Road Sign Detection and Translation in Bangla Using Image Processing and Machine Learning

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A thesis submitted to the Department of Computer Science and Engineering
in partial fulfillment of the requirements for the degree of
B.Sc. in Computer Science

Department of Computer Science and Engineering
Brac University
August 2019

Declaration

It is hereby declared that

1. The thesis submitted is our own original work while completing degree at Brac University.
2. The thesis does not contain material previously published or written by a third party, except where this is appropriately cited through full and accurate referencing.
3. The thesis does not contain material which has been accepted, or submitted, for any other degree or diploma at a university or other institution.
4. We have acknowledged all main sources of help.

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Abstract

For the drivers while driving, road signs play very important role but it is really challenging for the drivers' if they are not at home with the meanings of the signs. Driving is a process which is complex, continuous, and multitasking that involves driver's perceptive ability and motor movements. Road and traffic signs and vehicle information is presented in such a manner that distracts driver's attention intensely with increased mental workload leading to safety concerns. Road sign recognition and translation system is basically a system for intelligent vehicle which guides the driver to obey the traffic rules. These are the traffic rules which are represented in a small pictorial form, erected at road sides. Our proposed work represents the process of recognizing the captured sign and then translate the detected sign in Bangla. Translation of an image is done by matching multiple images. We are presenting a system for detecting and recognizing the signs displayed around us and voice synthesizing their contents with an algorithm for detection and recognition of road sign using image processing and machine learning method. We have used a template matching algorithm to match the road signs with the database after recognizing road signs it will be translated in Bangla or English according to user preference and manufactured as voice output note. The detection, recognition and speech synthesis modules each will perform their respective tasks effectively and efficiently, and the future advancement of the currently proposed system is promising.

Keywords: Sign Detection; Image Processing; Template Matching; Gray Scaling images; Translation Bangla/English; Voice Output.

Dedication

We would like to dedicate our thesis to our parents, family members and friends.

Acknowledgement

First of all, the entire praise to the Great Allah for whom we were able to tackle any and all interruptions that we had to face.
Secondly, to our thesis supervisor Dr.MD. Ashraful Alam sir for his continuous guidance throughout our work. He was available to us a lot whenever we needed any kind of advice regarding our work from him.
Thirdly, the whole judging panel of AI and Machine Learning for giving us the opportunity to present our work in front of them.
And last but not the least, to our loving parents without their motivation it would have been much harder for us. Because of their firm belief in us, we are now going to achieve our Bachelors degree in Computer Science and Engineering .

Table of Contents

List of Figures

List of Tables

Nomenclature

The next list describes several symbols & abbreviation that will be later used within the body of the document

BRTA Bangladesh Road Transport Authority

CNN Convolutional Neural Network

HOG Histogram of Oriented Gradients

HSV Hue Saturation Value

IDE Integrated Development Environment

LoG Laplacian of Gaussian

LUT Look-Up Table

OpenCV Open Source Computer Vision Library

ROI Region of Image

STL Standard Template Library

STSD Swedish Traffic Sign data

SURF Speeded Up Robust Features

SVM Support Vector Machine

TSDR Traffic Sign Detection and Recognition

Chapter 1

Introduction

1.1 Motivation and Goals

In present days the number of road accidents in our country has increased rapidly. Last year in July, there was a case where a bus driver drove the bus onto a crowd of people who were about to aboard another vehicle, injuring seven people and killing two college students. And this is due to the fact that the driver was not obeying the traffic rules and regulations and instead was indulging in a mad race with another driver. This horrific event shook the country. Across Dhaka, many students belonging to different institutions came forward in protest. Events like this and many more are what attracted our attention to the degrading conditions of our country's road and the lack of obedience to the rules of the road. Though sometimes it is not the drivers fault entirely. The condition of most of the roads are such that it is not that easy for drivers to pay attention while driving without falling into the nooks and crannies for them to notice any road signs that may lie by the road. Road signs are intended to preserve the safety of the drivers. They assist to generate the direction on the roadways. If any driver fails to understand what the sign is about, his/her life may be at risk on the road. Therefore, detecting and recognizing the road signs is a must for the drivers. The purpose of our work is to help the drivers in detecting the road signs and make them aware about the signs. In our work, we are trying to help them in figuring out the road signs' meanings. Our system will let them know what does the particular sign stand for and the signs will be translated both in our native language so that the drivers can follow the signs easily and in English as well aiming at the foreigners.

1.2 Project Scope

Detection of road signs is a system by which the drivers are capable to recognize the signs placed on the road and can drive accordingly. Translating the detected road sign can be an easy way for the drivers to navigate. Few other countries have already made this system but we are doing the translation both in our own language, Bangla and in international language, English. Moreover the voice output will help the drivers to be concentrated in driving only as they don't need to look upon the signs. Through our system we are trying to ensure a safe driving on roads.

