BE Project Report entitled

"SIGNATURE VERIFICATION USING MACHINE LEARNING"

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Submitted by

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In

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Faculty Guide

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DEPARTMENT OF COMPUTER ENGINEERING

CERTIFICATE

This is to certify that the project entitled " **SIGNATURE VERIFICATION USING MACHINE LEARNING**" has been carried out by Aditi Deven Patel (150110107003) and Mansi Jainendra Tandel (150110107054) under my guidance and supervision for the VIIITH semester final –examination of Bachelor of Engineering in computer department (semester-8) at G H Patel College Of Engineering and Technology, Vallabh Vidyanagar during academic year 2018-2019.

Date:

Place: GCET,V. V. NAGAR

Prof. Priyang Bhatt — Signature and name of guide

Dr. Maulika S. Patel — Signature and name of Head of the Department

DECLARATION OF ORIGINALITY

We hereby certify that we are the sole authors of this report and that neither any part of this work nor the whole of the work has been submitted for a degree to any other University or Institution.

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We declare that this is a true copy of our report, including any final revisions, as approved by our supervisor.

Team:

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Place: GCET, V. V. Nagar Date:

Name of Guide: Prog. Priyang Bhatt

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OFFLINE SIGNATURE VERIFICATION USING

MACHINE LEARNING

Submitted By

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Work place

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ABSTRACT

Signature Verification is a useful aspect to identify and authorize individuals. It is usually employed for individual's signature authentication in cheques used by banks, in courts for justice(e.g. authentication of will) and forensic investigation to identify whether the signature is genuine or forged. As every individual has a unique handwriting style as a unique fingerprint, this makes verifying of signatures easier. A unique handwriting is identified based on character size ,character shape, character alignment and character style that is visually disparate. 60 signature samples five each from 12 different persons are collected for training and testing of data that is used to extract and classify the patterns belonging to the same class that leads to more accurate results. This can be accomplished in four steps: 1)Data Acquisition, 2)Image Preprocessing , 3)Feature Extraction and 4)Verification using SVM.

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CHAPTER 1: INTRODUCTION

In the growing world of today, the need of security mechanisms for different purposes has become an essential part. A person's identity must be kept safe. There are many ways by which a person can be identified uniquely.

1.1 Problem summary and introduction

Although, technology has evolved in years with the individuals turning towards paperless world, the importance of documents written by hands has perpetuated and the issues of recognition and authentication of the writer has been a vigorous area of research.. The type of classification algorithm in machine learning used is :Support Vector Machine (SVM).Signature samples from 12 different authors are accumulated. 60 genuine signature samples are collected five each from the twelve individuals, and 60 forged signature samples are collected five each from the twelve individuals other than the genuine ones. An Image preprocessing algorithm is implemented using Anaconda [1] to transform the samples collected to grayscale initially .After this, the image is thresholded to binary format i.e. black and white. The SVM classification algorithm is implemented using Anaconda [1] followed by feature extraction using techniques of Aspect ratio, Bounding Box, Surf, Sift, Imagehash, etc. Verification of the signature using training and testing of images is the final step of the implementation steps and the value of precision to identify the forged signature from genuine one lies between 0 and 1.

1.2 Aim and Objective

The Signature Verification technique is a useful aspect to authorize individuals. It is usually employed for individual's signature authentication in cheques used by banks, in courts for justice(e.g. authentication of will) and forensic investigation to identify whether the signature is genuine or forged. A unique signature is identified based on character size ,character shape, character alignment and character style that is visually disparate. This can be accomplished in four steps: 1)Data Acquisition, 2)Image Preprocessing , 3)Feature Extraction and 4)Verification using SVM. When there is a need to verify his/her identity there must be some method and/or technology. So, we have decided to develop a technology for verification of a person's signature.

1.3Problem specification

Signature Verification is a useful feature to authenticate individuals and is used for many purposes such as signature verification, bank cheque authentication, forensic investigation etc. Techniques such as offline signature verification using pixel matching(biometric), online verification based on DWT features extraction and neural network classifications are available. We will be solving the problems of frauds with its author's signature, so that their personal information such as banking information, billing and credit/debit card information should be kept safe. So, the aim will be providing a higher accuracy that can be used by anyone to verify an individual's signature.

CHAPTER 2: Literature Survey

We referred the following research papers:

1) Imran Ahmed SIDDIQI and Nicole VINCENT, 2007 IEEE[2]

In 2007, Imran Ahmed SIDDIQI and Nicole VINCENT presented an effective way of writer identification in handwritten documents. This was done by extraction of characteristics that were specific to a writer. To utilize the redundant patterns within a handwriting, it was divided into a large number of small sub-images, and the sub-images that are morphologically similar were grouped together by the ones that fall under the same classes. This was followed by extraction of patterns, which occur frequently for a writer. Then the author of the unknown document is identified by a Bayesian classifier algorithm.[2]

2) Simon Bernard et al. 2007 IEEE[3]

In 2007, Simon Bernard et al. used Random Forests for Handwritten Digit Recognition. The Random Forest algorithm that is an ensemble learning method for classification and other tasks .It was implemented on the MNIST handwritten digits database[10] and conclusions were made on Random Forest global behavior according to their parameter tuning.[3]

3) Sajjad S. Ahranjany et al. 2010 IEEE[4]

In 2010, Sajjad S. Ahranjany et al. presented a highly accurate handwritten character recognition system for Farsi/Arabic digits using Convolutional Neural Networks(CNN). It was achieved by fusing the recognition outcomes of a number of Convolutional Neural Networks with gradient descent training algorithm. Firstly, the automatic extraction of input pattern's features is done by using a CNN for Farsi digits. Secondly, the outcomes are fused to compensate the recognizers' errors of boosted classifiers. The experiments were conducted on extended IFH-CDB test database that consists of Farsi/Arabic handwritten characters.[4]

4) Srikanth Doss K.R. 2011 IEEE[5]

In 2011, Srikanth Doss K.R. proposed a method for handwriting recognition using a variant of decision trees. The vital idea of this method is divide and conquer. The algorithm identifies the image in form of predefined glyphs. On the basis of arrangement of the recognized glyphs, the exact character in the image is identified by juxtaposing with the predefined glyphs using pattern trees. These set of predefined pattern trees is an indication of each character. The input symbol is juxtaposed with each of the patterns and the highest match is found and the correct character is recognized.[5]

5) Fotini Simistira et al. 2014 IEEE[6]

In 2014, Fotini Simistira et al. addressed the issue of structural analysis of mathematical expressions by constructing feature vectors to represent the spatial affinity of the objects (mathematical symbols or sub-expressions) and employing machine learning techniques

Support Vector Machines (SVM) and Artificial Neural Networks (ANN) to recognize the spatial relation between them.[6]

6) U Ravi Babu et al. 2014 IEEE[7]

In 2014, U Ravi Babu et al. presented an off-line handwritten digit recognition based on structural features that do not require thinning operation and size normalization. The paper provides efficient and reliable methods for recognition of handwritten digits. A Euclidean minimum distance criterion is used to find minimum distances and KNearest Neighbor classifier is used to classify the digits. A MNIST database[10] is used for both training and testing the system.[7]

7) Raid Saabni 2015 IEEE[8]

In 2015, Raid Saabni performed Handwritten Digit and Digit Strings Recognition using Adaboosting Extreme Learning Machines. Conventionally, the variations of Multi-Layer Neural Networks (MLNN), yielded a very high recognition rates on handwritten digits, but lacked the speed in training time. Extreme Learning Machine (ELM) reduces the time needed to train a MLNN .The ELM analytical process of learning reduces the time of learning in comparison to back propagation by refraining the process of iterative learning. A process has been proposed which boosts few Extreme learning machines that make use of Ada-boosting for improving the recognition rates iteratively. In order to improve the ability of the ELM: a pre-processing step is used, and to improve the boosting: a special weighting process is used. [8]

The research paper that we referred are as follows and the use of their work is given below.

Sr.No	Author & Year	Techniques Employed	Dataset Sources	Remarks
1.	Imran Ahmed SIDDIQI and Nicole VINCENT, 2007 IEEE[2]	Naïve Bayesian classifier machine learning algorithm	Collection of Scanned Images of Handwritten Documents Mode-Offline	Utilization of redundant patterns that highlight the frequent details.
2.	Simon Bernard et al. 2007 IEEE[3]	Random Forest machine learning algorithm	MNIST Database Mode-Online	Tunes two RF parameters: the number L of trees in forests and number K of random features selected in splitting process and analyze the correlation between RF performances and parameter values.
3.	Sajjad S. Ahranjany et al. 2010 IEEE[4]	Convolutional Neural Network(CNN)	Extended IFH-CDB test Database having Farsi/Arabic Handwritten	Automatic extraction of input pattern's features using CNN, Recognition Rate strategies: Rejection, Boosting and Fusion. High Time Complexity, High Accuracy

			Characters Mode-Online	
4.	Srikanth Doss K.R. 2011 IEEE[5]	Variant Of Decision Trees machine learning algorithm	Tamil Characters from different sources Mode-Online	Pattern tree construction for each Tamil character and difference co-efficient value for choosing minimum path.
5.	Fotini Simistira et al. 2014 IEEE[6]	Support Vector Machine(SVM) and Artificial Neural Networks(ANN) machine learning algorithm	MathBrush and CROHME 2012 Mode-Online	Construction of Feature Vectors for spatial affinity between objects, Multiclass SVM classifiers with Gaussian kernel, High Time Complexity
6.	U Ravi Babu et al. 2014 IEEE[7]	Euclidean distance for finding minimum distance, K-Nearest Neighbor(KNN) classifier machine learning algorithm	MNIST Database Mode-Online	Features used are number of holes, reservoirs in four directions, maximum profile distances in four directions and fill hole density for recognition of digits
7.	Raid Saabni 2015 IEEE[8]	Ada-boosting machine learning algorithm	MNIST Database, CVL Dataset Mode-Online	ELM use Ada-boosting to improve recognition rates. Image pre-processing to enhance the ability of ELM, Low Time Complexity

