Taiz University Faculty of Engineering &IT Department of

Software Engineering

Automatic Handwritten Digit Recognition

on Students' grades papers off-line

Graduation project submitted to the Department of Software Engineering to obtain a bachelor's degree in the Department of Software Engineering

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Abstract

The major objective of this project is to develop an automated handwritten digit recognition technique to recognize handwritten numeral strings. It plays an essential role in automation systems that deal with digits such as postal codes, banking account digits, etc. In this project, A system capable of reading and reviewing students' grades written on grade papers is implemented. This system will be suitable for the college in reducing grade processing costs in terms of time and labor, also the system finally inserts the grades into an Excel file To enable the employees to import it automatically into the database. To accomplish this task, This research performs five steps: image acquisition, preprocessing, segmentation, feature extraction, and classification. Morphological operations and thresholding are used in segmentation, and topological and Statistical features are used in the features extraction stage and in classification. In this project, different machine learning techniques, which are SVM, ANN, and CNN architectures are used to accomplish high performance on the digit string recognition problem. The classifier is trained using several dataset consists of mnist,MAD and TPDataset are used to achieve performance on the digit string recognition problem. It is designed to be executed in a normal pc and The program code is written in Python 3.6.9 and supported with the usage of Graphical User Interface (GUI). The results conclude that the used techniques have performed with an identification rate ranged from 98.32% to 99.88%·

Keywords

OCR,Handwritten Digit Recognition, CNN, SVM, PCA,ANN

Acknowledgement

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TABLE OF ABBREVIATIONS

OCR	Optical Character Recognition
ANN	Artificial Neural Network
SVM	Support Vector Machine
CNN	Convolutional Neural Network
CNND	Dual Cellular Neural Network Architecture
KNN	k-nearest neighbor
DLQDF	Discriminative-learning-quadratic discriminant function
MLP	Multi layer Perceptron
RBF	Radial Basis Function
DDD	Directional Distance Distribution
MNIST	Modified National Institute of Standards and Technology

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CHAPTER 1: INTRODUCTION

1.1 Overview

to let the computer understand the digit is this process called Optical Character Recognition (OCR)[1]. The main goal of this project is to build system to recognize handwritten digits in both Arabic and English language . there is important concern in the college for new sydstems that can be used to read and review students grades automatically. Such system can greatly reduce the workload of college employees. Handwriting digit recognition has become a standard research part due to developments in technologies such as the handwriting catch tools and portable laptops [2]. In the field of handwritten characters recognition, there are two types of systems, which are known as on-line systems and off-line systems. On-line systems include recognition of handwritten characters by touch input, in other words, on-line systems recognize the character written by the user according to the input strokes. On the other hand, off-line systems include character recognition by scanned image, where no stroke information is known to the system. In this case, the amount recognition system is an off-line system since scanned grades paper is used as the input[3].

Several methods have been suggested for recognition of handwritten digits, It includes two phases, namely training phase and prediction phase. Image features are recognized by using spaces between words, and each word is segmented into characters, characters into multiple features, and feature vector is fashioned using shapes, height, width. Then classification is done using feedforward network[4].

In the field of OCR handwriting digit recognition has been intensively studied for Several years in several techniques and classification algorithms. These consist of, for illustration, Support Vector Machine (SVM), Convolutional Neural Network (CNN), artificial neural network (ANN). many of classifiers cannot sufficiently handle the original data, feature extraction is executing aftar of the pre-processing stages that has the purpose of reducing the dimension of data and selecting the effective data [5].

manual feature selection is a inconvenient mission that cannot handle the primary image, but an automatic extraction technique by CNN able to discover features directly from the primary image[6]. A CNN is a feedforward net that extracts topological features from

images. It assembles attributes from the primary image in the first layer and uses its last layer to organize the digit[7]. in the classification phase, the SVM makes the greatest isolation hyperplane in the great dimensional characteristic space, The goal of obtaining such hyperplane for the maximize the margin [8]. Also, ANN is an simulation of a actual nervous system, which is frequently nonlinear. It involves of a network of artificial neuronthat are connected, ANN becomes widely used in resolving nonlinear problems as pattern recognition[9].

Principal component analysis (PCA) is analysis technique that usually extracts the best data. PCA is a great and general tools applied for information discovery and compression in machine learning. It includes linearly translating a group of associated variables into another illustrations that accentuate the difference between observations. Efficiently, it reduces the sizes of the watched data by removing increase ,The further main benefit of PCA is that when the forms are discovered in the data, then the data is reduced without much damage of information[10].

1.2 Problem of Statement

there are many fields dealing with handwritten digits written manually by users , One of the major areas is the educational sector which deals with enormous amount of document image and manually processed .This manual process takes a lot of time and consumes human resources. the subject of digit recognition appears. A system for recognizing the digits may be as an approach for dealing with such application. In other words, to let the computer understand the digit that is written manually by users and views them according to the digital format.

1.3 Research Objective

The objectives of this research are:

- to create a system that is capable read handwritten digits on students grades filed .

- To recommend which algorithms can increase the accuracy of handwritten digit recognition to up to 99% based on the estimated results.

- Apply the basic concepts in the image processing and deep learning algorithm so we will achieve the goal.

1.4 Research Methodology

We will use algorithms for data training of dataset and high-precision number classification using CNN, ANN and SVM ,As we inferred all these previous algorithms from a set of previous researches where they are the best and best in the classification accuracy as shown in the following table 1.1

Researchers Name	Year	Method	Dataset	Recognition Accuracy	Problem
Maji et al. [11]	2009	SVM	MNIST	93:3%	dataset was not found as nonlinear or Inseparable
IlmiN et al [10]	2016	ANN	MNIST	96%	1- it has a significant computational cost 2- it does not take the structure of the data space into account 3- it provides low recognition rate for multi-dimensional sets
Wang Z,ChangS [12]	2016	CNN	MNIST	99.14%	It has the highest runtime

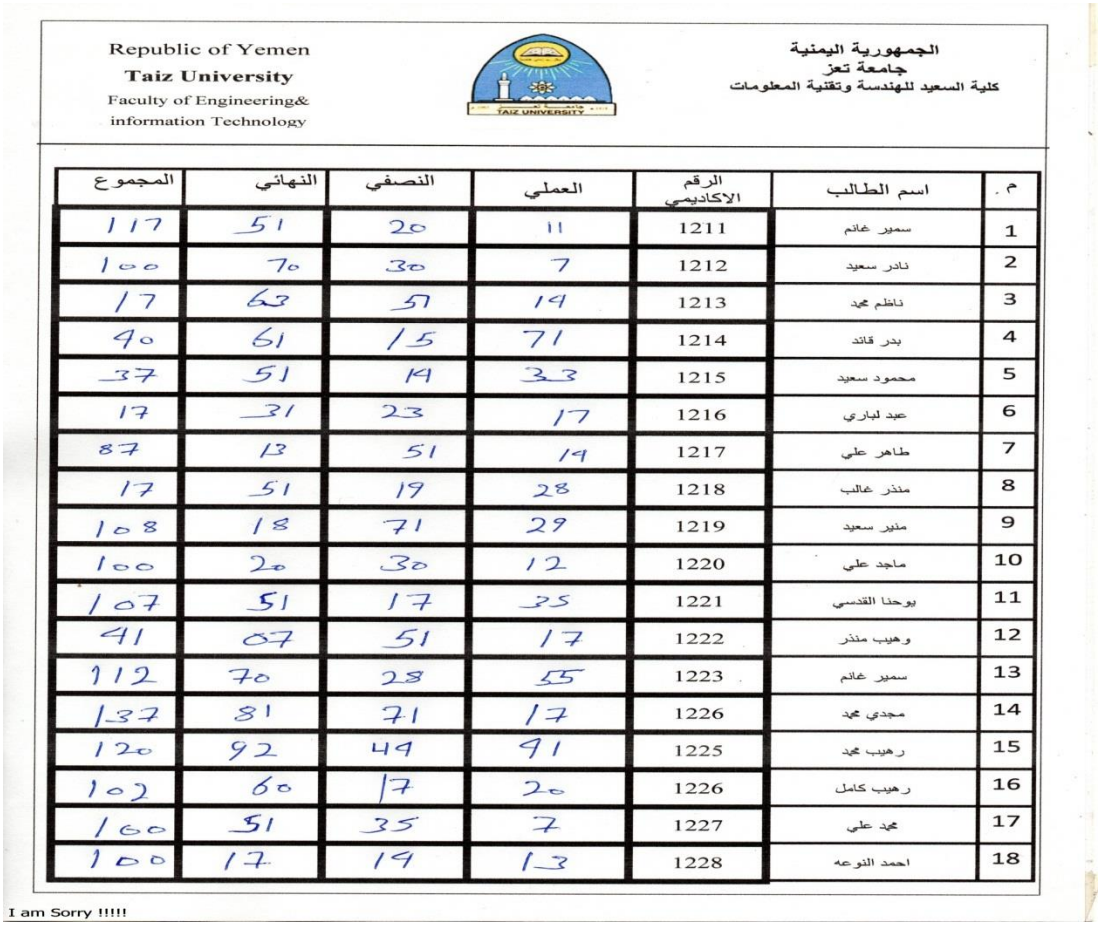
Table 1.1: Research Methodologies comparison

● After several comparisons between dataset we found the most accurate datasets is MNIST in training and test using algorithms CNN and SVM . the MNIST dataset used standard datasets in English digit recognition systems and it is freely existing [51]. MNIST dataset is modified from the NIST dataset [51, 52].