1.3 Overview

After many researches on several methods and processes related to road sign detection and translation in a specific language, the project has started. In this paper we have first discussed about some of the previous work that has been done in this field related to detection of road signs using image processing and different machine learning techniques, and how different approaches lead to different yet satisfying results, which shows that there are no limitations when it comes to approaching any subject matter. We have presented the proposed model of the system that we have worked on and explain the workflow. We discussed how the video is fed into the system using the OpenCV library's built in method and converted them to grayscale. Then it is segmented using edge detection and matched with an existing image in our data set with the help of template matching and SVM(Support Vector Machine). Then finally a voice output is generated to make the user aware of the contents ahead of the camera. We have mentioned some of the important libraries and algorithms used in the process and explained as to why we have chosen to work with them. After that we have discussed on the relative results we have acquired from the process which is concurrent with the size of our data set. Finally we have concluded our paper and discussed some of the future plans we have for this project that we hope to achieve soon.

Chapter 2

Literature Review

While working on our thesis project we had to study and understand some works and research that have been done previously which are relevant to TSDR system, and there have been quiet fruitful results in the past, some employing the use of simpler algorithms like template matching and colored segmentation and some more recent ones are done employing different Computer Vision and Machine Learning techniques like, (SVM), (CNN), boosting, random forest etc. which result in more effective system for end users. A group has worked on object recognition in outdoor environments. The objects selected for this work are traffic or road signs in highways and cities, the detection part of which is handled with the help of a genetic algorithm. The system also analyzes the condition of the sign with recognition [23].A sign indicates the obviousness of a fact, quality or condition. Currently some work is being done on Chinese sign interpretation. A prototype has been developed that recognizes Chinese sign as input from a video and interpret the signs into English or voice stream. The sign interpretation with spoken language can be advantageous to people with visual impairments and increase their environmental awareness [11].

2.1 Obstacles confronted in sign detection and recognition

During our project, we knew we will have to deal with some of the same problems that had been faced by our predecessors in this topic. For example, problems regarding the quality of the image captured for processing or the quality of the road sign within the frame. The quality to the image may be later preprocessed and intensified in computational process, let it be lighting problem or angle of perception, but what of the condition of the sign itself which may be aged, damaged due to weather or roadside accidents, which is the case for most signs on the highways of this country. For these reasons and more such system for road sign detection was necessary which is efficient enough to generate clear, concise and precise results that can provide extra information to the user than what is given to the system itself[13].

2.2 Background of TSDR

In 1984 in japan, the concept of automated road sign detection system was explored for the first time, as stated by Paclik[9]. And since that day this topic have gotten

attention from a lot more people in different countries, all of whom are trying to come up with the most efficient and user friendly system for TSDR system for assistance of the driver that will generate results in real time with maximum percentage of accuracy. Akatsuka and Imai[1], were one of the first to attempt building an automatic TSDR in real-time system, by using RGB color space for sign segmentation. In [2], the author employed the use of Hough transform on the edges of ROI's, which could be considered as the first try at traffic sign recognition provided the structural information of the sign. This was later modified or improved upon in [6] where color based segmentation was utilized to exaggerate the features of the sign. In [4] a model was put forth for the real-time applications of TSDR system which seemed an attractive at the time that first uses color segmentation and forms an extract of traffic sign to contrast with an existing database of traffic signs for recognition.

2.3 TSDR using Color Segmentation

In many foreign countries, the traffic signs are differently colored based on the meaning of the signs and the urgency or importance of them for all the vehicles on the road. Therefore many researchers opt to employ the color-based TSDR system. Some authors of published papers on the subject matter like in [12], tried to examine the difference of color on traffic signs based on the lighting surrounding it, then came to the conclusion that the affect were not that prominent and put forth an easy to understand algorithm for segmentation. The authors in [5][3] generated codes to find traffic signs from color combination in the image using RGB color space and later employed multiple shape filters to identify the traffic sign within the ROI. Color quantization method in HSV color model was adopted by Liu et. Al. in [16], following which ROI scaling and border tracing were also done. Using CIECAM97 color model, colors that shows characteristics similar to signs were identified from real-life images by authors of [14]. In [10] Perception neural network was utilized to classify images after transforming them by wavelets. Gómezin [20] put forth a comparative analysis between multiple methods of segmentation based on multiple color spaces utilized in depicting features in traffic signs.