Table 2.1 Literature review table

CHAPTER 3: DESIGN AND ANALYSIS METHODOLOGY

3.1 AEIOU Summary

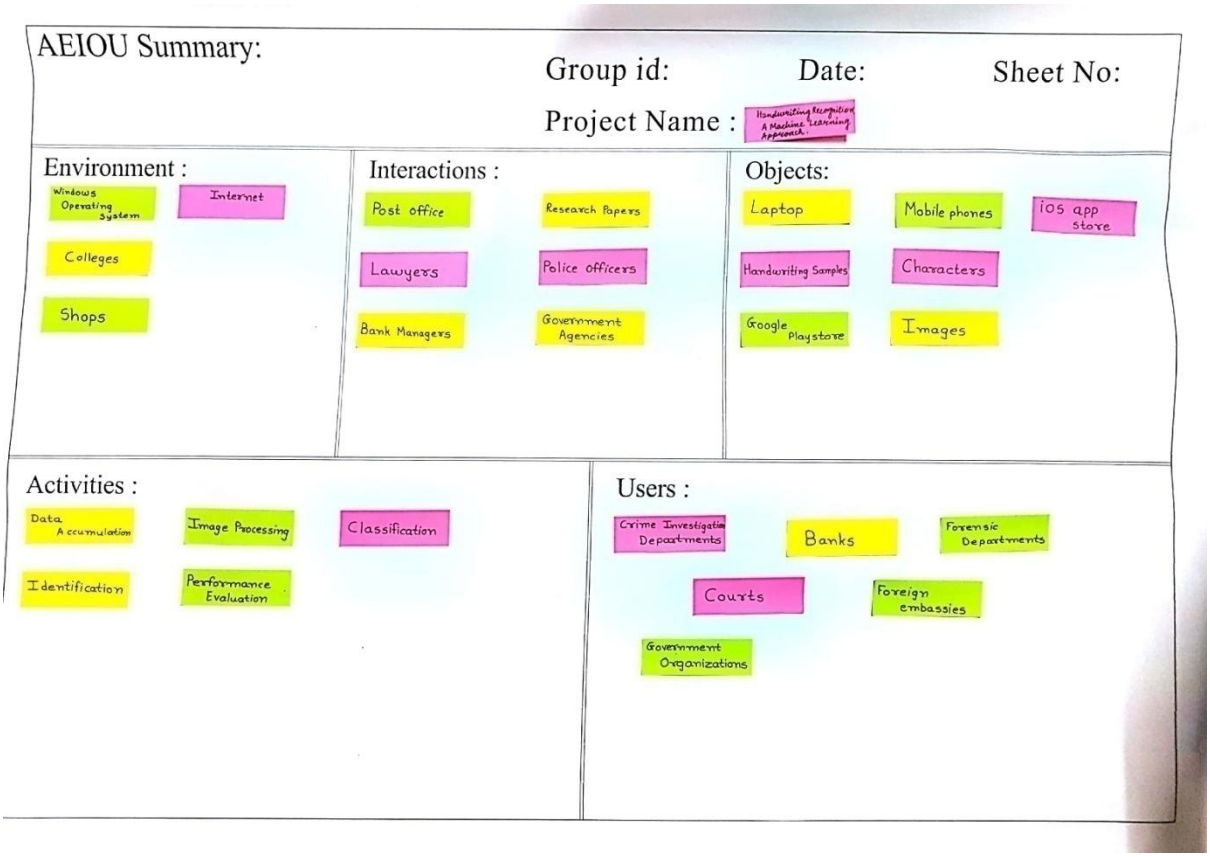

Fig.3.1.1AEIOU summary canvas

- **Activity**
  - Data accumulation
  - Image processing
  - Classification
  - Identification
  - Performance evaluation
- **Environment**
  - Windows operating system
  - Internet
  - Colleges
  - Shops
- **Interactions**
  - Research papers
  - Post office
  - Government agencies
  - Lawyers
  - Police officers

- Bank managers

- **Objects**
  - Laptop
  - Mobile phones
  - Characters
- **Users**
  - Government organizations
  - Crime department
  - Forensic departments
  - Banks
  - Courts
  - Foreign embassies

3.2 Product Development Canvas

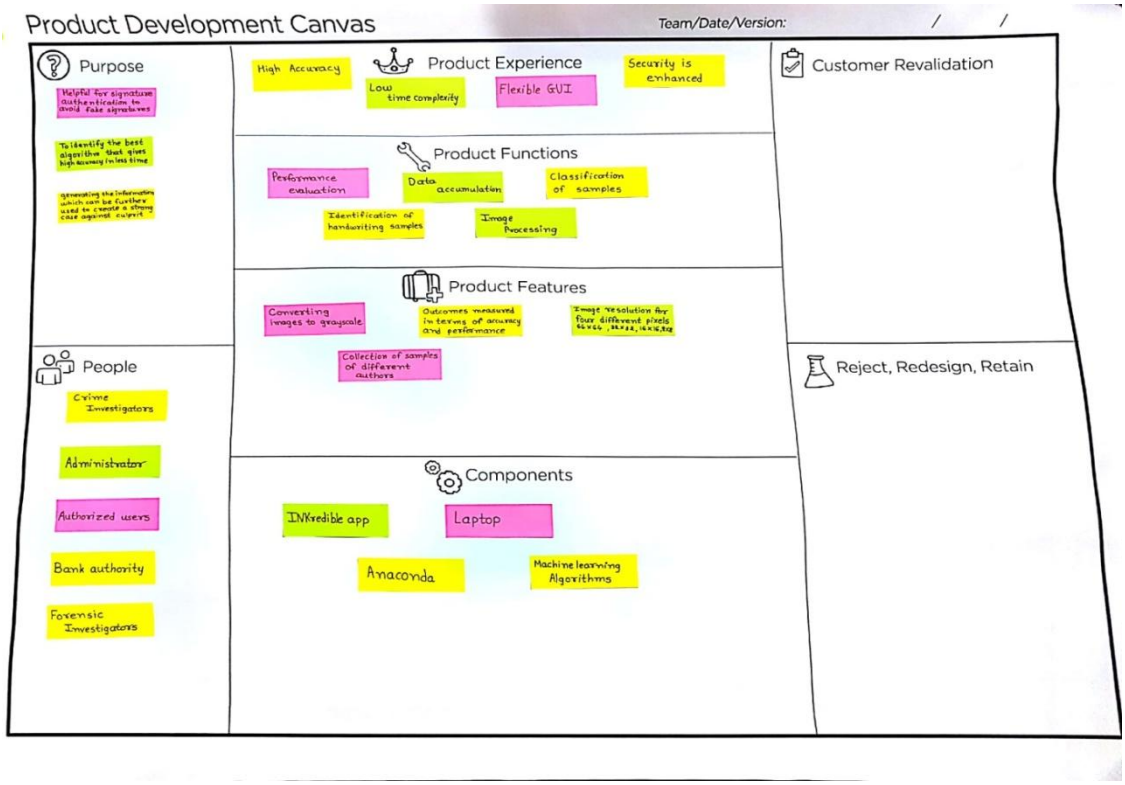

Fig.3.2.1 Product development canvas

- **Purpose**
  - Helpful for signatures authentication to avoid fake signatures
  - To identify the best algorithm that gives high accuracy in less time
  - Generating the information which can be further used to create a strong case against culprit
- **People**
  - Administrator
  - Authorized users
  - Bank auhority
  - Crime investigators
- **Product functions**
  - Performance evaluation
  - Data accumulation
  - Image processing
  - Classification of samples
  - Verification of handwriting samples
- **Product experience**
  - High accuracy
  - Low time complexity
  - Security is enhanced
  - Flexible GUI
- **Product features**
  - Converts images to grayscale
  - Outcomes measured in terms of accuracy
- **Components**
  - Machine learning algorithm(SVM)
  - Anaconda Navigator
  - Laptop

3.3 Empathy Mapping Canvas

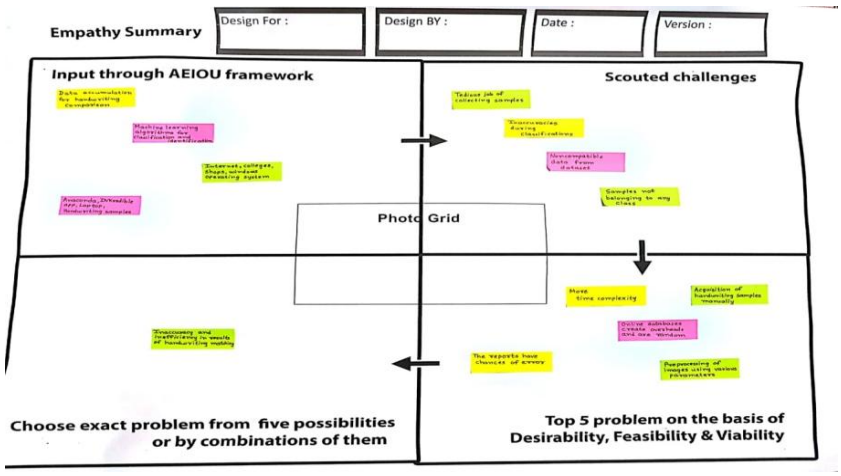

Fig.3.3.1 Empathy mapping canvas

- **Input through AEIOU framework**
  - Data accumulation for handwriting comparison
  - Machine learning algorithm for classification and verification
  - Internet,colleges,shops,windows operating systems
  - Anaconda,laptop, handwriting samples
- **Scouted challenges**
  - Tedious job of collecting samples
  - Inaccuracies during classifications
  - Noncompatible data from dataset
  - Samples not belonging to any class
- **Top 5 problem on the basis of Desirability, Feasibility & Viability**
  - More time complexity
  - Acquisition of handwriting samples manually
  - Online datasets create overhead and are andom
  - The reports have chances of erroeneous
  - Processing of images using various parameters
- **Choose exact problem from five possibilities or by combinations of them**
  - Inaccuracy and inefficiency in results of handwriting matching