● The project is the programming language Python is used to implement the handwritten digit recognition system. Python is an open source programming language and together with Tensorflow, Keras , Tkinter and opencv libraries, it makes a good environment for image processing and machine learning. Python is elected because it is user-friendly and well documented, and the libraries have many suitable functions

1.5 Scope and Limitations

The scope of this project is to construct an off-line Handwritten Digit Recognition on students grades paper system and compare the different classifiers and combination approaches. Grades standard paper which consists of the following fields: (student name ,academic number, practical grades ,mid-level grades, final grades, total grade) This project focuses mostly on segmentation and recognition of the components in the five fields except the student name because each student has a unique academic number he distinguishes him from other like this structur:



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الجمهورية اليمنية
جامعة تعز
كلية السعيد للهندسة وتقنية المعلومات

م	اسم الطالب	الرقم الاكاديمي	العملي	النصفي	النهائي	المجموع
1	سمير غانم	1211	11	20	51	117
2	نادر سعيد	1212	7	30	70	100
3	ناظم محمد	1213	19	51	63	17
4	بدر قائد	1214	71	15	61	90
5	محمود سعيد	1215	33	19	51	37
6	عبد لباري	1216	17	23	31	17
7	طاهر علي	1217	19	51	13	87
8	منذر غالب	1218	28	19	51	17
9	منير سعيد	1219	29	71	18	108
10	ماجد علي	1220	12	30	20	100
11	يوحنا القدسي	1221	35	17	51	107
12	وهيب منذر	1222	17	51	07	41
13	سمير غانم	1223	55	28	70	112
14	مجدي محمد	1226	17	71	81	137
15	رهيب محمد	1225	91	49	92	120
16	رهيب كامل	1226	20	17	60	102
17	محمد علي	1227	7	35	51	160
18	احمد النوعه	1228	13	19	17	100

I am Sorry !!!!!

Figure 1.1 Standard image of students grdes papers

Also The boundaries of this project include:

1- The image acquisition should by Scanner printer.

2- The picture resolation should be at least 4 mb and thire formula is jpg.

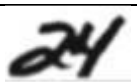
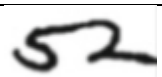
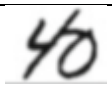
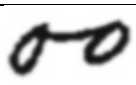
3- The digits should be in the middle of each field and not touching the boundaries of the table.

4-The recognition method rarely shows unreliable outcomes due to the similarly shaped digits;

5- the process of touching point between digits be on two digits only.

6- the touching point between the digit should be according to set of criteria as shown in figure 1.2.

Table 1.2: touching point between tow digit

Category	Type	Style of touching	Examples	Category
Single-touching	1			
	2			
	3			
	4			
Multiple-touching	5			

CHAPTER 2: LITERTURE REVIEW

This chapter will include a detailed overview of previous literature and techniques used in this field and focus on the important topics, corresponding to this study. Firstly, in this portion offerings types of handwritten character recognition systems. In the second part purveys in depth summary of the latest works in the filed of handwritten character recognition system . in the third portion offerings an overview to the approaches to OCR. Also . the last section will provide a summary of the next stage of the study, based on the best algorithms and best methodologies

2.1 types of handwritten character recognition systems

2.1.1 Online Optical character recognition (OCR)

In online handwritten digit recognition, characters and words are recognized real time as soon as they are written, and therefore, have temporal data. online systems get the position of the pen as a purpose of time directly from the interface. This usually done over pen-based interfaces where the writer Writes with a special pen on an electronic tablet. Dynamic information, which are commonly existing for online text recognitions, are number of hits, order of hits. direction for each hit, and rapidity of writing within each hit. This existing information contributions in recognition of documents and normally leads to improved implementation systems compared to offline recognition. advantage of online recognition system above offline systems is interactivity. adaptation of writer to digitizer ,less prone noise, and available temporal information. The disadvantage is that the entire document is not existing for handling, and therefore information needs to be handled dynamically.

2.1.2 Off-line Optical character recognition (OCR)

in offline recognition, the letters aren't took dynamically. Online handwriting recognition is more exact when equaled to offline handwriting recognition because of the absence of information[6]. Therefore, there can be research done in this area to improve offline handwriting recognition. The key task in offline handwriting recognition is to recognize the character of words. There are diverse approaches for identifying the characters of a word in offline handwriting, in the other words Off-line handwriting identification is the method of

discovery letters and words are present in digital image of handwritten text. It is the subfield of optical character recognition.

2.2 Related work in the field of Handwriting Digit Recognition System

Tamas Szirhnyi and Jozsef Csicsvari ,In 1993 [11], the authors have conducted research for character recognition This technique utilized a new architecture, named CNND, This CNND contains more than one analog cellular neural Networks (CNN) and several digital logic, combining the benefits of the quick equivalent CNN signal processing and the easy for choice ability of digital logics. This study illustrations by using architecture CNND method can be utilized for identification of several fonts printed or handwritten digits. the experiments Implemented on images (40 * 40) pixels with a identification rate of more than 95%. The main development of CNND system over the competing types is that there is no additional feature extraction technique implemented in slow hardware. Also in the CNND system, image processing steps and feature extractions are done in fast analog units, and the decision is made in fast memorized digital units. This CNND system can be improved easily using other special cloning templates.

Cheng-Lin Liu∗, Kazuki Nakashima, Hiroshi Sako, Hiromichi Fujisawa In 2003[12] .they applied several classifiers involve the k-nearest neighbor(knn) classifiers , three neural Network classifiers , a discriminative learning quadratic discriminant function (DLQDF) classifiers , and two support vector classifiers. The authors used several types of feature extraction which chaincode feature, gradient feature, profile structure feature, and peripheral direction contributivity as feature extraction . the experiments Implemented on three databases are CENPARMI, CEDAR, and and MNIST. And 80% recognition accuracies are given to the test data set of each database. this research noting that the accuracies of the gradient feature extracted from fine gray-scale images are consistently higher than those of the features extracted from binary and pseudo-gray images.

J. Sadri, C. Y. Suen, and T. D. Bui in 2005[13], they suggested a novel method for segmentation and recognition of unconstrained handwritten digit. The suggested system utilities a collecting of foreground and background attributes for separation of touching numeral.we have also used a new technique for feature extraction which lower of variations in the shape of the digits and utilized MLP nural network for classification.the NIST SD19 and CENPARMI dataset are used for assessing the system. As a outcome, the recognition system was capable to achieve 96.07% recognition rate. This research indicated that to increase the performance and efficiency of the segmentation and recognition processes by improved exploiting all sources of knowledge, and using advanced machine learning methods.

Sadri, Suen ,In the beginning of 2007[14], showed that the accurate use of context knowledge in segmentation, evaluation, and the survey could remarkably improve the overall performance of the handwritten digit recognition system. The NIST SD19 and CENPARMI dataset were used to assess the performance of suggested technique.As a outcome, the recognition system was capable to achieve 95.28% and 96.42% recognition – segmentation accuracy on handwritten digits by using Artificial neural network(ANN) and Support Vector Machine (SVM) classifiers, respectively.

Nitin Sharma and Arun Rana in 2012[15] produced an effort to recognize a handwritten characters by SVM classifier and MLP Neural Network. Several of SVM kernel as the linear kernel, polynomial kernel, and quadratic kernel-based SVM classifiers are utilized. In the SVM classifier mode, here are double stages of training and testing. From every character, about 25 features are obtained with the help of which SVM is trained. Between the three kernels used the linear kernel gives an accuracy of 94.8%. and 80.96% accuracy for Neural Network. The outcome achieved for recognition of handwritten characters illustration that reliable classification is potential by SVMs.

E. Juharwidyningsih, C. Fatichah ,In 2013[16], The authors have extracted the attributes of digit and mathematical operators. They have used SVM for classification as well as to remove the noise from the dataset. A feature extraction method has been used on NIST dataset which involves of uppercase, lowercase, and mixture of uppercase and lowercase.

Saeed AL-Mansoori, In 2015[57], The auther use ANN to recognize and predict handwritten digits from 0 to 9 .The proposed neural network was trained and tested on a dataset of 5000 samples were obtained from MNIST. The dataset was trained by using gradient descent back-propagation algorithm and further evaluated using the feed forward algorithm. The performance of the method varies by the number of hidden unit and the number of iterations. The output was then adjusted to the optimal parameters of the system. The proposed system estimates handwritten numbers with accuracy rate 92% .

A. Alsaafin and A. Elnagar ,In 2017[18], they suggested an offline handwritten Arabic decimal digits recognition method for finding where they used coefficients of correlation with SOMs where the work was divided into three methods only. Firstly the method is simple: the suggested solution uses two basic methods which are proven to be simple and quick, the correlation coefficient method and the SOM method. Furthermore, the method is highly accurate: the findings are almost 100% consistent with the proposed method. Thirdly, the approach is highly effective: in only a few milliseconds the proposed approach is recognized. They intend to use this approach for handwriting Arabic and English characters recognition in future work. KH Tohidul Islam,Ghulam Mujtaba,Dr.Ram Gopal Raj,Henry Friday Nweke ,In 2017[58], The researchers used digits images pixel as features vector and ANN as classifiers. used MINST dataset for evaluating this experiment. From the results, it can see that the experiments result achieved 99.60% recognition accuracy. In the further optimize the parameters of ANN to obtain higher accuracies with low implementation time.

S. Shamim, M. B. A. Miah, M. R. Angona Sarker, and A. Al Jobair ,2018[19], designed a model its main aim was to identify isolated handwritten numbers that can be remembered effectively. Multilayer Perceptron , Support Vector Machine, Naives Bayes, Random Forest, J48 and Random Tree were used for digit recognition with program WEKA in order to use various methods to learn algorithms. This study shows that Multilayer Perceptron's peak accuracy of 90.37% was achieved, the main problem is to address the feature extraction and accurate classification methods... Shamim in 2018[18] suggested the ten cross-validation technique to choose the parameter to gain the maximum recognition rates.

Whereas, this examine showed that the implementation of SVM with RBF is better than with other kernel, accesses above 93%.

Meer Zohra, D.Rajeswara Rao In 2019[20] generating Comprehensive comparison among several algorithm to determine which provides better performance in the recognition task. As a outcome, the recognition system was capable to achieve 99.4% and 97.1% and 97.9% recognition correctness on handwritten digits by using Convolutional Neural Networks (CNN), K-Nearest Neighbor (KNN), Support Vector Machine(SVM) with polynomial kernel classifiers , respectively, on the MNIST handwritten digit dataset . he determined that CNN tends to give better performance for this handwritten digit recognition process.

Salaeh ali ,ahmed mohamed, in 2019[21] suggested a recognition method for handwritten digits with unidentified size. The suggested technique employs a novel cascade of hybrid principal component analysis network (PCANet) and support vector machine (SVM) classifier named PCA-SVMNet, Cascaded steps of PCA-SVMNet classifiers are built and trained to identify several kinds of isolated and associated or connected numerals. All PCA-SVMNet classifier is accomplished independently by mixtures of actual and touching digits, The initial PCA-SVMNet phase is proficient to identify separated handwritten digits (0 . . . 9) and non- separated digits to the following phases . The test results on NIST-SD19,TP dataset , Investigates on the TPdatabase focus the benefits of the suggested technique by accomplishing above 95% of identification rate. In this experiment using NIST SD19 dataset, where maximum of the strings contain only isolated numbers, the method achieves state-of-the-art results compared to segmentation-free approaches and related outcomes with segmentation-based methods.

