

**COMPUTER AIDED ANALYSIS OF
HANDWRITTEN
DEVANAGARI DOCUMENTS FOR
FORENSIC APPLICATIONS**

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HANDWRITTEN DEVANAGARI DOCUMENTS
FOR FORENSIC APPLICATIONS**

by

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Technology**

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I dedicate this thesis :

To my parents for unconditional love and support

*To my husband, Purushotham, without whose caring support it
would not have been possible*

Certificate

This is to certify that the thesis titled “**Computer Aided Analysis of Devanagari Documents For Forensic Applications**” being submitted by **Ms. Nivedita Yadav** to the Amarnath and Shashi Khosla School of Information Technology, Indian Institute of Technology, Delhi, for the award of the degree of Doctor of Philosophy, is a record of bona-fide research work carried out by her under our guidance and supervision. In our opinion, the thesis has reached the standards fulfilling the requirements of the regulations relating to the degree.

The results contained in this thesis have not been submitted to any other university or institute for the award of the degree or diploma.

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Abstract

The studies on handwriting are quite old. The variations in handwritings, both inter-writer and intra-writer have made this popular research area in the field of pattern recognition. This thesis addresses the problem of automated forensic handwriting analysis for handwritten Devanagari documents. All Indian scripts are very different from English. They are based on Devanagari script which is among the top five widely spoken languages in the world. We present a systematic examination of Devanagari documents for different forensic applications like forgery detection, writer recognition, writer verification, writer recognition using multiple feature combination, multiple word based forgery detection and discriminative primitive selection for Devanagari text.

We present a new database "DevLipi" on Devanagari for forensic analysis of handwriting. We have collected 10 pages from each writer and they were asked to write one page per day. This was done to capture as many variations as we can in the handwriting to study the inter-writer and intra-writer variations. We have a collection of 400,000 handwritten words.

We also propose a technique for selection of most discriminatory primitives of Devanagari script. We use feature selection method to select a set of primitives, which can help in better and faster discrimination of writers. Both identification and verification models can be used for the forensic analysis of handwriting. In our study, we have considered the handwritten documents which cover a large range of natural variations. Discrimination studies based on words and characters are reported for English,

Arabic etc in current literature. However, such discrimination of handwritten words based study is missing for Devanagari documents.

We have also investigated skilled forgery based on multiple words. In this study, we take samples from a group of subjects where we ask them to write words which contain discriminative primitives, in their natural handwriting. We also take another group of subjects where we ask them to forge the collected genuine handwriting documents to make a forged document that is convincingly similar. The collected handwriting samples are digitised and we extract word level HOG features and compute shape descriptors. By using these features we discriminate between authentic and forged handwriting samples using SVM classifier.

Finally, we present a novel MKL based identity determination framework which provides a feature combination framework for the forensic document analysis. In this framework, set of novel features are introduced, which are optimally combined by the proposed MKL formulation in kernel space for improving the identification results. We consider both the aspects of identity determination, i.e., identification and verification. The proposed MKL formulation is applied for both the problems where a novel Genetic algorithm based solution is presented for optimizing the MKL formulation.

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Glossary

FDE	Forensic Document Examination
CEDAR	Center of Excellence for Document Analysis and Recognition
EER	Equal Error Rate
FAR	False Acceptance Rate
GSC	Gradient, Structural Concavity
IBM	International Business Machine
KNN	K Nearest Neighbor
MKL	Multiple Kernel Learning
HOG	Histogram of Oriented Gradients
RBF	Radial Basis Function
RBF-SVM	Support Vector Machine with RBF kernel
ROC	Receiver Operating curve
ROI	Region of Interest
SFS	Sequential Forward Selection
SVM	Support Vector Machine
2-D	Two Dimensional
VSC	Video Spectral Comparator
SD	Shape Descriptor
FMT	Fourier Mellin Transform
EHOG	Envelope Histogram of Oriented Gradients
SC	Shape Context
DPI	Dots per inch
FMT	Fourier Mellin Transform
SC	Shape Context
CFT	Computational featureset