2.4 TSDR using Shape-based Classifiers

With the introduction of system for object Recognition, the possibilities of building a more efficient TSDR system has been reaching the sky. And in this regard the tools which are most often and prominently used are provided by machine learning approaches. A very simple application of using machine learning approaches for traffic sign detection and recognition by color thresholding and shape analysis is put forth in [7]. However, the author in 2003 published a paper [13] that depicted the utilization of LUT's in HSI to detect ROI's and used genetic algorithm for detection as it provided more effective detection system irrespective of distance, position, angle, damage or obstacles in the path of observation. Another approach was explored in [15] where image is segmented then traffic sign was identified while keeping any damage of the sign into account, using support vector machine (SVM). A unique approach was presented in [8] where distance transform, a template based correlation technique, is utilized in detection and classified by radial basis function

networks. So it can be seen that in western countries employ the use of both color segmentation and template matching methods to make their TSDR systems more effective and efficient.

2.5 Current works of TSDR System

Since entering into the 2000's the concept of detection, recognition and notification of traffic signs have been making strives as more and more new techniques and branches of machine learning are being introduced to the modern world. [18] in 2008 put forth a method where a trained cascade of multi-layer perception machine segments the pixel in YCbCr color space where it generate more satisfying results than SVM. In [17] radial symmetry detector was used to detect speed limit sign on road while the detector was strapped atop a moving vehicle to test its' performance. In 2010 [21] depicted how disparate different traffic signs were when color distant transform was used with the combination of one-vs-all nearest neighbor classification and how superior it was in terms of performance.

Chapter 3

System Implementation

3.1 Proposed Model

In the presented model, shown in Fig. 3.1 in the beginning the system takes the video feed and converts it into grayscale. After that it performs segmentation on each frame to check if relevant structures or patterns are available. If ROIs are available, the system reads that part of image in the frame and crops out the area of interest. Then model then match the road sign image template with the captured images. After matching it generates a voice output in Bangla whether the sign is.

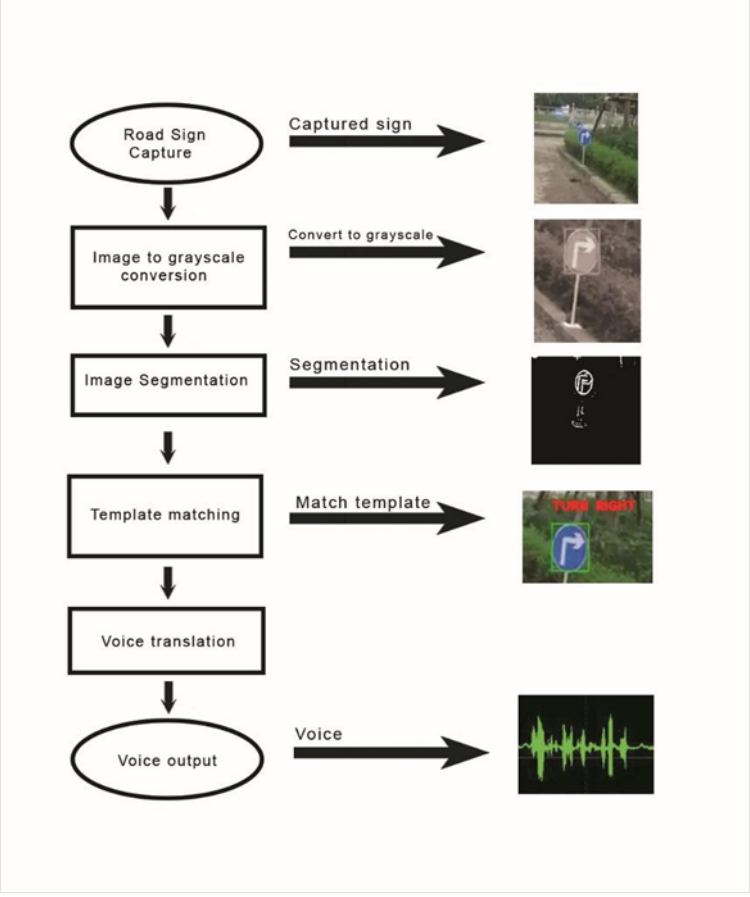

Figure 3.1: Flowchart of proposed model.