Holi, G., & Jain, D. K et at , in 2019 , [61].They suggested building a system takes check images as input and extracts the numbers from the field account number, date and amount. Initially, image checks are preprocessed, followed by the segmentation of numbers by a simple analysis of the connected part. The digit images collected shall be normalized and given as an input in the CNN classifier. A large data series is added to the classifier: MNIST, MATLAB, and our data series are also qualified. In training and testing, the cumulative collections of 91,000 pictures are used. The whole list for the account number,

date and sum is created by post-processing. The degree of recognition for 50 pictures is 95.59%.the future work is to automate the extraction of character and digits from bank cheque and also to address the touching digits.

Fathma Siddique, Shadman Sahib, MD. Abu Bakr Siddique,In 2019[23], The researchers comparison of performance for various hidden layers. The variations of accuracies observed for 15 epochs by varying the hidden layers. The accuracy curves were produced for case for different parameter using CNN MINST. The maximum and minimum accuracies were detected for difference hidden layers variation with a batch size of 100. The maximum accuracy in performance was found 99.21% for 15 epochs (Conv1,pool,Conv2, pool2 with 1 dropout) and minimum accuracy in performance was found 97.07% epochs (Conv1,pool,Conv2, pool2 with 1 dropout). *In 2019[59],* M. Suhail Akhtar, Hammad A. Qureshi*, Mafawez Al-Harbi+, Hani Al-Quhayz , The researchers use wavelet transforms, and wavelet packet transform using KNN and SVM classifiers. The overall average accuracy of KNN after wavelet packet transform is 96.24% on the ten-fold cross-validated data and 97.04% on the test data. However, the overall average accuracy using SVM is 96.29% on the ten-fold cross-validated data The acquired results using KNN and SVM classifiers are comparable. It means the extracted features are good features. We further improved the results by determining the high accuracy subbands and then used them for classification . The stated accuracies are still comparable for both k-NN and SVMs (RBF) which are 97.5% and 98.38% respectively. Given the low error rate that is reached by the proposed method on the MNIST data, we arrange that wavelet packets analysis is good for features extraction for handwritten digits. Moreover, the results acquired are comparable to the top techniques advanced so far.

2.3 Approaches to OCR

OCR is a method which identifies handwriting or print text in scanned documents .However Digit recognition it serves many purposes as well .for example, the post offices for sorting the mail, license plate recognition, in banks for reading checks, in street number recognition, etc. The phases involved in OCR are preprocessing, feature extraction and classification.

2.3.1 Image Acquisition

First capture the image of the digit is categorized in a standard image format. In the context of digital imaging, an image file format is a typical way to organize and store image data. It explains how the data is organized and the type of compression if any that is used. Image formats are generally classified as lossly or non- lossly image formats which are used dependent on the application, it is commonly a requisite that non-lossy image formats are used in medication . the most important image formats are:

1. **Joint Photographic Experts Group**(JPEG).
   A variable compression mechanism is used, where you can control the degree of compression when storing, to obtain a suitable file size, so that you can get a very small file size, but of course with poor image quality. Files that support large color gradations (more than 16 million colors)
2. **BitMap**(BMP) .
   One of the oldest formats that Microsoft invented, the PMP format also holds 16 million colors and does not use a compression mechanism. The images with this extension are of high quality, large size and can be used on all operating systems.
3. **Tagged Image File Format** (TIFF).
   originally designed to store images coming from the scanner or processing software. This formats is also popular with professional publishing applications. It is among the oldest formulas used. It has the same color gradations as JPG, but without compression, and this is what distinguishes it. And many designers and photographers prefer to use it if they want to print, especially if they print large sizes because these files can reach (4 million x 4 million) pixels.
4. **Graphics Interchange Format**(GIF)
   Short for Graphics Interchange Format is limited to an 8bit palette of just 256 color s. GIF is still a popular internet image format, because the image size is relatively small compared to the other types of image compression.

2.3.2 Preprocessing

Preprocessing are very significant phase in handwritten digit recognition for recognized digits. The purpose of preprocessing is to remove noise and to binarise the image, background extraction, scaling, and image sharpening and normalize the input data [23]. the task of Preprocessing into the following steps which are showed in Figure 2.1.

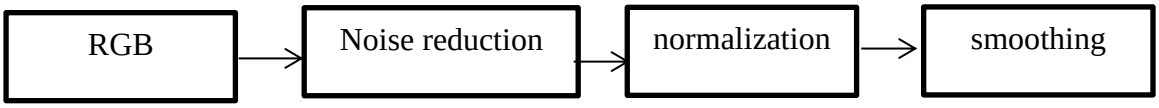


Figure 2.1: Block diagram describing Preprocessing steps.

1) **Conversion Image RGB to Gray Scale**
   The image data is originally in RGB mode and immense contrast is reduced and strength for a grayscale is used. Then the digit representation of image in the binary form[24, 25]. There are two key categories of binarization approaches.

   1) **Global thresholding:**

   A single threshold value is used for general pictures in this algorithm. Sahoo et al [26]. Have compared 20 global thresholding techniques based on based on uniformity and shape measures..

   2) **Local threshold:**

   Regional threshold this method uses the spatial information for several kinds of thresholds for each pixel. The thresholding of Otsu provided the best results, according to the comparison. There are also different methods of local thresholding. In an analysis of the thresholding methods by Trier and Jain[27], Sezgin and Sankur [28].

2) **Noise Reduction**
   Noise reduction is the method of eliminating noise from an picture [29] [30]. There are multiple techniques to decrease noise. Principally, the noise filtering function is utilized to eliminate the noises and reduce bogus items in the picture. another

method is to utilize Morphological processes which are mainly processes. It can achieve on the input pictures by the structure element[31].

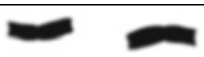
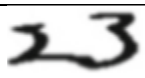
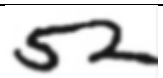
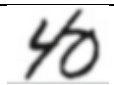
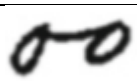
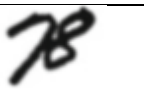
1) Filtering: this will eliminate noise and reduce bogus dots usually brought by irregular write surface or poor data acquisition equipment. For this reason, specific spatial and frequency domain filters can be built. The intention is to mix a predefined mask with the image in order to give a pixel value according to the gray values of its corresponding pixel. Filters can be designed for smoothing ,sharpening, thresholding ,filtering slightly textured or colored background, and contrast correction purposes [32], Even we take an example, Symmetric Gaussian filter function is used for smoothing equally in all directions.
2) Morphological operations: The fundamental idea behind morphological processes is the extraction of a text image to replace logical operations for convolution operations. The linking strokes [34], splitting the linked strokes [33], smoothing of contours, thin characters [35, 36], and cutting the boundaries can be applied on several morphologic operations .
3) **Normalization**
   Normalization is considered as the important preprocessing issue for handwritten Optical Character Recognition (OCR),Because to decrease each kinds of variations and to find normalized data[37].
   Size normalization:
   it is utilized to change the size, location of the picture .This stage is requisite for decreasing the figure variation among pictures of the class to enable the attribute generation and increase their classification[43].
4) **smoothing**
   the smoothing technique is prepared to normalize the edges,decrease a great frequency noise in the picture. In addition, the smoothing background requires different pre-processing techniques to achieve a specific output imag[37].

2.3.3 Segmentation

Segmentation is the maximum challenging portion of the classification function for hand - written digits[44]. This is the main motivation for this problem is because of the size of each digit, the number of digits and the gap It is unidentified among the numbers. for this issue, a full digit segmentation algorithm will succeed. if at the time of writing the characters in the grade picture are well separated, then each part will represent a whole character. Unfortunately ,this is rarely the case. If some characters touch, overlap, or

disjoint, each connected component would consist of multiple characters or character parts[45]. There are five types of digits that touch Strings and these can be further categorized into single digit touch strings and multiple touch Digit strings.

Table 2.1 Categories of touching digits.

Category	Type	Style of touching	Examples	Category
Single-touching	1			
	2			
	3			
	4			
Multiple-touching	5			

recently many segmentation methods have been suggested, which background information, foreground information, and sometimes the combination of both to produce possible segmentation cuts ,However, discovery best segmentation hard due to their changeability in the place. To guarantee the best segmentation. Ciresan et al [55]. Used two Convolutional Neural Networks (CNNs) classifiers, the first classifier used for the identification of isolated digits, while the second classifier is used for the classification of two-touching digits. By comparing the scores of the classifiers, the input test image can be labeled as one isolated or two-touch digits. Both CNNs are educated without any negative instances .

Gattal et al [46].proposed a segmentation and recognition approach for handwritten digit strings with unidentified length. This process was conducted by combining many different segmentation approaches based on the structure link between connected digits. The authors employed histogram of vertical projection in addition to the contour analysis. In addition, sliding window Radon transform methods.

2.3.4 Feature extraction

A good feature should specifically define the image and be able to describe other similar images in the same way that there are usually two types of features: structural features and statistical features.

1. **Structural features:**

   It describes geometrical and topological characteristics of a pattern by representing its global and local properties**.** Such as Area of the digit, Height, Width, and Width to Height ratio features**[47].**

2. **statistical features:**

   Statistical features are derived from the statistical distribution of pixels and describe the characteristic measurements of the pattern. For statistical attributes, a variety of algorithms and measures are used, such as Chaincode algorithm, PCA-based. Chaincoding is a statistical contour-based feature extractor, which represents an image by storing the image boundaries in terms of directions. PCA is an eigenvector-based multivariate analysis technique that usually extracts the best data. To facilitate calculations.
   An important method-Directional Distance Distribution (DDD) is a measure of the representation of the total pixel distribution. DDD measures the distance information for black and white pixels in eight directions. Since the input picture is binary, DDD is a reliable function that considers both black and white pixels and their representations.