3.4 Ideation Canvas

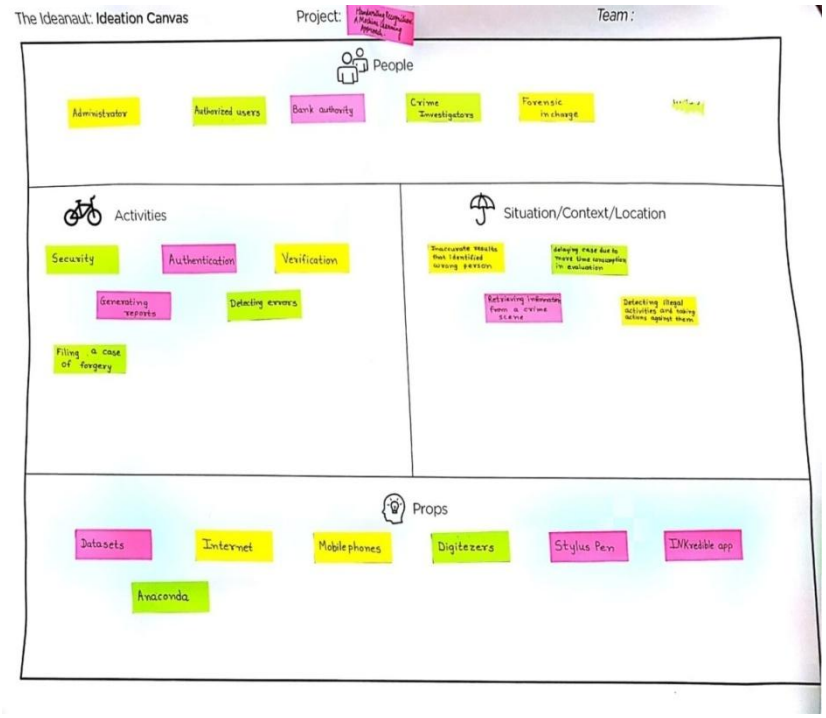

Fig.3.4.1 Ideation canvas

- **People**
  - Administrator
  - Authorized users
  - Bank authority
  - Crime investigators
- **Activities**
  - Security
  - Authentication
  - verification
  - Generating reports
  - Filing a case of forgery
  - Detecting errors
- **Situation/Context/Location**
  - Delaying a case due to more time consumption in evaluation
  - Inaccurate results that identified wrong person
  - Detecting illegal activities and taking actions against them
  - Retrieving information from a crime scene
- **Props**
  - Datasets
  - Internet
  - Digitizers
  - Stylus pen
  - Mobile phones
  - Anaconda

CHAPTER 4: IMPLEMENTATION

4.1 System Flow

Signature verification is an extensive feature extraction procedure (mostly through image processing) and pattern recognition problem. The procedure of signature verification is given below. An inaccurate system produces false outcomes which may convict wrong person. A system whose performance evaluation system has higher time complexity, makes the system inefficient.

The following are the steps required to achieve our motive for obtaining highly accurate and high performance systems for Signature Verification using Machine Learning.

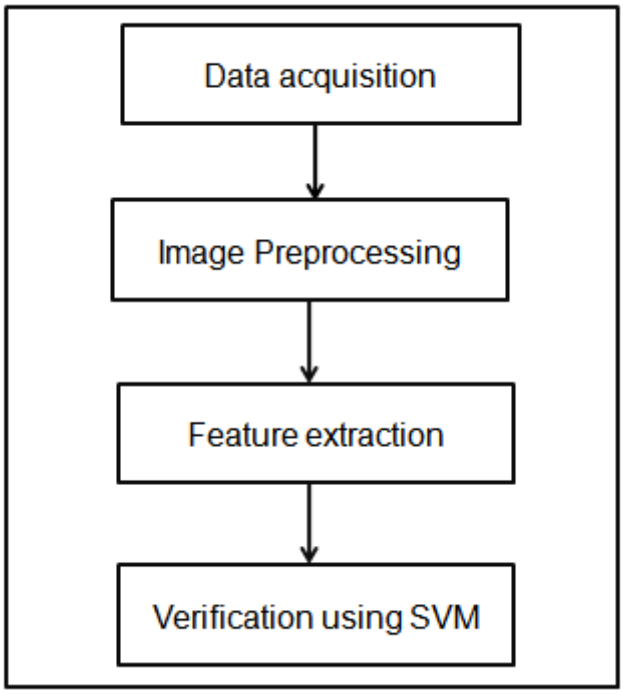

Fig.4.1.1.System Flow for Signature Verification using Machine Learning

1) Data Acquisition: To gather signature samples from different people.
2) Image Preprocessing: To convert from RGB format to grayscale and binary format.
3) Feature Extraction: To obtain various features from preprocessed images like aspect ratio, surf, sift, bounding area, etc.
4) Verification using SVM: To train and test images based on the features extracted to acquire the precision of the forged signatures.

4.2 Data Acquisition

- Collection of samples plays the most important gateway to the proposed project work. Our system requires a dataset which consists of signature samples of various authors. There are two approaches to acquire images for further processing, which are: (1) Offline approach (2) Online approach.
- In online signature sample collection there can be use of digitizers such as tablet screens or smart phones. These tablet screens allow users to use stylus pen to create their samples of signatures by their own. On-line signature verification is a process that captures the actual production of a signature and verifies its authenticity automatically. In offline signature sample collection, samples are scanned from paper.
- As our approach is offline signature verification, our dataset is obtained using the offline approach. The dataset that we have used, consists of signature samples from 12 different authors. 60 genuine signature samples are collected five each from the twelve individuals, and 60 forged signature samples are collected five each from the twelve individuals other than the genuine ones.
- Samples of genuine signatures from 12 authors from the dataset that we have used are as following:

Fig.4.2.1 Signature of author 1

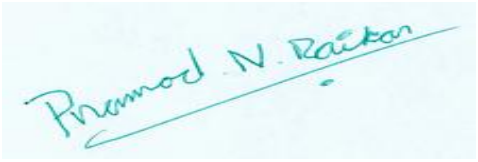

Fig.4.2.2 Signature of author 2

Fig.4.2.3 Signature of author 3

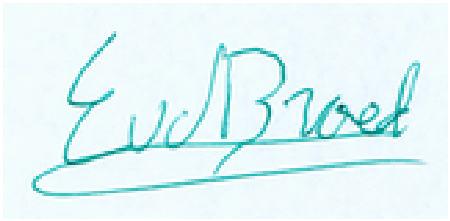

Fig.4.2.4 Signature of author 4

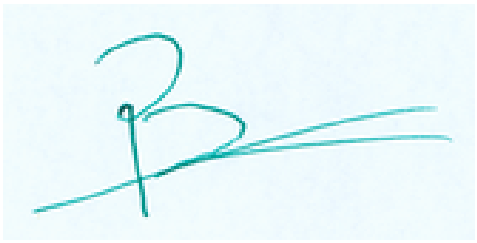

Fig.4.2.5 Signature of author 5

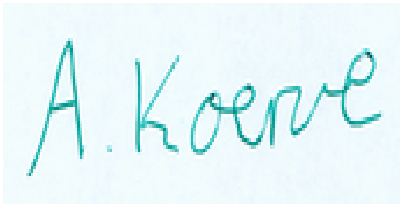

Fig.4.2.6 Signature of author 6

Fig.4.2.7 Signature of author 7

Fig.4.2.8 Signature of author 8

Fig.4.2.9 Signature of author 9

Fig.4.2.10 Signature of author 10

Fig.4.2.11 Signature of author 11

Fig.4.2.12 Signature of author 12

4.3 Image Preprocessing

- Image preprocessing techniques convert an image into a digital form. It can also perform various operations on input images. The samples of handwritten signatures may contain a colorful background. The quality of these images may be lower as the scanning or capturing of word images is done.The objective of image preprocessing is mainly to eliminate or reduce inconsistencies from handwritten words or handwritten signatures.
- We have included two steps of image preprocessing: (1) Conversion of samples into greyscale images (2) Image thresholding
- The sample images from dataset are of RGB format. Greyscale images simply reduces complexity. Conversion of image to B/W – each pixel will either be ‘1’ (for white) or ‘0’ (for black).

Fig.4.3.1 Greyscale image of the signature sample

- Image thresholding partitions an image into two parts such as in foreground and in background in simple words. It checks each pixel value. If the pixel value is greater than a threshold value, it is assigned one value, else it is given another value. These preprocessing steps helped reducing the complexity with the colored images for further processing.

Fig.4.3.2 Thresholded image of the signature sample

4.4 Feature Extraction

Feature Extraction is used to reduce the data that is useful for further processing by measuring certain "features" are get extracted from the processed image. After the preprocessing of the signatures, now they are ready for the feature extraction. Some useful features are get extracted from the signature portion area that helps to verify the signature of individuals. The different extracted features are discussed below.

1) Aspect Ratio (Width to Height Ratio)

The height and width may vary however the width to height ratio of the signature area would remain nearly constant.

```
In [1]: runfile('C:/Users/Aditi/Desktop/pp/imgsize.py', wdir='C:/Users/Aditi/Desktop/
pp')
aspect ratio:  2.0875
```

Fig.4.4.1 Aspect Ratio of Preprocessed Signature

2) Signature Occupancy Ratio

The amount of space occupied by the signature within the entire image is known as the signature occupancy ratio.

```
In [3]: runfile('C:/Users/Aditi/Desktop/pp/f2.py', wdir='C:/Users/Aditi/Desktop/pp')
signature occupancy ratio is:  1.0422029799516344
```

Fig.4.4.2 Signature Occupancy Ratio of Preprocessed Signature

3) Signature Density Ratio

The density ratio of the image is obtained after partitioning the cropped image vertically into 2 equal halves and then calculating individual number of pixels comprising the signature in each of the parts.