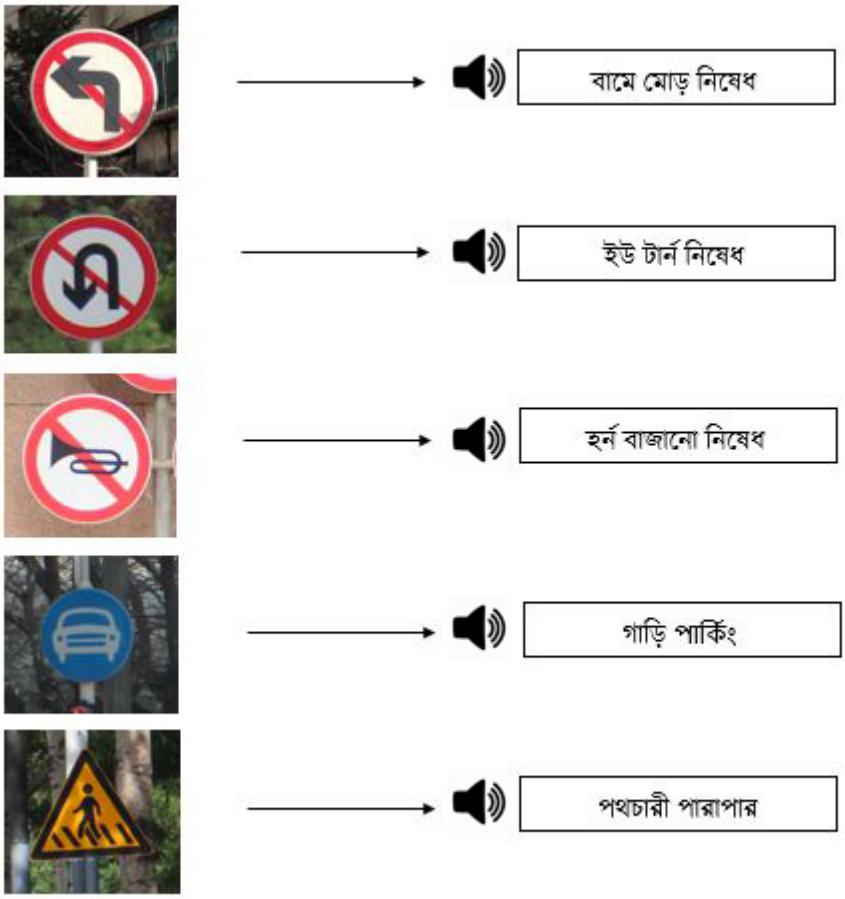

Figure 3.2: Road Sign and Voice Output in Bangla.

3.2 Work Flow

3.2.1 Image Input

To take an image as input, we have used a built in function of OpenCv in our system. We have accessed the primary camera of the device currently at use by setting a parameter (Zero) and then feed the captured video to the algorithm of the system.

3.2.2 RGB to Grayscale conversion

In our research, the image captured here is in the RGB format, in which the size of each pixel is 24. This in turn can make the computational process lengthier than it should be. So, the image is converted to grayscale to reduce size of each pixel to 8, hence, reducing the computational time. The height and width of the images are also measured by using OpenCV and Laplaceian of Gaussian Blur is used to remove extra textures of the neighborhood image. This in turn helps in edge detection process. Every pixel of the image is processed by calculating the average of pixel value corresponding to its location. Since in Gaussian Blur method negative values are ignored, we have used the Laplaceian of Gaussian Blur to preprocess the image.

However, to binarize the image, we have used the simple Threshold in which for every pixel the Threshold value is set to 32 whereas the maximum intensity for grayscale image is 255. However, in our research if the pixel value is much bigger than our Threshold value, it will convert the pixel in White.

3.2.3 Image Segmentation

It is a process of partitioning an image into parts for detection of shapes that we are searching for. In our work, we have used the function cv2.Canny () from Edge Detection algorithm. In this function, the first parameter is for the input image that we have converted into grayscale. In the second and third parameter minimum and maximum value is set respectively. For the next parameter, aperture size is used to find the gradients of the image and by default its value is 3. Moreover, to detect the shape and to get the lines from the image we have used cv2.HoughLinesP () function in our Image Segmentation stage to search for circles, ellipses or hexagons. The parameter of the function contains the grayscale image as input, value of rho, value of theta, the value of the minimum length of the line that we want to detect and the value of the maximum line gap between line segments to treat them as single line. Thus we have done the segmentation of the images in our work.

3.2.4 Template Matching

The Template Matching is a process to achieve the optimal equivalence of a template within an input image. In our project, we have used SVM Algorithm for template matching. Our data was initially distributed into following sections : i) for training, ninety percent of images and ii) for testing, the remaining ten percent. After segmentation and detection of all circles, ellipses or hexagons in the image, their co-ordinates are noted and cropped out from the original image to verify the contents within the shapes. Finally that cropped image is match to or trained data to classify the sign. Thus templates matching is done in this work.