2.4 Classification Methods in Machine Learning And Deep Learning

The most important way to recognize patterns is visual identification. Optical recognition is one of the main techniques for pattern recognition. One of the most used classifiers in the

form of recognizing numbers, there are many algorithms and it is distributed into only two fields, and each field consists of many algorithms as follows:

2.4.1 Machine learning

Machine learning is the field of computer science that lets machines to be able to learn without direct programming. This learning assistances in expecting and knowledge from the records introduced with the help of algorithms executed. machine learning processes are used to accomplish the task. Several of these activities. Some of these activities consist of identification, computer vision, weather predicting, OCR, treatment, real-time decisions.

2.4.1.1 Artificial Neural Network (ANN):

Artificial neural network (ANN) is an abstract simulation of a real nervous system, which is adaptive, distributed and mostly nonlinear A node in a neural network can be assumed as a neuron in the brain. All node is associated to last nodes across weights which are altered in the machine learning method through training. A value is computed for each node constructed on values and methods of preceding nodes. This method is named forward propagation. The last production of the net is related by the goal output, then weights are corrected to diminish a misbehavior purpose telling whether the net predicted appropriately. This procedure is named back-propagation.

Simple ANNs consist of three layers that are interconnected it's input layer, hidden layer and output layer. It may contain hidden layers. ANN becomes commonly utilized in solving nonlinear difficulties such as pattern recognition, prediction.

2.4.1.2 Support Vector Machine (SVM)

Support Vector Machine (SVM) tecnhnique developed by Vapnik and Cortes (1998) is a effective discriminant classifier that has been effectively useful to many pattern recognition or classification problems and has achieved positive conclusions. Besides, due to its easiness, flexibility, expectation ability and general optimality, it is considered to be the most traditional tool for resolving linear and nonlinear classification issue. Support Vector Machine (SVM) is common to use in many systems, as it is a good algorithm for speech recognition, identification, disease classification in images, and computer vision in the natural language.SVM is mainly developed for binary approach classification,multiclass

configuration recognition difficult can also to be determined by connecting several binary SVM classifiers. Two traditional approaches are broadly used to resolve the multi-class difficult of binary classifier SVM: One Against One and One Against All. For the One Against One approaches, a classifier is arrangement for each pair of classes to isolated the classes two by two. By Against, in the One Against All approaches, a classifier is arrangement for all kind and classified to the separation of this class from the others. One Against One is mostly used for recognition for the reason that of its low difficulty. key purpose for developing SVM occurrence related to additional processes [49].

2.4.2 Deep Learning

Deep learning is a group of machine-learning algorithms that work at obtaining various levels of representation that lead to specific abstraction layers. Deep learning is a powerhouse. You can use it to make a robot understand, translate languages, render a medical diagnosis, or create a driven car [51]. The deep learning family is more commonly used than the role related algorithms for machine learning approaches based on data representations [52]. Learning can be supervised or unsupervised [53] . It is a category of algorithms in the learning of machines that teach multiple levels of representation, leading to different layers of abstraction that lead to data sense .

2.4.2.1 Convolutional Neural Network (CNN)

The calculating in CNN is stimulated by the Persons brain. Persons observe or recognize things visually. We (persons) train our children to identify things by viewing him/her hundreds of images of that thing. This aids a child recognize or make a estimate around things he/she has never viewed already. A convolutional neural network(CNN) works in the similar way and is general for exploring visual imagery. Convolutional neural network(CNN) incorporates the attribute extraction and classification stages and needs least pre-processing and feature extraction labors. A CNN can extract rich and correlated attributes mechanically from pictures. Furthermore, a CNN can grant extensive identification correctness even if there is only a little training data existing[50].

The CNN is a multi-layered family of networks, designed especially for use in two-dimensional data such as pictures , It is stimulated in notion by previous effort on neural

networks with time delays, which reduce the demands for learning equations by swapping weights in a transient dimension and are intended for speaking and time processing[56].

The functioning of convolutional neural network (CNN) depends generally on the select of hyper-parameters [51], which are typically definite on a experimental and error base. Several of the hyper-parameters are, specifically, activation function, total of epochs, kernel size, learning rate, hidden units, hidden layers. These factors are extremely vital as they control the method an algorithm studies from data.

A key convolutional neural network includes three modules, specifically, the convolutionallayer, the pooling layer and the output layer. The detailed description is as follows

1) Convolutional layer:

   There are only few parameters in this row, such as multiple filters, filter height, stride, etc. The filter slides along with the input data and brings out dot products between the filter values and the input data points.

2) Pooling layer:

   This layer decreases the dimension of the data input, minimizing the equations, the number of parameters and thus the overlap. In general, the bonding layer between convolution layers is inserted. This discards previous layer activations and therefore causes the next convolution layer to learn from a limited range of data.

3) Fully-connected layer :

   Neurons in this layer connected to all previous layer neurons as explained. As described above.

2.5 Summary

In this chapter The current literature relevant to research has been examined . In particular, it emphasized numerous operating techniques to be considered, namely image preprocessing, the selection of features and relevant machine learning classifiers. The

acquisition of data resources and the development of the plan should address these factors to reach the highest accuracy in handwritten acknowledgement.

The pre-processing of images is necessary such as normalization, slant corrections, or elastic distortions because the slanting numbers and blurred images will influence feature removal accuracy. Besides, if the data are scarce and there are transforming variant features in the distribution to be studied, the application of transformations can generate additional data and may also improve performance, such as scaling, horizontal and vertical skewering, etc. Followed by the feature extraction step, the data dimension is reduced when the relevant information is removed. Type selection is one of the critical factors for performance in a handwriting recognition system and has a significant influence on the classification edges detection recognition , Zoning is a method for partial interpretation of knowledge on partitions of a particular pattern. elements directly from the raw image using the automatic extraction process NIST SD 19 data sets that include lower and high-case letters and numbers show that the neurogenesis of an adaptive machine learning algorithm is well suited for the stable-plasticity dilemma that is long-challenged.

Where the best techniques in CNN were discovered and the techniques were retained, which is SVM and ANN and in the following sections. More research and detailed discussion of handwritten digit is needed for greater accuracy, sharpening, standardization.

CHAPTER 3: DESIGN AND METHODOLOGY

3.1 Introduction

In this section we are describing the various steps and accepts such as methods, tools, datasets used, how the models are created and how the models were trained are tested,also we are discussing how algorithms used and presented the block diagram of the suggested system.

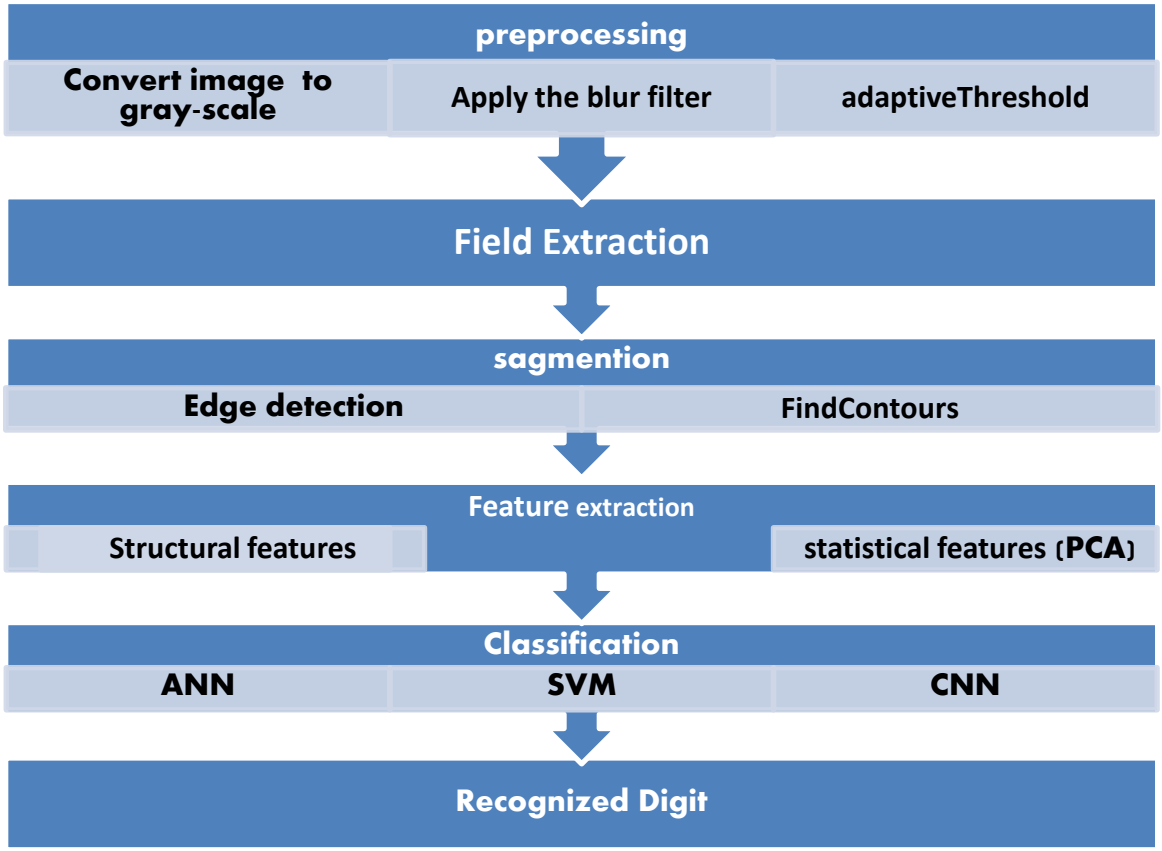


Figure 3.1 Block diagram of a Proposed system .

3.2 Method

Experiments are performed to identify the best methods of machine learning for the identification of digital images. The algorithms compared are SVM, ANN, and CNN. This experiment is structured in such a way that, initially, the input data, which is the image data, is divided into two sections, which are training data and testing data.