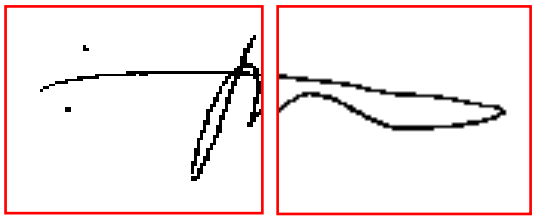

Fig.4.4.3 Signature divided vertically into two halves

```
In [6]: runfile('C:/Users/Aditi/Downloads/f3 (1).py', wdir='C:/Users/Aditi/Downloads')
Number of black pixels in part1: 291
Number of black pixels in part2: 250
signature ratio is:  1.164
```

Fig.4.4.4 Signature Density Ratio

4)Critical Points

The critical points or the corner pixels of the cropped image are detected using the Harris-corner detection algorithm. Harris Corner Detector provides a very robust way to detect corners in an image. The corner points are considered by looking through small window. Shifting a window in a flat region gives no 11 change of intensity in all directions where shifting a window for an edge gives no change of intensity along the edge direction but shifting a window for a corner region gives change of intensity all directions. Change of intensity for shift {u,v}

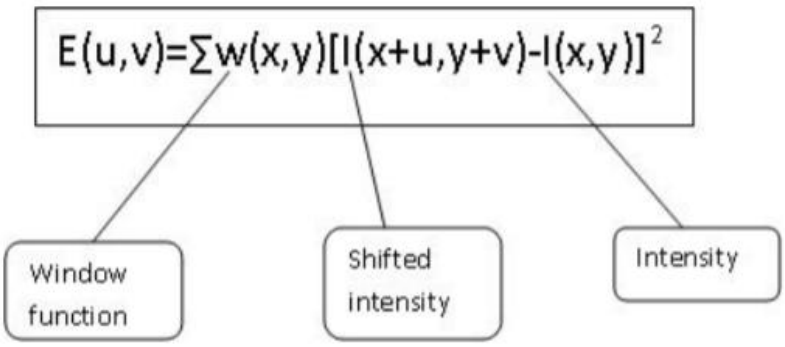

Fig.4.4.5 For making corner detection E(u,v) has to be maximized

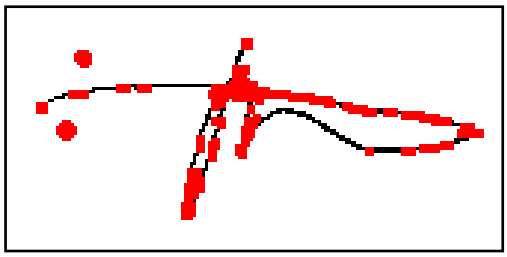

Fig.4.4.6 Signature Image depicting the critical points

5)Center of mass

The center of mass of the signature devotes the pixel where the concentration of the entire image pixel is localized.

$$x_{CM} = \frac{m_1 x_1 + m_2 x_2 + \ldots}{m_1 + m_2 + \ldots}$$

$$y_{CM} = \frac{m_1 y_1 + m_2 y_2 + \ldots}{m_1 + m_2 + \ldots}$$

Fig.4.4.7 Formula for calculating COM

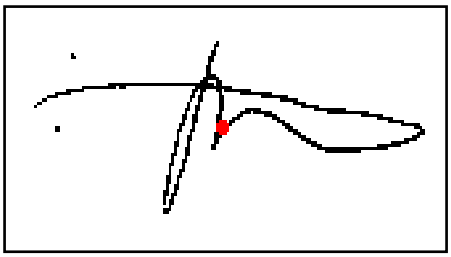

Fig.4.4.8 Signature image depicting the center of mass(in red)

6)Slope of center of mass of two halves of the signature

After splitting the signature vertically into two halves the center of mass of each portion is find out and then the slope of the two center of mass is calculated.

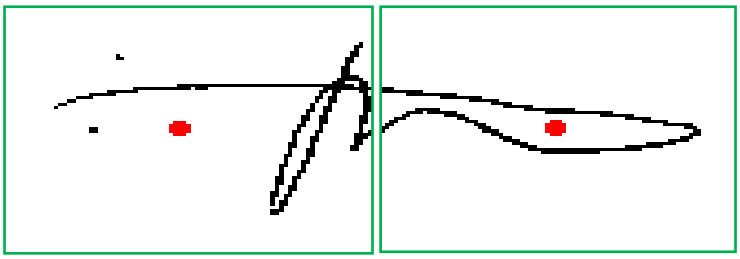

Fig.4.4.9 Com of left half Fig.4.4.10Com of right half

7)Center of mass of the sub-segments

For more critical analysis, the vertically splitted each two halves of signature portion is again splitted horizontally into two halves and the center of masses of those portions is get calculated.

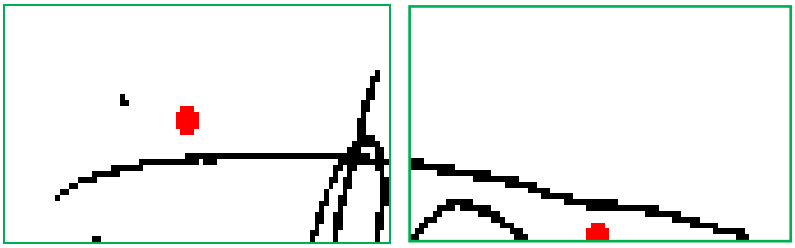

Fig.4.4.11 Com of upper left half Fig.4.4.12 Com of upper right half

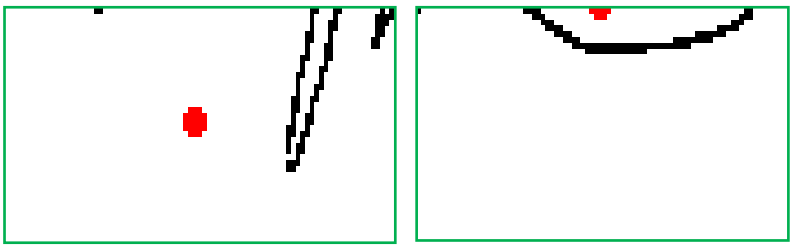

Fig.4.4.13 Com of lower left half Fig.4.4.14 Com of lower right half

8)Region Based Features

First the connected region portions are find out from each signatures then some useful geometrical based features like are extracted from the each region portions of the signatures.

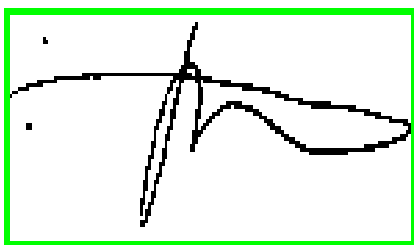

Fig.4.4.15 Image depicting the regions

9)Speed Up Robust (SURF) Features

SURF is robust to the changes in viewing conditions, rotations and scale. SURF represents some useful feature points.

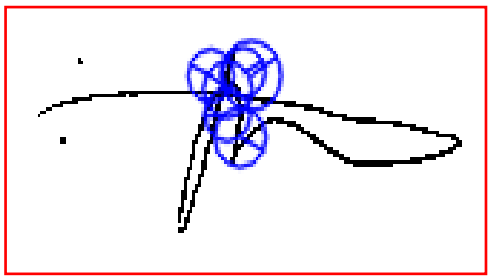

Fig.4.4.16 Image depicting the surf-regions

10)Scale Invariant Feature Transform (SIFT) Features

In SIFT sift.detect() function finds the keypoint in the images. Each If we want to search only a part from an image, then we can pask ine mask. A special structure that has many attributes like (x,y) coordinates, angle, size of the meaningful neighbourhood , response that specifies strength of keypoints etc. is known as a keypoint. OpenCV also provides cv2.drawKeyPoints() function. It drwas the small circles on the locations of keypoints. If we pass a flagflag,cv2.DRAW_MATCHES_FLAGS_DRAW_RICH_KEYPOINTS to it, it will draw a circle with same size of that of a keypoint and it will even show its orientation.

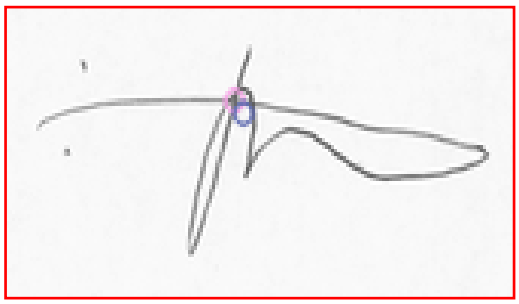

Fig.4.4.17 Keypoint drawing

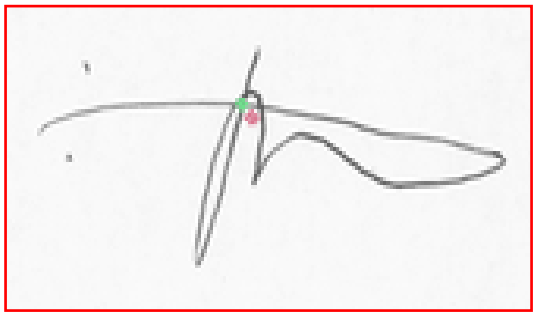

Fig.4.4.18 Keypoint drawing of its size

11) Convex Hull Area

Convex Hull will appear as same as contour approximation, but it is not the same. Here, cv.convexHull() function checks a curve for convexity defects and corrects it. Generally, convex curves are the curves which are always bulged out, or at-least flat. If it is bulged inside, it is called convexity defects.

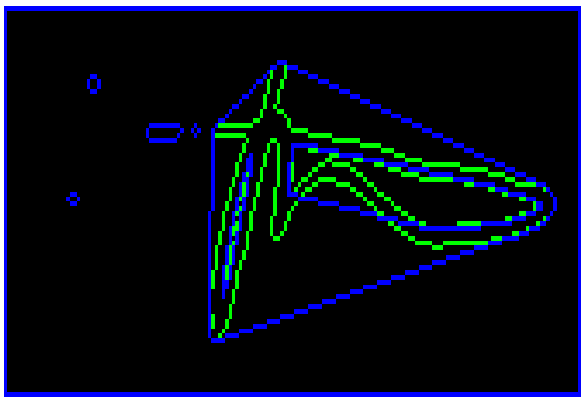

Fig.4.4.19 Convex Hull(blue)and Contours(green)

12) Contour Area

Contours can be explained in simple words as a curve joining all the continuous points (along the boundary), which have thesame color or intensity. The contours are used as a toll for object detection and shape analysis.Contour area is the feature of Contour which is given by the function **cv2.contourArea()** or from moments.

