paper Currency Recognition Using Gaussian Mixture Models Based on Structural Risk Minimization", Journal of Computer Engineering and Applications, 2006-13.

[6] Y. Weiqi, Z. Yu, "A Fast Recognition System for Paper Currency Numbers" , Journal of Computer Engineering, 2005-24.

[7] M. M. Alimushwan, A. Mohaimin, R. Islam, S. Chowdhury, M. H. Ali, "Fake Currency Detection using Image Processing Method", BRAC university dspace.

[8] Z. Ahmed, S. Yasmin, M. N. Islam, R. U. Ahmed, "Image Processing Based Feature Extraction of Bangladeshi Banknotes", The 8th International Conference on Software, Knowledge, Information Management and Applications (SKIMA 2014), 18-20 Dec. 2014.

[9] M. M. Rahman, Bruce Poon, M. A. Amin, H. Yan, "Recognizing Bnagladeshi Currency for Visually Impaired", International Conference on Communication in Computer and Information Science, July 2014.

[10] R. F. Sajal, M. Kamruzzaman, F. A. Jewel, "A machine vision based automatic system for real time recognition and sorting of Bangladeshi bank notes", 2008 11th International Conference on Computer and Information Technology (ICCIT), 24-27 December, 2008.

[11] K. K. Debnath, J. K. Ahdikary, M. Shahjahan, "A currency recognition system using negatively correlated neural network ensemble", 2009 12th International Conference on Computer and Information Technology (ICCIT), 21-23 December, 2009.

[12] K.Yoshida, M. Kamruzzaman, F. A. Jewel, R. F. Sajal, “Design and implementation of a machine vision based but low cost stand alone system for real time counterfeit Bangladeshi bank notes detection”, 2007 10th International Conference on Computer and Information Technology (ICCIT), 27-29 December, 2007.

[13] Demonstration Video. [online] Available at: http://bit.ly/30CNxWz [Accessed 1 Nov. 2019].

APPENDIX A

Research Reflection

By doing this research we have learned various approaches in the field of image recognition, as well as understood the necessity of using technologies for the people who face serious difficulties. In the very beginning of our research, we started to implement the recognition using Tensorflow, but we found that if the objects are of similar shapes then Tensorflow can't recognize properly, as well as the image quality needs to be better. So we moved to feature based image recognition. Also we've learned the importance of time complexity as recognition time needs to be lower and accuracy needs to be higher in this case. The whole implemented application is based on OpenCV. By doing this research, we learned various preprocessing techniques that OpenCV made easy. While implementing the research as android application we learned offline integration of OpenCV SDK for Android. Though it increases the size of the application but reduces the problem of downloading OpenCV SDK externally as well.

APPENDIX B

Related Issues

Various research and development has been done in the field of image processing and recognition. But it is also very important to use these researches as implemented system to make real-life usable. In this report we have used image recognition to help the people who are visually impaired to recognize paper currencies. Similarly image recognition can be used to them on other sectors like reading book, getting help in the road by providing directions, learning different shapes, using internet and so on. Not only of people who are visually impaired, but also it can be used for children education. Image recognition can be helpful to teach a child on learning different things, learning alphabets etc.

Ferdousur Rahman Report

ORIGINALITY REPORT

11%	7%	9%	8%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Chetanya Puri, Arijit Ukil, Soma Bandyopadhyay, Rituraj Singh, Arpan Pal, Kayapanda Mandana. "iCarMa", Proceedings of the First Workshop on IoT-enabled Healthcare and Wellness Technologies and Systems - IoT of Health '16, 2016 Publication	2%
2	aut.researchgateway.ac.nz Internet Source	2%
3	Hee-Jung Lim, AeJung Im, Han-A Cho. "The association between visual impairment and dental care utilization in the Korean elderly", Archives of Gerontology and Geriatrics, 2019 Publication	1%
4	paginas.fe.up.pt Internet Source	1%
5	Submitted to University of Sheffield Student Paper	1%
6	Communications in Computer and Information Science, 2014.	1%

	Publication	
7	Submitted to Daffodil International University Student Paper	<1%
8	docplayer.net Internet Source	<1%
9	Yuan, Weiqi, Yu Zhang, and Phillip A. Laplante. "", Real-Time Imaging IX, 2005. Publication	<1%
10	Kexue He. "A Classification Method for the Dirty Factor of Banknotes Based on Neural Network with Sine Basis Functions", 2008 International Conference on Intelligent Computation Technology and Automation (ICICTA), 10/2008 Publication	<1%
11	twitter.com Internet Source	<1%
12	Submitted to Glasgow Caledonian University Student Paper	<1%
13	jivp-eurasipjournals.springeropen.com Internet Source	<1%
14	www.ijesit.com Internet Source	<1%
15	Submitted to Federal University of Technology Student Paper	<1%

16	Submitted to University of South Australia Student Paper	<1%
17	Submitted to Loughborough University Student Paper	<1%
18	Submitted to Leeds Beckett University Student Paper	<1%
19	www.szonyi.hu Internet Source	<1%
20	web2py.iiit.ac.in Internet Source	<1%
21	Fan-hui Kong, Ji-quan Ma, Jia-feng Liu. "Paper Currency Recognition using Gaussian Mixture Models Based on Structural Risk Minimization", 2006 International Conference on Machine Learning and Cybernetics, 2006 Publication	<1%
22	Submitted to University of Mauritius Student Paper	<1%
23	Tamarafinide Victory Dittimi, Ching Yee Suen. "High correlation-based banknote gradient assessment of ensemble classifier", International Journal of Wavelets, Multiresolution and Information Processing, 2019 Publication	<1%

24	Suriya Singh, Shushman Choudhury, Kumar Vishal, C.V. Jawahar. "Currency Recognition on Mobile Phones", 2014 22nd International Conference on Pattern Recognition, 2014 Publication	<1%

Exclude quotes	Off	Exclude matches	Off
Exclude bibliography	Off		