3.2.5 Voice Output

After doing the processes mentioned above, our system detects the road sign and generates a predefined text which in turn gives a predefined voice output in Bangla using Play sound. It is the most straightforward package for playing mp3 or WAV file. We have chosen it for our work as it simply playbacks what the detected road sign indicates.

Chapter 4

Dataset and Used Method

4.1 OpenCV

OpenCV is a BSD licensed software library that contain more than 2500 algorithms to give aid to machine learning and computer vision purposes like recognizing faces and objects static or moving, classify human action in videos, make landscape images of an entire scenery by stitching smaller images together etc. the possibilities are great yet growing each day [27]. Although OpenCV is primarily written in C++ with an interface that works with STL containers effortlessly, It also has Python, Java and MATLAB interfaces that can support any Windows, Linux, Mac OS and Android. One of the main reason we have chosen openCV for implementing our thesis project is because of its' lenience towards real-time vision application as for our project we needed to access the camera of our device and feed the procured data to the system through the implementation of our code.

4.2 NumPy

It is a python programming language library. It also supports high level mathematical operations on large and multi-dimensional arrays and matrices. It is an open-source software. Instead of scalars, operations of NumPy in python and give MATLAB a run for its money as long as the operations take place on arrays on matrices. Some of NumPys' features include.

- Contains robust n-dimensional array objects.
- Has up-to-date functions.
- Can be integrate with C/C++.

The reasons behind choosing this library is that the library OpenCV uses NumPy arrays to store and do operations on data. Indexing and masking with arrays make it easy to get specified pixels of images and it is used to resize and reshape images at the time of training or preprocessing.

4.3 Python

Python is a translated, high-level and broadly used programming language. The construct of the language and its' object oriented approach is designed to aid programmers, professionals or a novice can write clear, concise code of any scale. For its' extensions of libraries it is also thought of as a "batteries included". Python codes are very easy to write and understand as it makes great use of the white spaces in the code due to indentation that indicates which lines of code are under a particular method and which method is run after the other etc. Though some rules of Python are complex but still not as complicated. Any function can be executed on python in lesser lines of code than java or C++. The reason for which we have chosen to use python as the programming language of our project is it helps in concentrating on main functions of an application as it takes care of the general programing tasks. It is a productive language that helps in development of application very fast in multiple areas and is best choice for data analysis and artificial intelligence. For our project we used python version 3.6 as it has access to the built in accessories of the previous versions which were required for the project.

4.4 Dataset

We started the dataset collection form Bangladesh road sign according to BRTA (Bangladesh Road Transport Authority) there are 5 kinds of road sign. These are Regulatory signs, Warning signs, Information signs, Additional signs, Traffic signals. We have collected 44 images of regulatory signs, 71 images of warning signs, 16 images of information signs, 10 images of additional signs also 2 images of traffic signals and each image has more than 30 types of image from different angles, different resolutions and different saturation so that we can get the best result and high accuracy. So we have 5000 images in total in our dataset.

Figure 4.1: Regulatory Road Signs.

Figure 4.2: Warning Road Signs.

Figure 4.3: Information Road Signs.

Figure 4.4: Some of our Dataset in Different Resolution.

4.5 SVM

It is a supervised learning model which contains many useful algorithms for regression and classification purposes. It is a "non- probabilistic binary linear classifier that represents examples as points in spaces, where two examples belonging to two different categories are placed as far as possible and when new samples are introduced to the space they are place with the other examples with which they are predicted to be similar with. Thus it is a discriminative classifier. Though considered as linear classifier it can also conduct non-linear classifications on a multi-dimensional spaces. SVM can operate in both supervised as well as unsupervised learning approaches that detects natural clustering of data to groups, in unlabeled data. SVM has some parameters like, regularization parameter, gamma and kernel, the values of which can enhance the accuracy of classification[26]. For our project we chose to work with SVM because when this algorithm is fed the feature vectors of the image it classifies them effectively and efficiently.

4.6 PyCharm

PyCharm is one of the integrated development environment (IDEs) for computer programming which is commonly used especially for the Python language. It analyses code, works as a graphical debugger, an integrated unit tester, integrate with version control system and supports web development with Django as well as Data Science with Anaconda. In recent days, many programmers choose Python to create software applications with the concise, clean and readable code base. They can even accelerate custom software application development by adopting an IDE like PyCharm. PyCharm is a cross platform with Windows, macOSand Linux versions. Simultaneously, the features provided by PyCharm help programmers to write a variety of software applications in Python quickly and efficiently. Moreover, the PyCharm UI can be modified by the programmers according to their particular requirements and preferences. Some of the major features of PyCharm

- Code Editor
- Code Navigation
- Refactoring
- Support for Popular Web Technologies
- Support for Popular Python frameworks
- Support for Python Scientific Libraries

Chapter 5

Experimental Result and Analysis

5.1 Test and Training Sets

Our dataset consists of 23 classes (In our dataset there are many signs based on bad lighting condition which is really hard to understand based on that we classify them into 23 classes) of 17 signs of road sign images. On average 300 images for training and 200 images for testing and validation. This gives us 5000 images for training and 4000 images for validation so in total 9000 images. We are also working on adding new dataset and preprocessing them to fit in our model training.