3.3 Tools Used

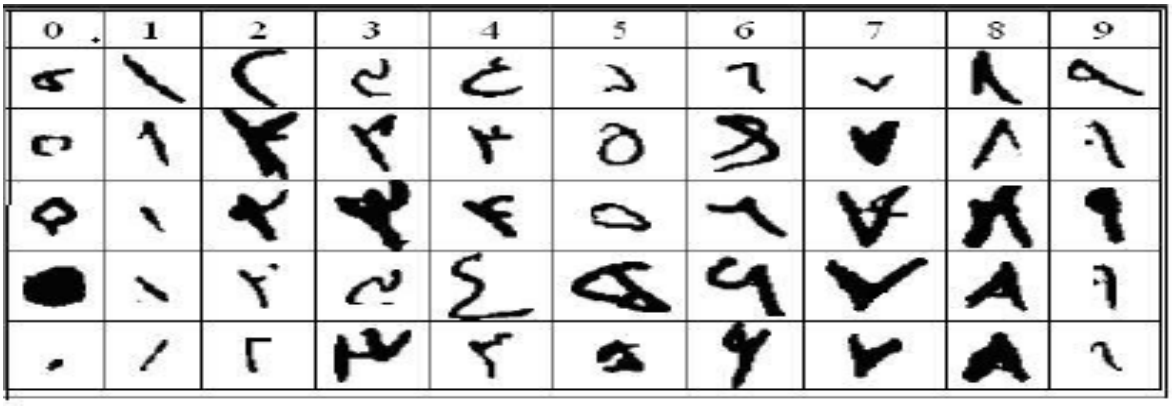
This study is to identify digits on images with the use of machine learning methods[19]. at first, we need to construct a suitable model or method for training and testing[54]. The program able to extract digits one by one to get target output for training & testing model. The implementation and the experimentation of the algorithm had been carried out by using Python and supported with the usage of Graphical User Interface (GUI). we have used the Python 3.6 version, TensorFlow backend, OpenCV, sklearn, Kera's it consists of the statistics and machine learning Toolbox which is used for training and testing the data using for different classifiers.

3.4 Dataset Used

The dataset is required for the training and testing we have three type of dataset MNIST database is used for isolated English handwritten digits, TP Dataset is used for tow connected English handwritten digits, and MAD Base is used for the training set of the isolated Arabic handwritten digit.

3.4.1 MAD DBase

(MAD DBase) Arabic handwriting recognition dataset . It was brought together from various institutions to ensure the incorporation of multiple writing styles: engineering, medical colleges, law schools, open universities (whose graduates cover a variety of ages), secondary schools and government institutions. written By 700 writers. Where each writer wrote every ten times every number (0-9). To form more than one image in several ways it contains 60,000 exercises and 10,000 test pictures MAD Base is a modified version of the ADBase standard that has the same format as MNIST Standard . So that it is represented in the following figure



1Figure 3.2 : MAD DBase Sample

3.4.2 mnist sample

Samples providing from MNIST (Modified National Institute of Standards and Technology) dataset contains handwritten digits whole of 70,000 pictures involving of 60,000 samples in training set and 10,000 samples in testing set, together with labeled pictures from 10 digits (0 to 9). Handwritten numbers are pictures in the form of 28*28 grayscale strengths of images representing an image along with the first column to be a label (0 to 9) for every image. The same has opted for the case of the testing set as 10,000 images with a label of 0 to 9.. Talking around the newer or more improved version which is like to the standard MNIST, an EMNIST or Extended MNIST have been appeared out in the year 2017 with the models of 2, 40,000 pictures in training set along with increment to 40,000 pictures in the testing set involving of handwritten digits.

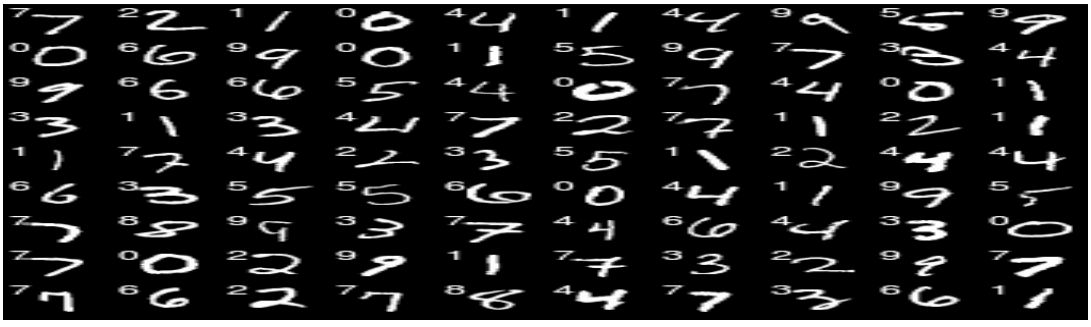


Figure 3.3: MNIST samples

3.4.3 TPDataset

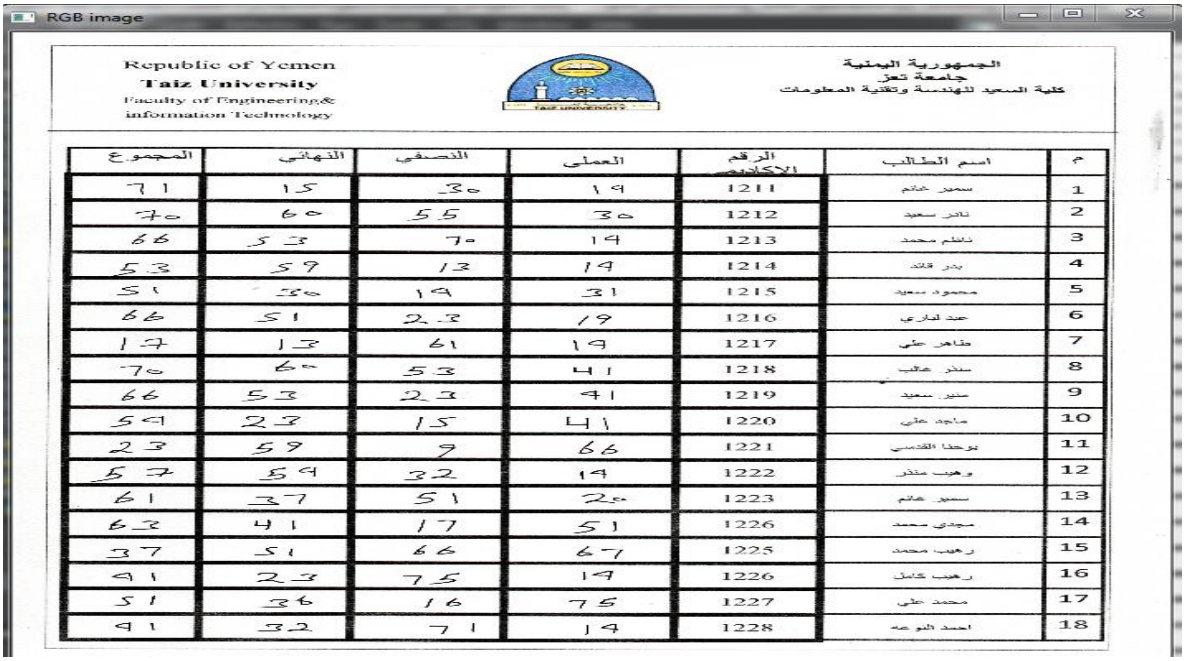
This second version (V2.0), used in [Touching Digits – Laboratório Visão Robótica e Imagem], of the database holds 79,466 sections distributed into the 100 classes of touching pairs, which correspond to the possible combinations of two digits. Some of the classes involving the digit 1 still contain fewer samples than other classes. Owing to the American style of handwriting, the digit 1 is very often with the other digit in the pair.

3.5 Major Stages of the System

3.5.1 Pre-processing

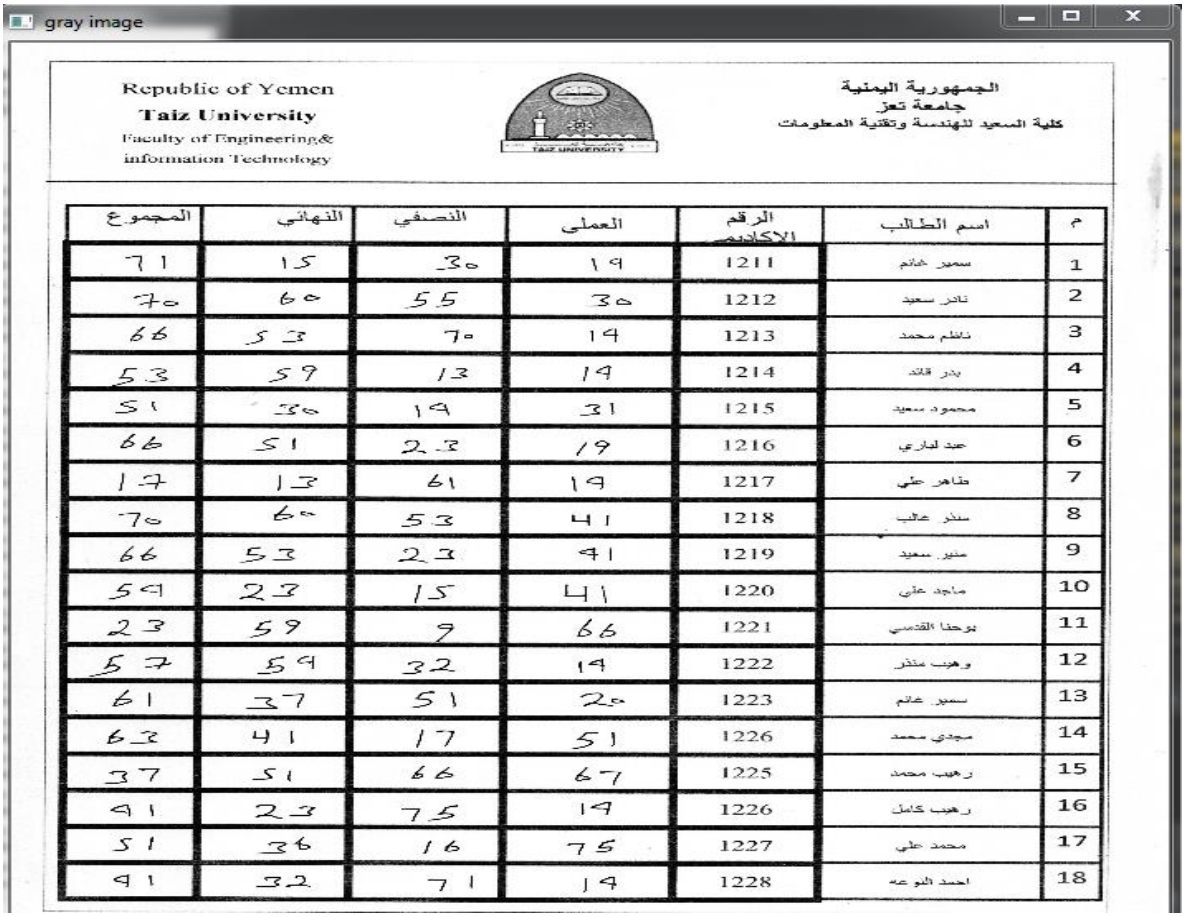
In pre-processing, the colored image is transformed to a grayscale image first. Then the picture is resized to preserve the aspect ratio. The input images varied in vertical length and all images had to be at the same height for segmentation and classification modules to work correctly .