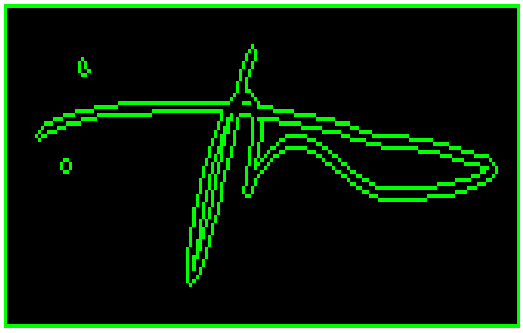

Fig.4.4.20 Contours of Signature

```
In [12]: runfile('C:/Users/Aditi/Desktop/pp/contourarea1.py', wdir='C:/Users/Aditi/
Desktop/pp')
contour area is: 13114.0
```

Fig.4.4.21 Contour Area

13) Image Hash

Perceptual hashing(pHash)considers the ‘transformations’ or ‘attacks’ on the input images that can distinguish dissimilar files. The attacks maybe of rotation, skew, contrast adjustment and other different compression/formats.

Fig.4.4.22 Genuine Signature used for image hashing

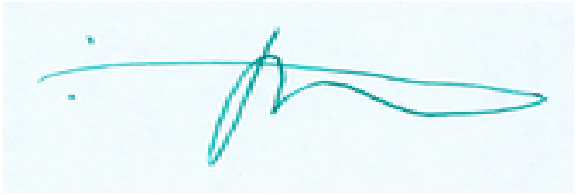

Fig.4.4.23 Forged Signature used for image hashing

```
In [20]: runfile('C:/Users/Aditi/Desktop/pp/imagehash1.py', wdir='C:/Users/Aditi/
Desktop/pp')
f3279cd84e24331b
f2c698b963489b36
False
24
```

Fig.4.4.24Different values of hash for dissimilar input images and the variation between them

4.5 Verification using Support Vector Machine

Linear Support Vector Classifier(SVC)

- The most applicable machine learning algorithm for our problem is Linear SVC.The objective of a Linear SVC (Support Vector Classifier) is to fit to the data you provide, returning a "best fit" hyperplane that divides, or categorizes, our data. From there, after getting the hyperplane, we can then feed some features to our classifier to see what the "predicted" class is. This makes this specific algorithm rather suitable for our uses, though you can use this for many situations.[13]

Result Analysis:

We had acquired 60 signature images 5 each from 12 genuine authors and 60 forged signatures 5 each from 12 unauthorized authors. After these images have been preprocessed and thereafter its various features were extracted like Aspect Ratio, Scale Invariant Feature Transform(SIFT), Image Hash, Contour Area, Convex Hull Area, Region of Interest and many more such features. The training and testing was performed on both the datasets using Linear SVC.

In this project we trained the SVC model in Spyder with the acquired feature data to test them with the forged signature and thus evaluate the efficiency of the extracted features on the designed model.

Features Used	Precision Rates using Linear Support Vector Classifier(SVC)(%)					Average(%)
	1	2	3	4	5	
Aspect Ratio, Sift, Image Hash	87.5	91.6667	95.8334	89.5834	83.3334	89.5834
Sift, Image Hash, Contour Area, Convex Hull Area	93.75	87.5	91.6667	85.4167	83.3334	88.3334
Aspect Ratio, Sift, Contour Area, Convex Hull Area	93.75	89.5834	91.6667	87.5	95.8334	91.6667
Contour Area, Sift, Convex Hull Area	89.5834	91.6667	85.4167	97.9167	87.5	90.4167
Aspect Ratio ,Sift, Image Hash, Contour Area, Convex Hull Area	95.8334	93.75	100.0	89.5834	91.6667	94.1667

Table.4.5.1 Precision Rates using Linear SVC(%)

We have compared the results and we conclude that using the Aspect Ratio ,Sift, Image Hash, Contour Area, Convex Hull Area features we obtain the highest accuracy and effective for Signature Verification.

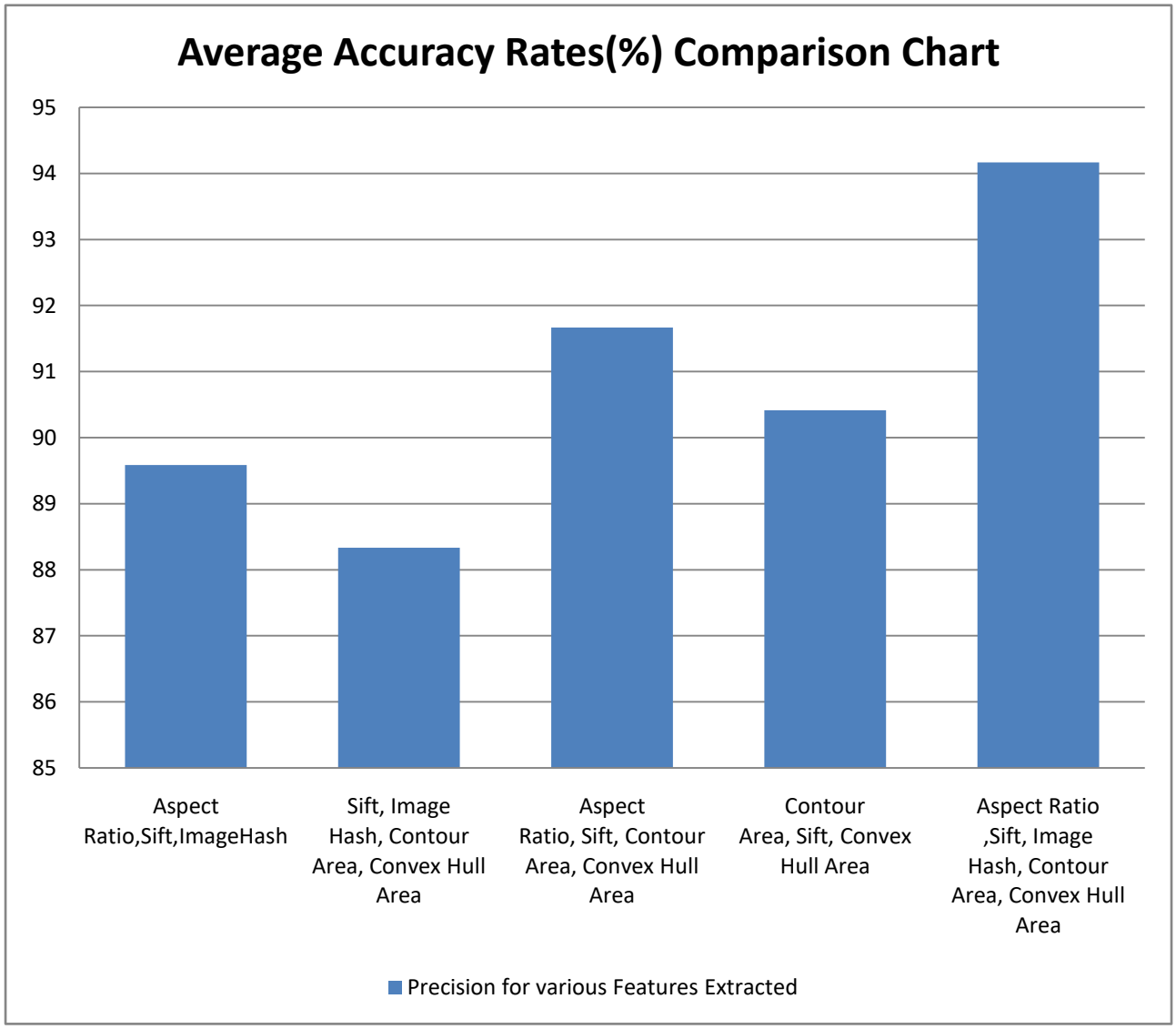

Fig.4.5.1 Average Accuracy Rates(%) Comparison Chart

We have plotted a Comparison Chart for the Average Accuracy Rates(%) using various combinations of the features extracted.From these we conclude that using the five important features(Aspect Ratio ,Sift, Image Hash, Contour Area, Convex Hull Area) gave us the highest accuracy.

CHAPTER 5: SUMMARY AND FUTURE SCOPE

5.1 Advantages of our work

- Recognition of an individual
- Less time complexity
- High accuracy
- Verification by handwriting of an individual
- Helpful in crime investigation
- Detection of forgery

5.2 Future scope

This project has focused on the offline handwriting and the techniques that are used for the verification of signature for the classification of them into the genuine or forgery. The verification of handwriting is carried out on the basis of the features of signature that are extracted using different static image processing techniques and the statistical results obtained after implementing machine learning . As this project the proposed model for offline signature verification engine, in continuation to this the next objective will be to propose some new model that will give higher accuracies. Future work can also be expanded to applying various machine learning algorithms on different features that can be extracted.

5.3 Tools and technology required

Software Requirement	Hardware Requirement
• Anaconda navigator • Windows Operating System(7/8/8.1/10)	• Intel i3 processor • 4 GB RAM • 100 GB Hard disk

Table 5.3.1 Required tools and technologies

5.4 Summary

In Signature Verification using Machine Learning we attempt to find out the precision to classify whether the signature has been done by an unauthorized author and is trying to break the confidentiality. This project makes a sincere effort to achieve the highest accuracy using different combinations of features extracted from both the dataset of images which is therefore fed into Linear Support Vector Classifier(SVC) for the training and testing purpose. The testing is done by comparing the test dataset images i.e. forged dataset of signatures with the trained dataset images i.e. genuine dataset of signatures.

