

Heaven's Light is Our Guide



DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING
Rajshahi University of Engineering & Technology, Bangladesh

**A Feature Fusion Based Approach for Handwritten Bangla
Character Recognition**

Author

Md. Mahin Chowdhury Bipu

Roll no: 123071

Department of Computer Science & Engineering
Rajshahi University of Engineering & Technology

Supervised by

Shyla Afroge

Assistant Professor

Department of Computer Science & Engineering
Rajshahi University of Engineering & Technology

ACKNOWLEDGEMENT

All praises to the Almighty Allah for granting His blessing upon me to accomplish this challenging task.

First of all, my deepest heartfelt gratitude and thanks to my honorable supervisor, **Shyla Afroge**, Assistant Professor, Department of Computer Science & Engineering, Rajshahi University of Engineering & Technology, Rajshahi, Bangladesh for her constant guidance, advice, co-operation, inspiration and every possible help throughout the work and preparation of this thesis. Her suggestions, encouragement, patience and support played a vital role in completion this thesis work.

I would also like to express my sincere appreciation and deepest sense of gratitude to my honorable teacher **Prof. Dr. Md. Robiul Islam**, Head, Department of Computer Science & Engineering, Rajshahi University of Engineering & Technology, Rajshahi, Bangladesh for his valuable support, recommendation regarding this thesis paper. Next I would like to be grateful my friends for their continued support. They provided the full encouragement required throughout the entire journey of this work.

Finally, I would also like to thank all those who help to create a nice research environment in spite of many obstacles. I would like to thank my family and well-wishers for their encouragement and support.

December, 2017
RUET, Rajshahi

Md. Mahin Chowdhury Bipu

Heaven's Light is Our Guide



DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING

Rajshahi University of Engineering & Technology, Bangladesh

CERTIFICATE

This is to certify that this thesis report entitled “A Feature Fusion Based Approach for Handwritten Bangla Character Recognition” submitted by Md. Mahin Chowdhury Bipu, Roll: 123071 in partial fulfillment of the requirement for the award of the degree of Bachelor of Science in Computer Science & Engineering of Rajshahi University of Engineering & Technology, Bangladesh is a record of the candidate own work carried out by him under my supervision. This thesis has not been submitted for the award of any other degree.

Supervisor

Shyla Afroge

Assistant Professor,
Department of Computer Science &
Engineering
Rajshahi University of Engineering
& Technology
Rajshahi-6204

External Examiner

Firoz Mahmud

Assistant Professor,
Department of Computer Science &
Engineering
Rajshahi University of Engineering
& Technology
Rajshahi-6204

ABSTRACT

Optical Character Recognition (OCR) is an abstruse area of pattern recognition. An active branch of OCR is handwritten character recognition. This paper presents Bangla handwritten character recognition based on a feature fusion endeavor. Character recognition mostly depends on impeccable features extracted from input images. Coupling of two distinct feature vectors obtained by Histogram of Oriented Gradients (HOG) and Gabor filter is illustrated here. To evaluate the recognition rate of input characters Extreme Learning Machine (ELM) is used which is a feed-forward neural network. A 5-fold cross-validation scheme has been applied to measure the performance of the system. While using individual feature extraction technique, HOG and Gabor filter show 90.5% and 91.2% accuracy respectively. However, using feature fusion approach provides a better accuracy of 96.1%.

Keywords— Optical character recognition; Feature extraction; Histogram of oriented gradients; Gabor filter; Extreme learning machine.

CONTENTS

| | |
|------------------------|------------|
| ACKNOWLEDGEMENT | ii |
| CERTIFICATE | iii |
| ABSTRACT | iv |

CHAPTER 1

| | |
|---|------------|
| Introduction | 1-7 |
| Introduction | 2 |
| 1.1 Optical Character Recognition | 2 |
| 1.2 Brief History of Character Recognition | 3 |
| 1.3 Bangla Scripts for OCR | 3 |
| 1.4 Problem Definition | 5 |
| 1.5 Background Study | 6 |
| 1.6 Objective of the Thesis | 7 |
| 1.7 Decomposition of Thesis | 7 |
| Conclusion | 7 |