- **Convert RGB to Gray image**
  We must convert RGB image to Gray image to get the binary image.



م	اسم الطالب	الرقم الاكاديمي	العملي	النصفي	النهائي	المجموع
1	سمير عاتم	1211	١٩	٣٥	١٥	٦١
2	ناذر سعيد	1212	٣٥	٥٥	٦٠	٧٥
3	ناظم محمد	1213	١٩	٦٠	٥٣	٦٦
4	بدر قائد	1214	١٩	١٣	٥٩	٥٣
5	محمود سعيد	1215	٣١	١٩	٣٥	٥١
6	عبد الباري	1216	١٩	٢٣	٥١	٦٦
7	طاهر علي	1217	١٩	٤١	١٣	١٧
8	نذير غالب	1218	٤١	٥٣	٦٠	٦٥
9	منير سعيد	1219	٩١	٢٣	٥٣	٦٦
10	ماجد علي	1220	٤١	١٥	٢٣	٥٩
11	توحنا القدسي	1221	٦٦	٩	٥٩	٢٣
12	وهيب منذر	1222	١٩	٣٢	٥٩	٥٧
13	نسير عاتم	1223	٢٥	٥١	٣٧	٦١
14	مجدي محمد	1226	٥١	١٧	٤١	٦٣
15	رهيب محمد	1225	٦٧	٦٦	٥١	٣٧
16	رهيب كامل	1226	١٩	٧٥	٢٣	٩١
17	محمد علي	1227	٧٥	١٦	٣٦	٥١
18	احمد الوعه	1228	١٩	٧١	٣٢	٩١

Figure 3.4: RGB image



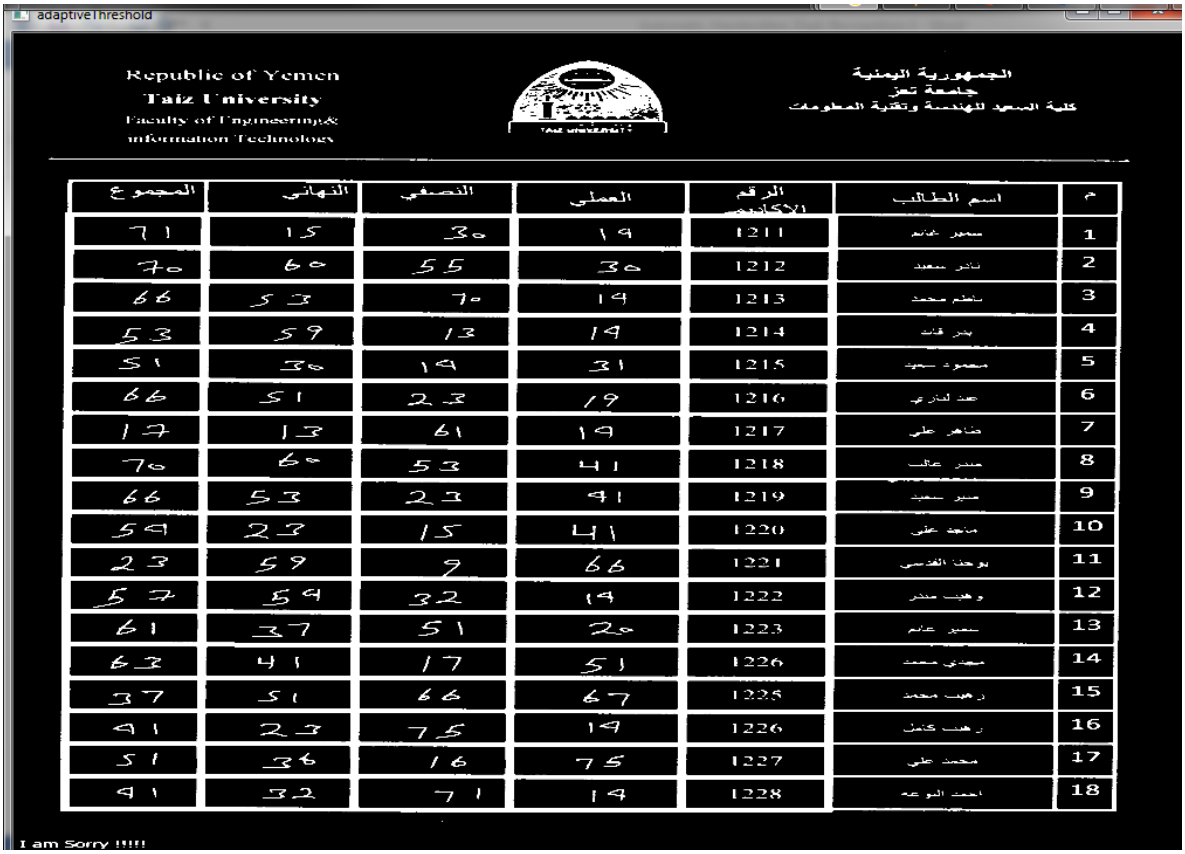
م	اسم الطالب	الرقم الاكاديمي	العملي	النصفي	النهائي	المجموع
1	سمير خانم	1211	١٩	٣٥	١٥	٦١
2	نادر سعيد	1212	٣٥	٥٥	٦٥	٦٥
3	ناظم محمد	1213	١٩	٦٥	٥٣	٦٦
4	بدر قائد	1214	١٩	١٣	٥٩	٥٣
5	محمود سعيد	1215	٣١	١٩	٣٥	٥١
6	عبد الباري	1216	١٩	٢٣	٥١	٦٦
7	طاهر علي	1217	١٩	٦١	١٣	١٧
8	منذر طالب	1218	٤١	٥٣	٦٥	٦٥
9	منير سعيد	1219	٩١	٢٣	٥٣	٦٦
10	ماجد علي	1220	٤١	١٥	٢٣	٥٩
11	يوحنا القدسي	1221	٦٦	٩	٥٩	٢٣
12	وهيب منذر	1222	١٩	٣٢	٥٩	٥٧
13	سمير عالم	1223	٢٥	٥١	٣٧	٦١
14	مجدي محمد	1226	٥١	١٧	٤١	٦٣
15	رهيب محمد	1225	٦٧	٦٦	٥١	٣٧
16	رهيب كامل	1226	١٩	٧٥	٢٣	٩١
17	محمد علي	1227	٧٥	١٦	٣٦	٥١
18	احمد النوعه	1228	١٩	٧١	٣٢	٩١

figure 3.5:Gray image

Figure 3.6: blur filter to remove the Gaussian noise in the gray image

- **Threshold the image (Convert it to binary):**

  Threshold is required to define which part of the image will be white pixels (foreground) and which belongs to black pixels (background).



م	اسم الطالب	الرقم الاكاديمي	العملي	النصفي	النهائي	المجموع
1		1211	19	30	15	71
2		1212	30	55	60	70
3		1213	19	70	53	66
4		1214	19	13	59	53
5		1215	31	19	30	51
6		1216	19	23	51	66
7		1217	19	61	13	17
8		1218	41	53	60	70
9		1219	41	23	53	66
10		1220	41	15	23	59
11		1221	66	9	59	23
12		1222	19	32	59	57
13		1223	20	51	37	61
14		1226	51	17	41	63
15		1225	67	66	51	37
16		1226	19	75	23	91
17		1227	75	16	36	51
18		1228	19	71	32	91

figure 3.6 : Convert the Gray image to a binary image.

- **Normalization and Reshape Data:**
  The handwritten MNIST digits in gray-level bitmaps have been size-normalized, centered and stored sequentially as 28 or 28 pixel images. The pixel values are between 0 and 255 in grayscale.Mostly the context is close to 0 and those past 255 represent the digit. In addition, the pixel values can be easily normalized to the 0 and 1 range by dividing each value by up to 255.The training set is constructed as a collection of 3-dimensional examples. A reduction of the image to a pixel vector is necessary for multi-layer perceptron models. In this case, an image reshaped to a size of 28 x 28 x 1 will have an input value of 784 pixels.The basic idea behind those layers is to standardize the output of an activation layer to improve convergence during training

3.5.2 Field Extraction

Field extraction refers to the extraction of region of interest, which in this case, is the students grades field. Since the location of students grades field is about the same in all image.