5.2 Results

We have trained our model with the training images. After running the program in Fig. 5.1-5.3 we can see the road sign detected and after detection it shows in word for different road sign. Also after recognizing it was gave a voice output in Bangla.

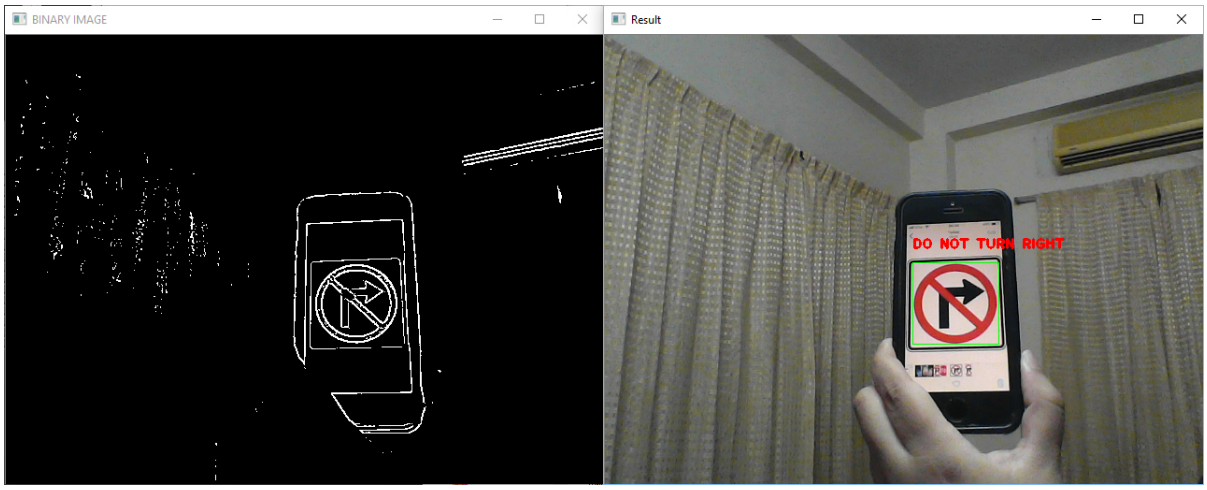

Figure 5.1: Road sign detection and translation for DO NOT TURN RIGHT sign.

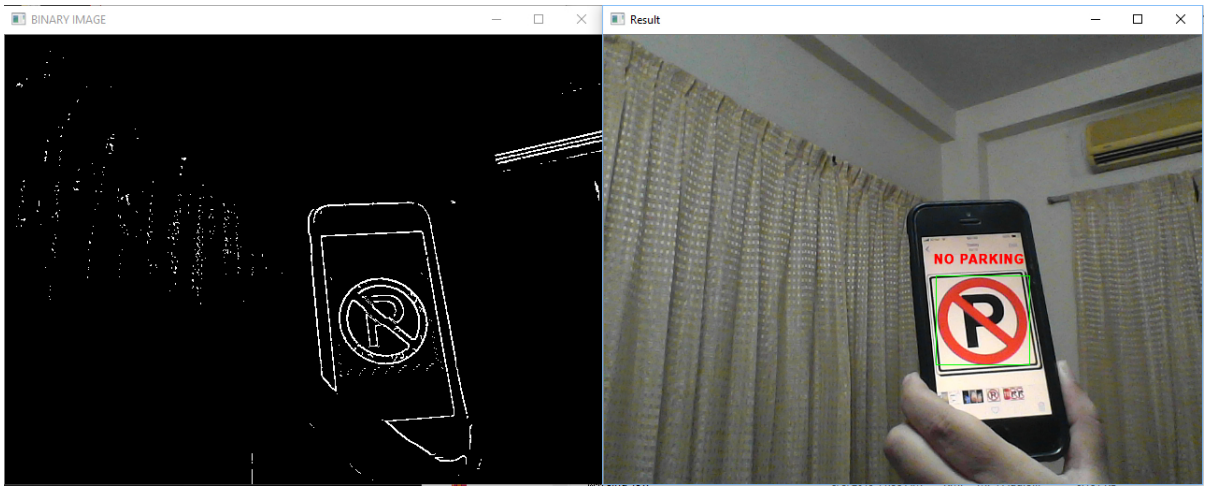

Figure 5.2: Road sign detection and translation for NO PARKING sign.