Chapter 2

| | |
|-------------------------------|-------------|
| Theoretical Background | 8-21 |
| Introduction | 10 |
| 2.1 Image | 10 |
| 2.2 Digital image | 10 |
| 2.3 RGB image | 11 |
| 2.4 Gray Image | 12 |

| | |
|---|-----------|
| 2.5 Image Acquisition | 12 |
| 2.6 Image Preprocessing | 13 |
| 2.7 Image Enhancement | 13 |
| 2.7.1 Enhancement by point processing | 14 |
| 2.7.2 Spatial Filtering: | 16 |
| 2.7.3 Enhancement in the frequency domain: | 18 |
| 2.7.4 Pseudo color image processing | 19 |
| 2.8 Geometric Distortion | 19 |
| 2.8.1 Translation | 19 |
| 2.8.2 Rotation | 20 |
| 2.9 Restoration | 20 |
| Conclusion | 21 |

Chapter: 3

| | |
|--|--------------|
| Character Recognition System | 22-40 |
| Introduction | 24 |
| 3.1 Steps of Bangla Character Recognition | 25 |
| 3.2 Input Discrepancy | 25 |
| 3.3 Optical Scanning | 26 |
| 3.4 Location Segmentation | 26 |
| 3.5 Preprocessing | 27 |
| 3.5.1 Binarization | 27 |
| 3.5.1.1 Otsu's Method | 28 |
| 3.5.1.2 Niblack's Method | 28 |

| | |
|--|--------------|
| 3.5.1.3 Sauvola Method | 28 |
| 3.5.1.4 Bernsen | 29 |
| 3.5.1.5 Local Maxima and Minima | 29 |
| 3.5.1.6 Adaptive Contrast | 29 |
| 3.5.1.7 Global-to-Local Approach | 29 |
| 3.5.1.8 Morphological Contrast Intensification | 30 |
| 3.5.2 Noise Removal | 30 |
| 3.5.2.1 Median Filter | 31 |
| 3.5.2.2 Gaussian Filter | 31 |
| 3.5.3 Skew Detection and Correction | 32 |
| 3.5.4 Segmentation | 32 |
| 3.5.4.1 Line Segmentation | 33 |
| 3.5.4.2 Word Segmentation | 33 |
| 3.5.4.3 Character Segmentation | 34 |
| 3.5.5 Scaling | 34 |
| 3.6 Feature Extraction | 34 |
| 3.6.1 Statistical Features | 35 |
| 3.6.2 Structural Features | 35 |
| 3.7 Recognition | 37 |
| Conclusion | 40 |
| Chapter: 4 | |
| Proposed System | 41-46 |
| Introduction | 42 |

| | |
|---|--------------|
| 4.1 Methodologies | 42 |
| 4.1.1 Pre-processing | 43 |
| 4.1.2 Feature Extraction | 43 |
| 4.1.3 Classification | 45 |
| Conclusion | 46 |
| Chapter: 5 | |
| Experimental Results and Analysis | 47-50 |
| Introduction | 48 |
| 5.1 Recognition Accuracy | 48 |
| Conclusion | 50 |
| Chapter: 6 | |
| Conclusion and Future Work | 51-52 |
| Conclusion | 52 |
| Future Development with Ongoing Research | 52 |
| REFERENCES | 53-55 |

LIST OF TABLES

| | | |
|------------|--|----|
| Table 2.1: | Ranges of gray scale | 12 |
| Table 5.1: | Comparison of Performances of Different Feature Extraction Techniques. | 48 |
| Table 5.2: | Recognition Rate of Feature Extraction Techniques. | 49 |

LIST OF FIGURES

| | |
|--|----|
| Fig. 1.1: Basic characters & numerals of Bangla script | 4 |
| Fig. 2.1: Image Enhancement Operation. | 14 |
| Fig. 3.1: The Components of OCR system | 25 |
| Fig. 3.2: The different areas of character recognition | 25 |
| Fig. 3.3: Pre-processing steps of image | 27 |
| Fig. 3.4: Binalization process | 30 |
| Fig. 3.5: Median filter. | 31 |
| Fig. 4.1: Overview of proposed system | 42 |
| Fig. 4.2: HOG features of a Bangla character for different cell size | 44 |
| Fig. 4.3: Fig 4.3: Magnitudes of Gabor filter | 45 |
| Fig. 4.4: Magnitudes of filtered character ‘ক’ | 45 |
| Fig. 4.5: Architecture of extreme learning machine | 46 |
| Fig. 5.1: Accuracy rates of different feature extraction techniques. | 50 |