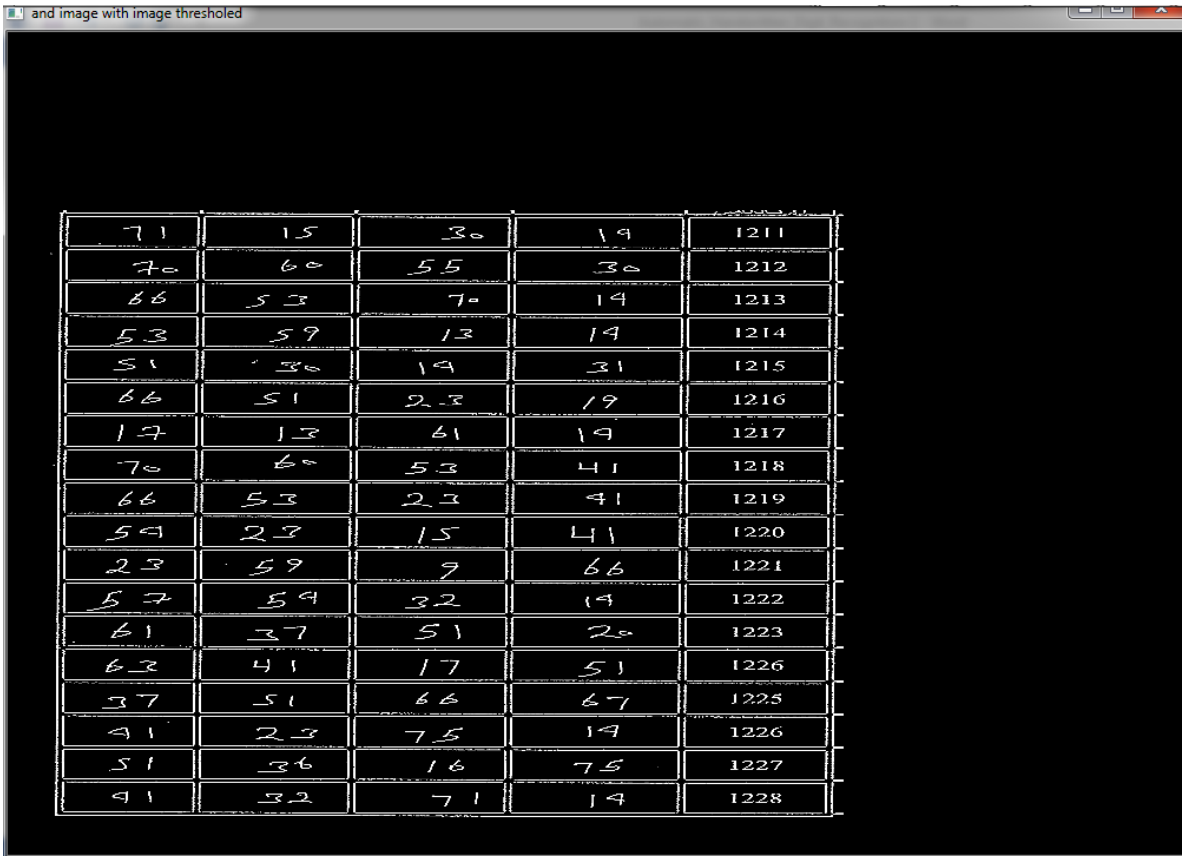


figure 3.7: Field Extraction of region of interest

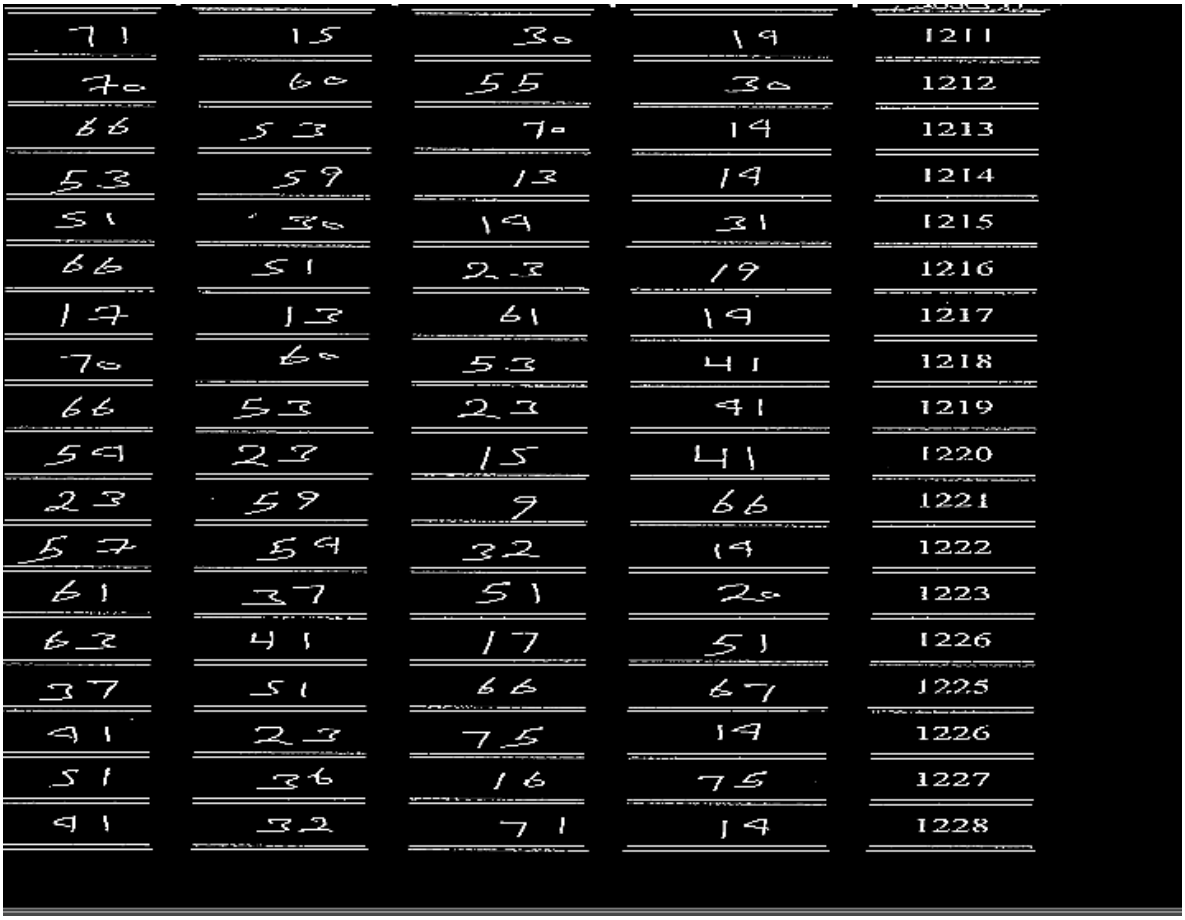


Figure3.8: Delete the horizontal lines

Figure3.9: Delete the vertical lines

3.5.3 Segmentation

Separate the image into relevant parts. Image segmentation is a way to separate objects from the image. segmentation is an important feature of identifying objects from the image. The edge of the object's position can be detected edge finder is used, The famous edge detections popular because it is an ideal way to locate border by good discovery, good location and a customized border response. By optimization method, Canny defined edges and almost recommended that the optimum detector is the maximum gradient for a Gaussian smooth image.

3.5.3.1 Segmentation of isolated digits

This phase uses the OpenCV library to find the contour points of the black pixel field, which are the digits in this case. Using the FindContours function of OpenCV, the points that are the edge of each digit are stored in vector form. This way, each connected component can be isolated from the extracted field as the boundaries of the components are traced. Split disjoint number from the image, but could not split if two or more numbers are connected or touching each other.

- **The Canny Edge Detection method used for detecting the edges works in five separate phase: -**

1) **Smoothing:** Since edge detection is susceptible to noise in the image, first step is to remove the noise in the image with a 5x5 Gaussian filter.
2) **Finding Gradients**: Edge pixels are those where the gray level values shift dramatically. Such pixels are calculated by measuring the image gradient. The gradient is a unit vector that points towards the increase in maximum intensity. The vertical and horizontal gradient components are first measured and the magnitude and direction are determined.
3) **Non-Maximum Suppression:** The edges are mostly blurred with no maximum deletion. In this point, the thick edges are transformed to about thin and straight edges based on the gradient magnitude, which can also be used for identification. During this process, the image is scanned in the edge direction and eliminates any non-edge pixel value resulting in thin line in the image output.
surrounding pixels.
4) **Hysteresis edge tracking:** The end output picture excludes edges that do not bind to a very definite (strong) edge. Strong borders are known in the final image as "Few Corners." The output image includes edges that are not solid but are consistent with hard edges.

3.5.3.2 Segmentation of connected digits

In the case of the connected components, no separating method is used to segment the connecting numerals. Instead, all two-digit connected numbers from '00' to '99' are trained so that the machine handles the connected numbers as a whole without further segmentation. Touching digits database is acquired from Touching digits (2010).

3.5.4 Feature Extraction

Giving the entire picture of the digit in the classifier is not a good idea. The merely use of pixel information can not generate a classifier that is accurate enough when checked with other images. Prior to the extraction function, the segments are resized to 28x28 to ensure that the computation time is short sufficient.Feature extraction is an important phase of any recognition system and in particular numerical recognition. There are basically two types of feature extraction method used.

1. Statistical feature extraction
   Principal Component Analysis (PCA) is a kind of statistical method that turns various feature indicators to a small number of indicators that describe the data sets from the perspective of the effectiveness of the features.

2. Structural feature extraction:
   for Structural feature extraction ,The length of a digit is used for recognition. After fitting the bounding box on each numeral, height and width are computed.

3.5.5 Classification and recognition:

3.5.5.1 Convolutional Neural Network (CNN)

is a multi-layered neural feed forward network with a highly supervised learning model that can be viewed as a mixture of two aspects: automated extraction functionality and a professional classifying framework. The description and weight of the function extractor back-propagation algorithm is applied. In addition, CNN can also collect image topology attributes. It summarizes features in the first layer from the primary image and classifies the last layer of the sequence. The best way to learn dynamic high-dimensional data is to recognize patterns and vary in how the convolution and sub-sampling layers are queried. In its composition, the distinction is. The first 64 featuer map layer is usually an

alternation in the convolution and sub-sampled filters and down samples of the layer or convolution ones. In the convolution layer, basic visual features are excluded from the local receptive domain. It is arranged into a network, also known as the function mapping, considered a basic unit of neurons. In the input image, which is the local receiving field, each group has 28x28 inputs connected to the 3x3 area. In addition a 2 ratio is established for the down sample procedure via convolution filtering. For various problems, including object recognition and handwriting character recognition, Where we summarize the layers of the bypass neural network with a complex of points as follows:

1. Convolutional layer with 64 feature maps with filter size 3x3
2. Pooling layer taking the max over 2 x 2 patches.
3. Convolutional layer with 128 feature maps with filter size 3x3.
4. Pooling layer taking the max over 2x 2 patches.
5. Flatten layer.
6. Fully connected layer with 1024 neurons and rectifier activation.
7. Dropout layer with a probability of 40%.
8. Output layer 10 neurons.