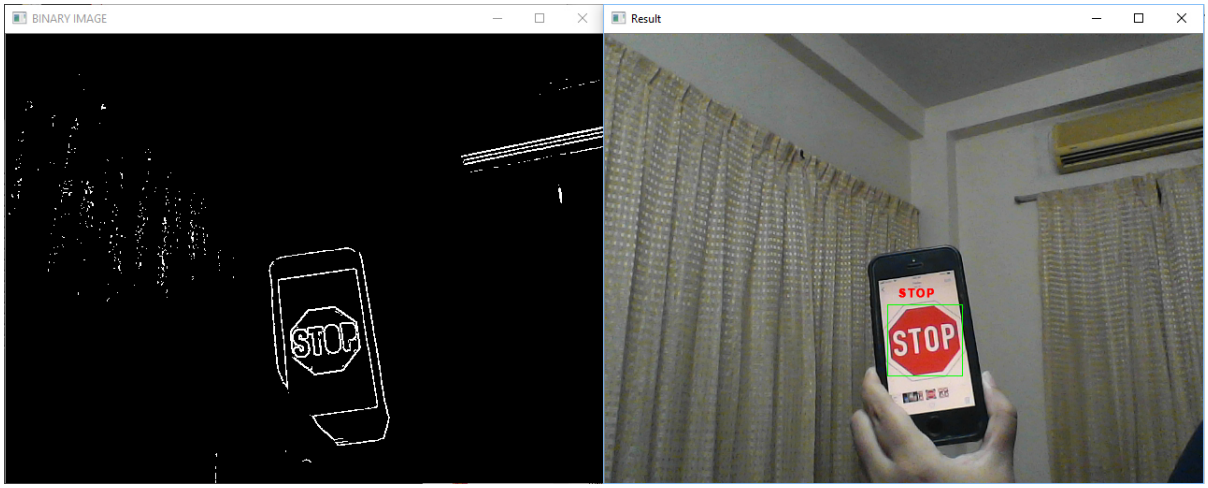

Figure 5.3: Road sign detection and translation for STOP sign.

Accuracy

In our model prediction accuracy increases from .40 upto .90 as the number of features increases.Features like gamma correction , threshold value, block size and gradients. Initially 4 or 5 features were not enough for classification in our context. Though 10 features were fast enough in training time and detection but producing an underfitting classifier . We are working on adding more features 12 features are mostly able to detect 90% accuracy.
There is saying like garbage in is equal to garbage out. Number of sample size and invalid data causes issues in training time result in detecting wrong object after initial training with 2000 , it correctly detect 70% time which increases up to 90% with 4000 and remain 5000 unchanged

Figure 5.4: Accuracy Measures Through Dataset.

Figure 5.5: Accuracy on Feature Selection.

5.3 Comparative Analysis

The following table, refers to all the previous related research works which are related to our project have been done in the past years. The methodologies and types of dataset that were employed in training and testing corresponding to their general accuracy from their respective presented models. There are pros and cons to their respective approaches employed. When a comparative analysis was conducted among these various methods, among the different methods two are common, where they used thresholding. We have also used different type methods that were unemployed by them.

Authors	Year	Paper title	Methods	Accuracy	Dataset
Y. Y. Nguwi, Kouzani	2008	"Detection and Classification of Road Signs in Natural Environment"[18]	Multiplier perceptron, scaled conjugate gradient	96%	Undefined
M. Prieto, A. Allen	2009	"Using Self-organizing Maps in the Detection and Recognition of Road Signs"[19]	Self-organizing map, neural network	Undefined	1,500 road scene images and 3,500 road sign images
A. Ellahyani, Md. E. Ansari, I. E. Jaafari	2016	"Traffic Sign Detection and Recognition Using Features Combination and random Forest"[25]	HOG, LSS, Thresholding in HSV color space, Random forest	95.12%	(STSD) containing 20,000 images and 3288 of them are of traffic signs.
S. B. Wali, Md. A. Hannan, S. Abdullah, A. Hussain, S. A. Samad	2015	"Shape Matching and Color Segmentation Based Traffic Sign Detection System"[24]	RGB color segmentation, median filter, pixel value for region detection	94.85%	Undefined
L. Chen, Q. Li, M. Li, Q. Mao	2011	"Traffic Sign Detection and Recognition for Intelligent Vehicles"[22]	Color-based segmentation, AdaBoost, SURF	92.7%	265 detected traffic signs of which 244 were classified correctly.
L. Chuan, P. Shenghui, Z. Fan, L. Menghe, K. Baozhong	2011	"A Method of Traffic Sign Detecting Based on Color Similarity"[23]	RGB Color space, Segmentation, thresholding, LOG,Canny, Operator Roberts	90.84% -94.17% (based on condition)	120 traffic signs on sunny and rainy day.