The genuine and forged dataset of signatures comprises of 60 images five each from 12 genuine authors and other 60 images from unauthorized person. After obtaining these images are preprocessed in which images are initially converted to grayscale and later on, converted to binary format(threshold image).These steps are necessary for removal of noises and bringing the images from RGB format to grayscale.The preprocessing is performed on genuine as well as forged signature dataset as the features will be extracted from both the datasets and matched to know whether the forgery is done or not.

The feature extraction is performed on the preprocessed images to get the features like Aspect Ratio, Signature Occupancy Ratio, Contours, Convex Hull Area, SURF, SIFT, Critical points and many more such features. The feature extraction is used to remove the unwanted parts of the signatures that are not useful and slows down the processing time. From the features extracted from testing dataset, Linear SVC is trained and the corresponding trained model is tested to detect the forged signatures using Spyder.

CHAPTER 6: CONCLUSION

The project contains a review on feature extraction and classification methods. Literature survey suggests many methods for feature extraction and classification. We have used Aspect Ratio, SIFT, Contour Area, Convex Hull Area and region based images for feature extraction. In our experiments, we combined various features to check the accuracy rates for the Signature Verification. Aspect Ratio, Sift, Image Hash using these features we got accuracy 89.5834%, then using Sift, Image Hash, Contour Area, Convex Hull Area these features accuracy was 88.3334% which was lesser than earlier combination. After that Aspect Ratio, Sift, Contour Area, Convex Hull Area features were used giving us more accuracy than the earlier methods of 91.6667%.This was still not a choice to be made for precision. Again a different collection of features such as Contour Area, Sift, Convex Hull Area was fed to the Linear SVC model but the accuracy was 90.4167% which was not a satisfactory result.Thus, a combination of Aspect Ratio ,Sift, Image Hash, Contour Area, Convex Hull Area gave us the highest accuracy among all the possible combinations of 94.1667%.So we can conclude that 94.1667% is the desired accuracy and is more effective for our project.

CHAPTER 7: REFERENCES AND BIBLIOGRAPHY

[1]	Anaconda[online]. Available: https://www.anaconda.com/
[2]	Writer Identification in Handwritten Documents Imran Ahmed SIDDIQI, Nicole VINCENT Laboratoire CRIP5 – SIP Université René Descartes – Paris 5 45, rue des Saints-Pères, 75270 Paris, Cedex 06{siddiqi,nicole.vincent}@math-info.univ-paris5.fr **Published in:** Ninth International Conference on Document Analysis and Recognition (ICDAR 2007) DOI: 10.1109/ICDAR.2007.4378685
[3]	Simon Bernard, Laurent Heutte, Sebastien Adam ´ Laboratoire LITIS EA 4108 UFR des Sciences, Universite de Rouen,France.{simon.bernard,laurent.heutte,sebastien.adam}@univ-rouen.fr DOI: 10.1109/ICDAR.2007.4377074
[4]	Sajjad S. Ahranjany, Farbod Razzazi Department of Electrical Engineering, Islamic Azad University, Science & Research Branch Tehran. Iran. Mohammad H. Ghassemian Department of Electrical Engineering, Tarbiat Modarres University, Tehran, Iran. E-mail: Ghassemi@modares.ac.ir sajjad ahranjany@ieee.org ,razzazi@srbiau.ac.ir **Published in:** 2010 IEEE Fifth International Conference on Bio-Inspired Computing: Theories and Applications (BIC-TA) DOI: 10.1109/BICTA.2010.5645265
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[6]	Fotini Simistira, Vassilis Papavassiliou, Vassilis Katsouros Institute for Language and Speech Processing "Athena" – Research and Innovation Center in Information, Communication and Knowledge Technologies Athens, Greece @ ilsp.athena-innovation.gr George Carayannis School of Electrical and Computer Engineers National Technical University of Athens, Athens, Greece carayan@softlab.ece.ntua.gr **Published in:** 2014 14th International Conference on Frontiers in Handwriting Recognition DOI: 10.1109/ICFHR.2014.35
[7]	U Ravi Babu Research Scholar, Aacharya Nagarjuna University, Assoc. Professor – GIET, Rajahmundry, A.P, India. uppu.ravibabu@gmail.com Dr. Y Venkateswarlu Professor & Head, Department of CSE, GIET Engg College, Rajahmundry, A.P, India. yalla_venkat@yahoo.com Aneel Kumar Chintha M.Tech (CSE) Student, GIET, Rajahmundry, A.P, India. aneelkumar.chintha@gmail.com **Published in:** 2014 World Congress on Computing and Communication Technologies DOI: 10.1109/WCCCT.2014.7
[8]	Raid Saabni School of Computer Science Department Tel-Aviv Yaffo Academic College, Tel-Aviv, Israel Triangle Research & Development Center Email : raidsa@mta.ac.il **Published in:** 2015 Fifth International Conference on Digital Information Processing and Communications (ICDIPC) DOI: 10.1109/ICDIPC.2015.7323034
[9]	Khaled Mohammed bin Abdl#1, Siti Zaiton Mohd Hashim*2 #Hadramout University for Science and Faculty of applied Science Technology,Yemen 1bin_abdel@hotmail.com *Universiti Teknologi Malaysia, Malaysia Faculty of Computer Science and Information Systems 2sitizaiton@utm.my **Published in:** 2009 IEEE International Conference on Signal and Image Processing Applications DOI: 10.1109/ICSIPA.2009.5478698

[10]	MNIST DATABASE of handwritten digits [online]. Available: http://yann.lecun.com/exdb/mnist/
[11]	Ziran Jiang, Aditya R. Mundada cs229.stanford.edu/proj2015/024_report.pdf
[12]	Indrajit Bhattacharya, Prabir Ghosh, Swarup Biswas Published in: International Conference on Computational Intelligence: Modeling Techniques and Applications (CIMTA) 2013 DOI: 10.1016/j.protcy.2013.12.445
[13]	https://pythonprogramming.net/linear-svc-example-scikit-learn-svm-python/

APPENDIX

I. Business Model Canvas

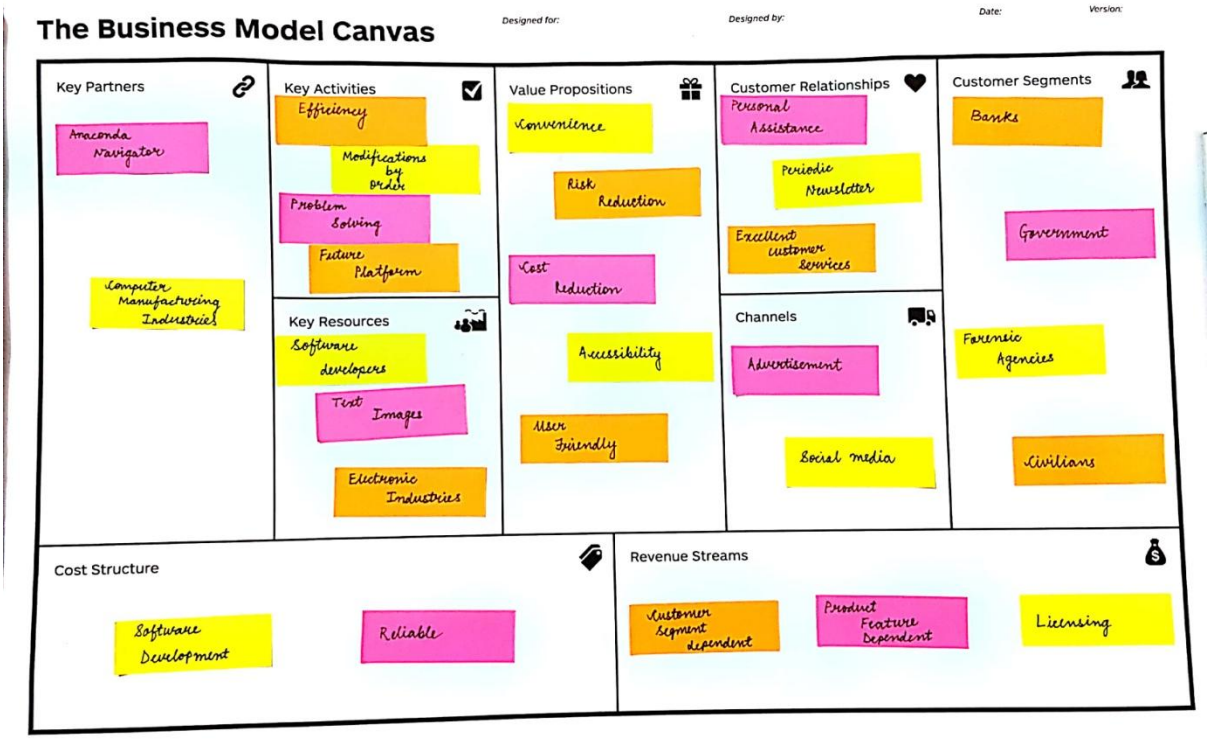

Fig. I Proposed business model canvas

II. Business Model Canvas Report

GUJARAT TECHNOLOGICAL UNIVERSITY

Chandkheda, Ahmedabad

Affiliated

G H PATEL COLLEGE OF ENGINEERING AND TECHNOLOGY

A Business Model Canvas Report On

SIGNATURE VERIFICATION USING MACHINE LEARNING

Under subject of

PROJECT– II(2180706)

B. E. IV, Semester – VIII

Computer Engineering

UDP PROJECT

Sr	Name of student	Enrollment No.
1	Aditi Deven Patel	150110107003
2	Mansi Jainendra Tandel	150110107054

Faculty Guide

Prof. Priyang Bhatt

Head of the Department

Dr. Maulika S. Patel

Academic year (2018-2019)