Table 5.1: Table of Comparative Analysis

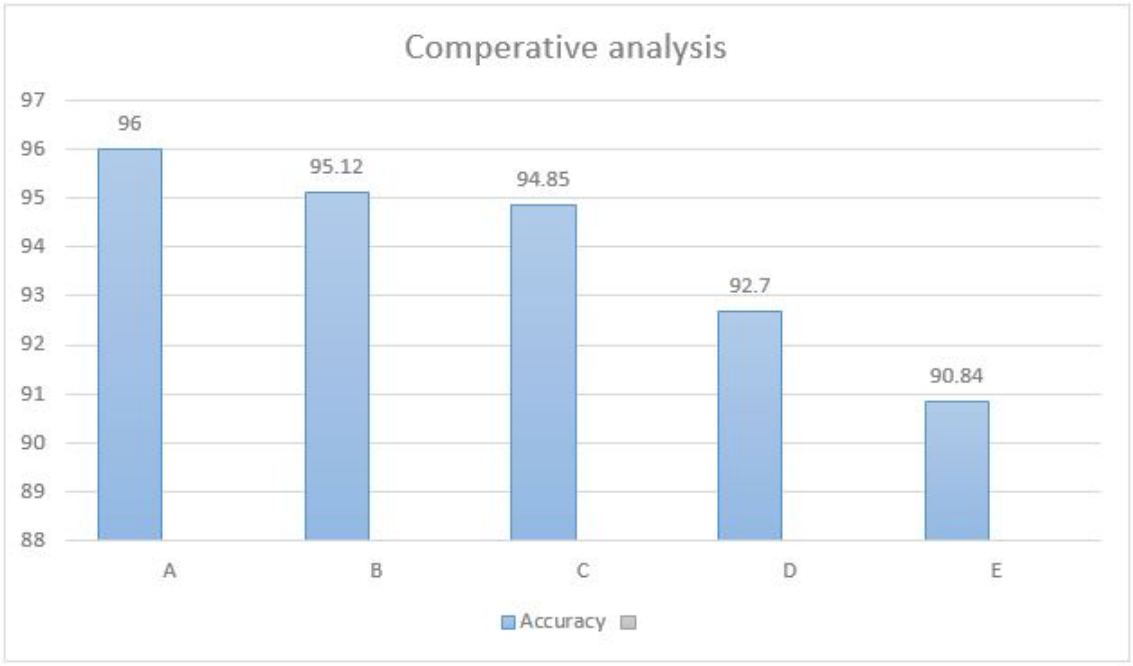

Figure 5.6: Comparative Analysis from previous research.

Chapter 6

Conclusion and Future Implementation

6.1 Conclusion

The death rate due to road accident in Bangladesh is increasing and not maintaining the road signs by drivers appropriately, is one of the reasons behind the accidents. Our project would serve a way of road sign detection and translation with a voice output system through image processing and machine learning so that it can accurately depict the signs ahead on the road and our program can let the driver know about what unknown may lie ahead so that they can easily and possibly a bit earlier be prepared to handle it and avoid causing injuries to themselves, any passengers they are carrying and anyone around their transport.

6.2 Future Plan

Our future plan includes the implementation of this system in a larger scale putting aside more language barriers apart from just Bangla and English. The main and only problem is that sometimes the actual meaning of a sentence may be misinterpreted in translation as often systems translate one word at a time. However, the inclusion of Machine Learning is so that the system can learn through data collected and experience at field. Another aim for future is making the process much faster and easier the image preprocessing, pattern recognition and translation process could be made while also increasing its accuracy level.

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Appendix

1. OpenCV library can be helpful for commercial, personal or even government use, with the number of users in the north of 47,000+ and over 18 million downloads. It is currently being used by numerous well established companies like Google, Yahoo, Microsoft, Intel, IBM, Sony, Honda, Toyota as well as some start-ups that know how to utilize the library to its' full extent like Applied Minds, VideoSurf, and Zeitera etc.

2. Python was first released in 1991. Numerous programming paradigms, including procedural, functional and object-oriented programming can be handled by this language.

3. PyCharm is developed by a company named JetBrains. Any programmer, who wants to use PyCharm, needs an official license for JetBrains which is completely free. We have used the profession license of JetBrains to get access to PyCharm which is a product of JetBrains and the license is absolutely free.