INDEX

Chapter 1: INTRODUCTION

- The Business Modelling Canvas is a one page overview that lays out both , what one should do , and how one go about doing it ; enabling the structured conversations around the management by laying the crucial activities and challenges involved with the initiative and how one relate to each other.
- The Visual format of the Canvas was first introduced by Osterwalder and Pigneur which is useful for both existing and new organizations and business .
- Existing Programmes can develop new initiatives and identify opportunities while becoming more efficient by illustrating potential trade-offs and aligning activities.
- New programmes can use it to plan and work out how to make the offering real.
- To make a BMC-Business Modelling Canvas , the easiest way to start is by fulfilling out what one does.
- This helps to keep the focus on the main goal as we fill out the other building blocks of the canvas.
- From there one can built the goal of the work and how it can be achieved by adding details about the other activities and resources that we have.
- Business Modelling Canvas is a strategic management and lean start up template for developing new or documenting existing business Models.
- It is Visual chart with elements describing the Nine elements in it , which includes:
  1. Key Partners
  2. Key Activities
  3. Value Proposition
  4. Customer Relationship
  5. Customer
  6. Key Resource
  7. Distribution Channel
  8. Revenue Stream
  9. Cost Structure

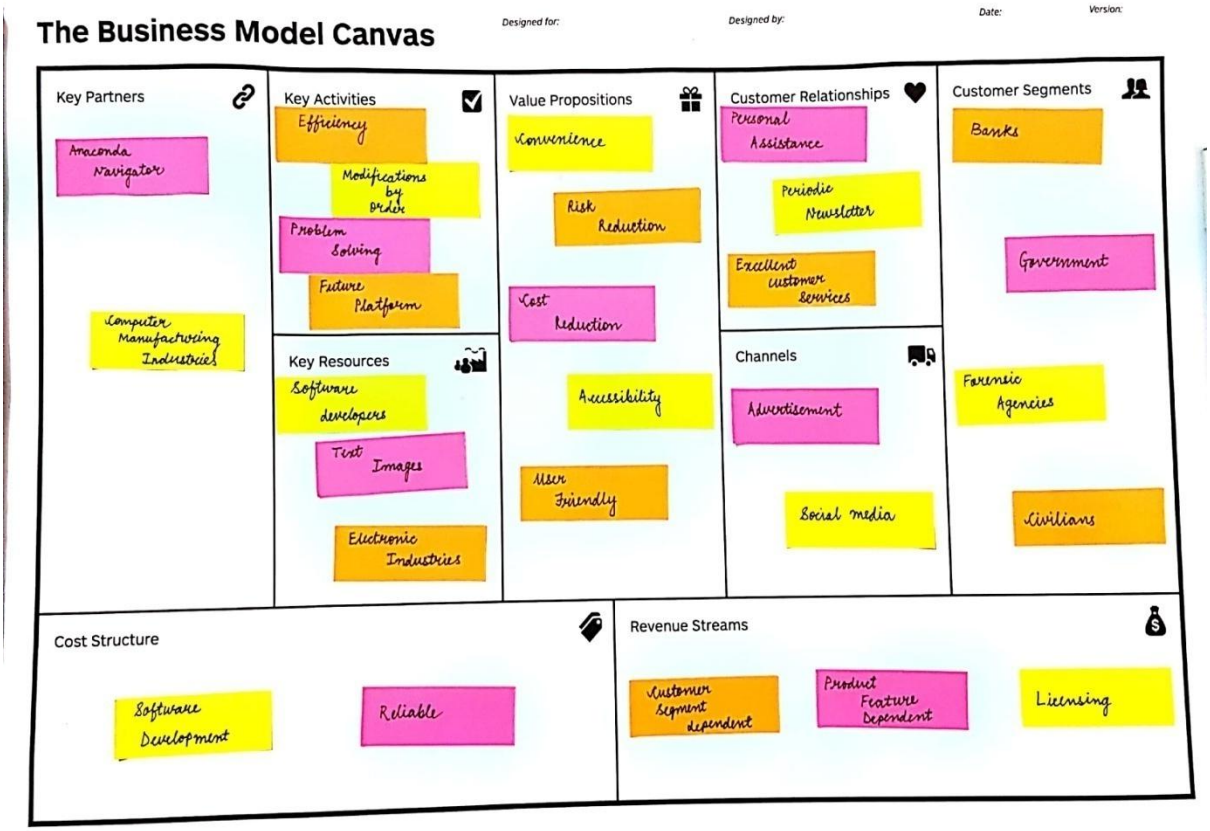

Fig. Proposed business model canvas

Chapter 2: CONTENT

1. KEY PARTNERS

This business block is intended to answer the following questions:

- Who are your key partners/suppliers?
- What are the motivations for the partnerships?

The Section includes the following points :-

- Anaconda navigator: Anaconda navigator is a graphical user interface included in Anaconda which allows its users to launch applications.
- Computer manufacturing industies: As our project is software oriented, our project requires a computer.

2. KEY ACTIVITIES

The Key Activities block aims at answering the following set of questions in your business model:

- What key activities does your value proposition require?
- What activities are important the most in distribution channels, customer relationships, revenue stream ?

The Section includes the following points :-

- Efficiency: High efficiency is aimed.
- Modifications by order: Software can be modified as per the requirements.
- Problem solving: It can help solving the problems related to forged signatures or forged handwritings.
- Future platform: Future platform may be very high as cases of forged signatures and forged handwriting are increasing.

3. VALUE PROPOSITION

The Value Propositions business block aims at providing answers to the following questions :

- What core value do you deliver to the customer ?
- Which customer needs are you satisfying ?

The Section includes the following points :-

- Convenience: This idea will be convenient for the usage.
- Risk reduction: This project will reduce the risk of forgery of an individual's handwriting.
- Cost reduction: The cost is reduced in comparison with other softwares.
- Accessibility: Easy access is provided.
- User friendly: It does not require much efforts by human being and design is user friendly.

4. KEY RESOURCES

This segment of the business model canvas answers the following questions :-

- What key resources does your value proposition require?
- What resources are important the most in distribution channels, customer relationships, revenue stream?

The Section includes the following points :-

- Software developers: Software developers are required for this project.
- Text images: Text images are mandatory for verification of handwriting of an individual.
- Electronic industries: In our project computer is required as a hardware component which is produced by electronic industries.

5. CUSTOMER RELATIONSHIPS

The customer relationship business block answers the following questions :-

- What relationship the target customer expects you to establish ?
- How one can integrate that project into the business format ?

The Section includes the following points :-

- Personal assistance: If required, personal assistance will be provided to our customers.
- Periodic newsletter: Periodic newsletter will be provided to all our customers to keep them updated about our services.
- Excellent customer services: Customers will be priority. Queries will be resolved as soon as possible. Working manual will also be provided to customers for their best understandings about our project.

6. CUSTOMER SEGMENTS

Customer Segment block is to present the list of Personals, organized by Customer Segment. If you have more than one segment. It is always recommended to prioritize them.

- Which classes are you creating for ?
- Who is the most important customer ?

The Section includes the following points :-

- Banks: Banks can use this project to verify an individual person's handwriting or signature. Many frauds can be avoided .
- Government: Different sectors of government can use this project.
- Forensic agencies: Forensic agencies can solve many mysteries and cases by using this project.
- Civilians: Civilians can use this project to verify a person's will.

7. CHANNEL

This block comprises of list of important channels , Personas or Segments if they differ substantially. This Block provides the following answers to the questions :

- Through which channels customers need to be reached ?
- Which channels works best ?
- How can they be integrated to your customer's routines ?

The Section includes the following points :-

- Advertisement: Advertisements can provide a link to communicate with others.
- Social media: Social media can help spreading awareness about our project and out aim of making the project.

8. COST STRUCTURE

Cost Structure business block provides a list of Cost Structure elements with notes on their relationship to Key Activities. This block in the business model answers the following questions

- What are the most cost in your business?
- Which key resources/ activities are most expensive?

The Section includes the following points :-

- Software development: This software has most of the qualities required.
- Reliable: This project is reliable.

9. REVENUE STREAM

Revenue Streams block of Business Model Canvas aims at answering the following questions:-

- For what value are your customers willing to pay?
- What and how do they recently pay? How would they prefer to pay?
- How much does every revenue stream contribute to the overall revenues?

The Section includes the following points :-

- Customer segment dependent: The revenue is dependent on our various customer segments.
- Product feature dependent: Various feature which are added and which may be added later on can help generate revenue.
- Licensing: Licensing is required for our project.

Chapter 3: CONCLUSION

Business model canvas will be helpful to students to embark entrepreneurship. One can make a good product from their project.

III. Patent Drafting Exercise

College	:	G. H. PATEL COLLEGE OF ENGINEERING & TECHNOLOGY, V V NAGAR
Department	:	Computer Engineering
Discipline	:	BE
Semester	:	Semester 8
Project Name	:	Signature Verification Using Machine Learning
Team ID	:	54177

Form 1 – APPLICATION FOR GRANT OF PATENT

Applicants :

Sr. No	Name	Nationality	Address	Mobile No.
1	Tandel Mansi Jainendra	Indian	Computer Engineering , G. H. PATEL COLLEGE OF ENGINEERING & TECHNOLOGY, V V NAGAR , Gujarat Technologycal University.	7069466585
2	Aditi Deven Patel	Indian	Computer Engineering , G. H. PATEL COLLEGE OF ENGINEERING & TECHNOLOGY, V V NAGAR , Gujarat Technologycal University.	9624188833

Inventors:

Sr. no	Name	Nationality	Address	Mobile No.
1	Tandel Mansi Jainendra	Indian	Computer Engineering , G. H. PATEL COLLEGE OF ENGINEERING & TECHNOLOGY, V V NAGAR , Gujarat Technologycal University.	7069466585
2	Aditi Deven Patel	Indian	Computer Engineering , G. H. PATEL COLLEGE OF ENGINEERING & TECHNOLOGY, V V NAGAR , Gujarat Technologycal University.	9624188833

I/We, the applicant(s) hereby declare(s) that:

Following are the attachments with the applications :

Form 2 - PROVISIONAL/COMPLETE SPECIFICATION

1 . Title of the project/invention :

Signature Verification Using Machine Learning

2. Preamble to the description :

Provisional

3. Description

a) Field of Project / Invention / Application :

Signature Verification using machine learning

b) Prior Art / Background of the Project / Invention :

Techniques such as offline signature verification using pixel matching(biometric),online verification based on DWT features extraction and neural network classifications are available

c) Summary of the Project / Invention :

Signature Verification is a useful aspect to identify and authorize individuals. It is usually employed for individual's signature authentication in cheques used by banks, in courts for justice(e.g. authentication of will) and forensic investigation to identify whether the signature is genuine or forged. As every individual has a unique handwriting style as a unique fingerprint, this makes verifying of signatures easier. A unique handwriting is identified based on character size ,character shape, character alignment and character style that is visually disparate. 60 signature samples five each from 12 different persons are collected for training and testing of data that is used to extract and classify the patterns belonging to the same class that leads to more accurate results. This can be accomplished in four steps: 1)Data Acquisition, 2)Image Preprocessing , 3)Feature Extraction and 4)Verification using SVM

d) Objects of Project / Invention :

Anaconda navigator,Intel i3 processor,4 GB RAM,100 GB Hard disk,Windows Operating System(7/8/8.1/10)

e) Drawings :

f) Description of Project / Invention : (full detail of project) :

Although,Technology has evolved in years with the individuals turning towards paperless world, the importance of documents written by hands has perpetuated and the issues of recognition and authentication of the writer has been a vigorous area of research.. The type of classification algorithm in machine learning used is :Support Vector Machine (SVM).Signature samples from 12 different authors are accumulated. 60 genuine signature samples are collected five each from the twelve individuals, and 60 forged signature samples are collected five each from the twelve individuals other than the genuine ones. An Image preprocessing algorithm is implemented using Anaconda [2] to transform the samples collected to grayscale initially .After this,the image is thresholded to binary format i.e. black and white. The SVM classification algorithm is implemented using Anaconda [2] followed by feature extraction using techniques of Aspect ratio, Bounding Box, Surf, Sift, Imagehash,

etc. Verification of the signature using training and testing of images is the final step of the implementation steps and the value of precision to identify the forged signature from genuine one lies between 0 and 1.

g) Examples :

h) Claims (Not required for Provisional Application) / Unique Features of Project

Usage of various features, Verification using SVM

4. Claims

5. Date and signature

6. Abstract of the project / invention

Signature Verification is a useful aspect to identify and authorize individuals. It is usually employed for individual's signature authentication in cheques used by banks, in courts for justice(e.g. authentication of will) and forensic investigation to identify whether the signature is genuine or forged. As every individual has a unique handwriting style as a unique fingerprint, this makes verifying of signatures easier. A unique handwriting is identified based on character size ,character shape, character alignment and character style that is visually disparate. 60 signature samples five each from 12 different persons are collected for training and testing of data that is used to extract and classify the patterns belonging to the same class that leads to more accurate results. This can be accomplished in four steps: 1)Data Acquisition, 2)Image Preprocessing , 3)Feature Extraction and 4)Verification using SVM

Form 3 – STATEMENT AND UNDERTAKING UNDER SECTION 8

Name of the applicant(s) :

I/We, Tandel Mansi Jainendra ,Aditi Deven Patel

Name,Address and Nationality of the joint applicant :

Hereby declare

(i) that I/We have not made any application for the same/substantially the same victim invention outside India.

(ii) that the rights in the application(s) has/have been assigned to

Name of the Country	Date of Applicati -on	Application Number	Status of the Application	Date of Publication	Date of Grant
N/A	N/A	N/A	N/A	N/A	N/A

(iii)That I/We undertake that upto the date of grant of the patent by the Controller, I/We would keep him informed in writing the details regarding

corresponding applications for patents filed outside India within three months from the date of filing of such application.
Dated this 20 day of April 2019

To be signed by the applicant or his authorised registered patent agent :	Signature....
Name of the Natural Person who has signed	Tandel Mansi Jainendra ,Aditi Deven Patel To, The Controller of Patents, The Patent Office, At Mumbai

IV. Periodic Progress Report

College	: G. H. PATEL COLLEGE OF ENGINEERING & TECHNOLOGY, V V NAGAR		
StudentName	: Tandel Mansi Jainendra		
EnrollmentNo	: 150110107054	Department	: Computer Engineering
MobileNo	: 7069466585	Discipline	: BE
Email	: mansimjtandel@gmail.com	Semester	: Semester 8

PPR Details

Periodic Progess Report : First PPR

Project : Signature Verification Using Machine Learning

Status : Submitted

1. What Progress you have made in the Project ?

Signature verification requires samples of signatures. Some signature samples are taken from different authors to verify if the signature is genuine or not. For this, we have taken genuine signatures and forged signatures from different authors. Further processing will be done on these samples. The input images for verification are stored in PNG or JPG format. On these images, further processing will be done.

2. What challenge you have faced ?

Our requirement is to find or create a dataset of signatures that must be relevant to our project. For this, we considered two approaches to create or find samples of signatures. In online signature sample collection there can be use of digitizers such as tablet screens. These tablet screens allow users to use stylus pen to create their samples of signatures by their own. In offline signature sample collection, samples are scanned from paper. We considered both approaches to find out the best approach for our project.

3. What support you need ?

We tried to find or create dataset of signature samples. We came across various datasets. Then we found out a dataset which was available. This dataset is based on offline signatures approach. It contains genuine signatures as well as forged signatures of various authors.

4. Which literature you have referred ?

The literature referred are: (1) Pixel Based Off-line Signature Verification System by Anik Barua , Mohammad Minhazul Hoque , A.F.M. Nurul Goni , Md. Ahsan Habib (2) Review on Off-Line Signature Verification Techniques for Reducing Forgeries/Fraud by Natasha Sharma and Munish Kumar

Comments

Comment by Internal Guide :
None

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Comment by HOD :
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PPR Details

Periodic Progess Report : Second PPR

Project : Signature Verification Using Machine Learning

Status : Submitted

1. What Progress you have made in the Project ?

After getting the dataset which consists of forged signatures as well as genuine signatures, we need to preprocess these images. We converted these sample images to greyscale images and threshold these images. The same threshold value is applied to every pixel in sample images.

2. What challenge you have faced ?

The sample images from dataset are of RGB format. So we need to convert these images to greyscale format. The handwriting samples may be written in colored background. Greyscale images simply reduces complexity. Image thresholding partitions an image into a foreground and background in simple words. It checks each pixel value. If the pixel value is greater than a threshold value, it is assigned one value, else it is given another value. These preprocessing steps helped reducing the complexity with the colored images for further processing.

3. What support you need ?

We needed some prerpocessing steps that could help reduce the complexity as well as the steps that could be helpful in further processing steps. We needed to find out which steps to perform on dataset. We used the opencv tutorials to perform the preprocessing steps.

4. Which literature you have referred ?

The literature referred are: (1) Thresholding tutorial by opencv.org (2) A New Character Segmentation Approach for Off-Line Cursive Handwritten Words by Amit Choudharya,*, Rahul Rishib, Savita Ahlawatc

Comments

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None

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PPR Details

Periodic Progess Report : Third PPR

Project : Signature Verification Using Machine Learning

Status : Submitted

1. What Progress you have made in the Project ?

We need to extract features from the preprocessed images. There are various features that can be extracted from the input images. The features that we extracted are: height to width ratio, signature density ratio, signature occupancy ratio, critical points, center of mass, slope of center of mass of two halves of the signature, center of mass of the sub segments, region based features, speed up robust features, scale invariant feature transform, convex hull area, countour area, perceptual hash of the image.

2. What challenge you have faced ?

After the preprocessing step, we needed to decide which features to extract. We also needed to decide which features to use for the verification process. We considered all the features mentioned above.

3. What support you need ?

We extracted all the features mentioned above. We tried to know about the possible features for our aim and referred to various articles. We needed to find the best possible features from all the features that can be extracted from the preprocessed images.

4. Which literature you have referred ?

The literature referred were: (1) A Study on Handwritten Signature Verification Approaches by Surabhi Garhawal, Neeraj Shukla (2) Morphological waveform coding for writer identi"cation by E.N. Zois, V. Anastassopoulos

Comments

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None

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PPR Details

Periodic Progess Report : Forth PPR

Project : Signature Verification Using Machine Learning

Status : Submitted

1. What Progress you have made in the Project ?

After the feature extraction step, we applied various features from the extracted features to find out the best possible outcome. After applying various combinations of features, we found out that the features which help giving the best possible outcome are scale invariant feature transform, convex hull area, countour area, perceptual hash of the image.

2. What challenge you have faced ?

The challenges were related to applying combinations of features and making the appropriate functions to get the outcome.

3. What support you need ?

The support needed was related to the usage of various features and understanding as well as using the functions to get the desirable outcome.

4. Which literature you have referred ?

The literature referred are: (1)Offline Signature Verification Using Machine Learning by Damayanti Ghosh , Sumit Kumar Baranwal (2) An article of signature verification by www.cse.msu.edu

Comments

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V. Plagiarism Report

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BE Project Report entitled "SIGNATURE VERIFICATION USING MACHINE LEARNING" Under subject of Project (2180706) (UDP Project) Submitted by 1 _Aditi Deven Patel _150110107003 __2 _Mansi Jainendra Tandel _150110107054 __Academic year 2018-19 8th semester(March-April 2019) In fulfillment of the requirements for Bachelor of Engineering In Computer Engineering Faculty Guide Prof.

Priyang Bhatt / Department of Computer Engineering G H Paatel College of Engineering & Technology / Gujarat Technological University Ahmedabad, Gujarat. ABSTRACT Signature Verification is a useful aspect to identify and authorize individuals. It is usually employed for individual's signature authentication in cheques used by banks, in courts for justice(e.g.

authentication of will) and forensic investigation to identify whether the signature is genuine or forged. As every individual has a unique handwriting style as a unique fingerprint, this makes verifying of signatures easier. A unique handwriting is identified based on character size ,character shape, character alignment and character style that is visually disparate.

60 signature samples five each from 12 different persons are collected for training and testing of data that is used to extract and classify the patterns belonging to the same class that leads to more accurate results. This can be accomplished in four steps: 1)Data Acquisition, 2)Image Preprocessing , 3)Feature Extraction and 4)Verification using SVM.