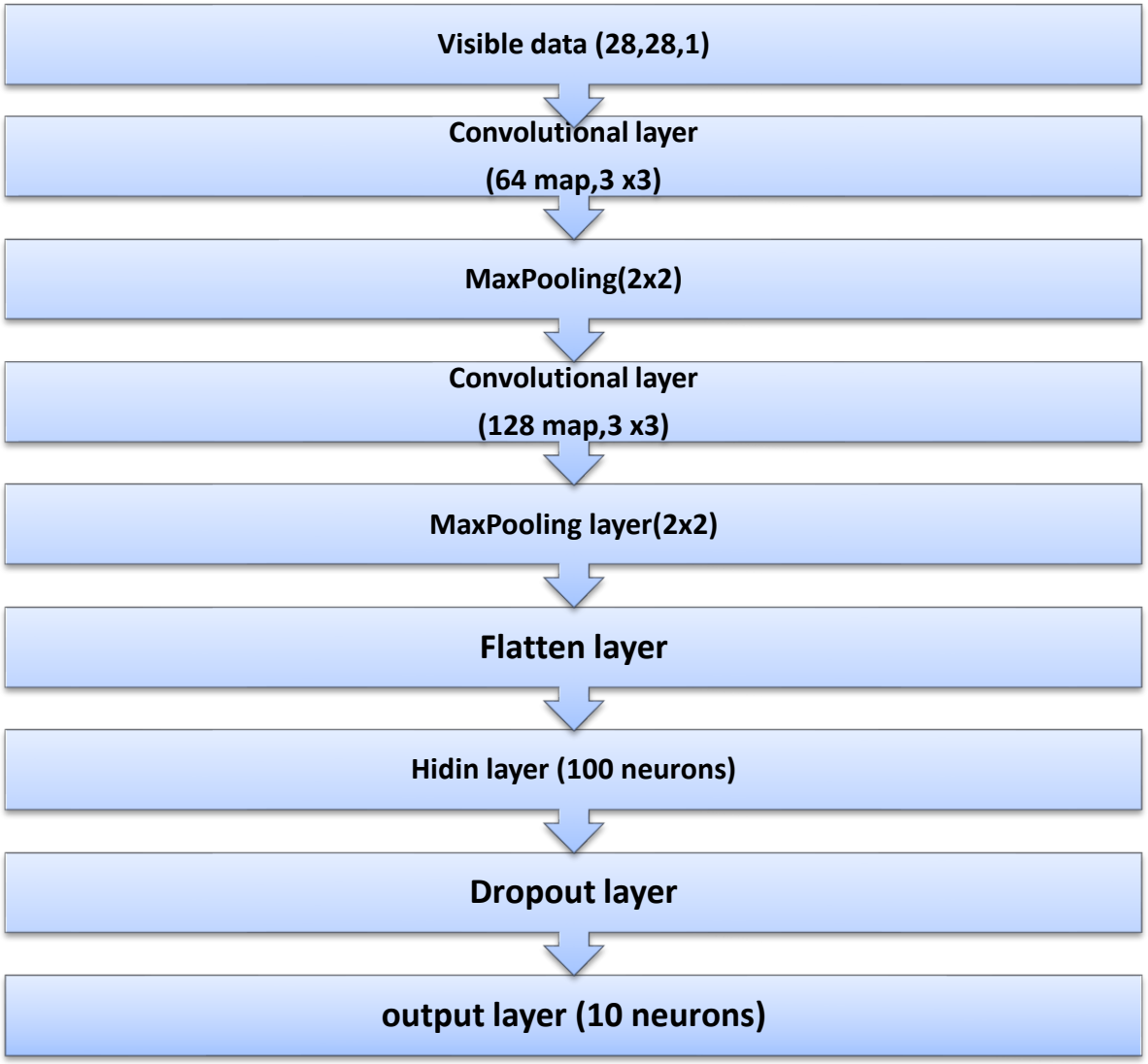


Figure 3.2 : Convolutional Neural Network Architecture

CNN assemblies three primary hierarchical fields such as local receptive area, weight sharing and spatial sub-sampling. Trainable weights are assigned to each connection for the standard neural network, but all elements of a feature map share the equal weight. The fact that the key feature detectors on a part of the image may be useful throughout the picture shows this trait. Since the exact position of the abstracted features is insignificant, the spatial resolution of the feature map is reduced by the sub-sampling layer. Such a layer includes as many characteristic maps as the previous convolutional layer, while with half

the amount of rows and columns. Specifically, each unit j is related to a 2x2 sensitive area. The bypass neuron works as shown in the following figure 3.3

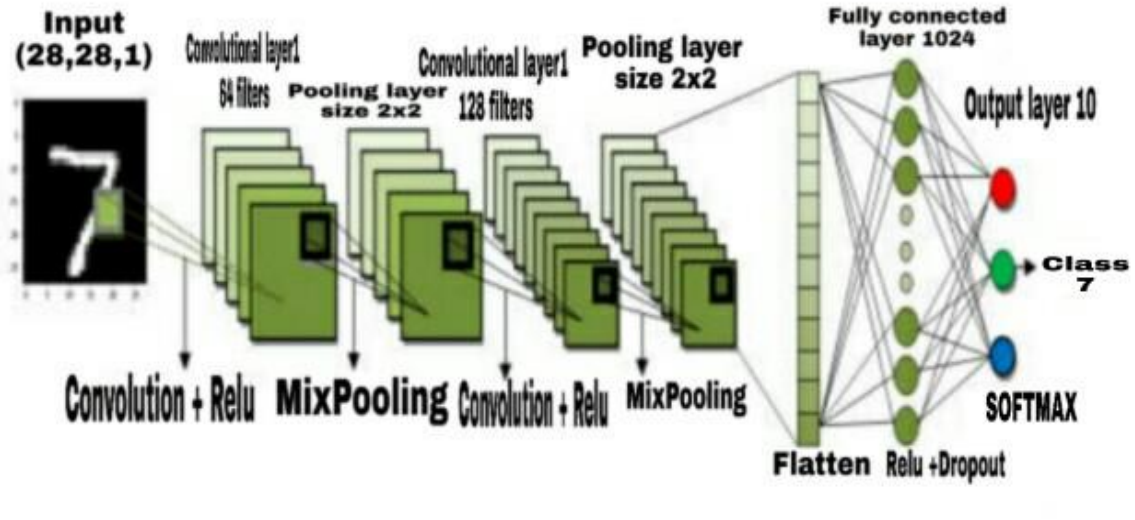


figure 3.3 CNN architecture

The original 28x 28 pixel image is adopted as input by layer. The layer consists of 2 convolution layers, convolutional layer1 and convolutional layer2, pooling leayer1 and pooling leayer2, N1 and out layer N2. The convolution and sub-sampling layers can be seen in Fig.3.3. The first convolution layer C1 consists in total of 64 maps of 28 to 28 rows. This S1 decreases the resolution by 2, while C2 increases the number of feature maps to 16 in next row. In this case, not every S2 feature map is connected to every C2 feature map. - unit of C2, at the same place in S1 subset, is associated with several receiving fields. flatten layer used to combination all feature maps to one vector, number of its elements equal to number of input neurons of next layer, it is dropout layer we used to reduce number of neurons.

3.5.5.2 Support Vector Machine

support vector machine (SVM) algorithm is a powerful classifier that is easily implemented for many pattern recognition or classification problems and has obtained positive results , It is also known as the most sophisticated method to solve linear and nonlinear classification problems due to its simplicity, durability, statistical potential and global optimality. SVM is

mainly implementing new techniques focused on mapping sample points to high-dimensional feature-spaces to determine the best division hyperplane or decision-making surface although the first SVM is a simple binary classification which is ideal for two classifying tasks. But for non-sparse complex data this does not offer sufficient isolation.

In order to classify, the SVM tries to find the best hyperplane, separating to the greatest extent points in two classes which properly classify the data. The SVM algorithm simply looks for the splitting hyperplane with the highest margin for linear separating functions. In addition, SVM has the kernel trick, which can achieve better accuracy, to resolve the problem of nonlinear results. a SVM with the Radial Basis Function (RBF) kernel is used. RBF kernel is defined as follows.

$$K(xi , xj) = \exp{-\gamma||xi-xj||}\ 2 \qquad (3.1)$$

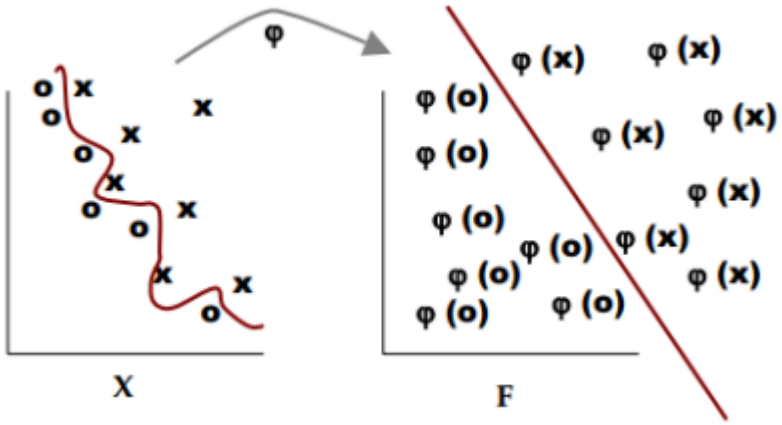


Figure 3.4: Transforming x to φ(x) to become linearly separable

When training with the RBF kernel, two parameters must be specified: cost C and γ .Low C makes the decision-surface smooth (more generalized). While a high C is intended to identify all training examples correctly (more specifically). γ determines how much impact a particular example of training has. The greater the meaning of γ , the more the other examples are to be affected. (2010 Vector Machine Support).

While SVM is a binary classifier on its own, there are established approaches to dealing with multi-class cases using one- against -one or one-against-all approaches. In this project,

the role of SVM in the Scikit-learn Library, SVC, implements the "one-against-one", for multi-class classification.For one-against-one method, if k is a class total, k(k-1)/2 is a binary classifier. They are trained and each classifier separates a pair of classes. The Decision Method shall be followed Based on a plurality vote. Take the training of the digit '1' as an example, the images '1' is loaded into the SVM as positive samples, yet another-digit images at a time They're fed as negative samples, let's say, '9.' In the second iteration, the pictures of '1' are trained against another digit, let's say '8.' This process continues until all k(k-1)/2 binary classifiers have been trained. The drawback is that a rather large number of binary classifiers must be educated.

3.5.5.3 Principal Component Analysis

PCA it used befor SVM to reduces the dimension of a data set, with the greatest possible conservation of information. The data set definition is compact and optimal. In a multidimensional space, data points are vectors. PCA is characterized mathematically as an orthogonal linear transformation converting the data into a new coordinate system, which means that the largest variance is located in the first coordinate, considered the first main variable, with any approximation of the data, which is the second greatest variance in the second coordinate.

The steps of PCA

1) Scale the data by subtracting the mean and dividing by std. deviation.
2) Compute the covariance matrix.
3) Compute eigenvectors and the corresponding eigenvalues.
4) Sort the eigenvectors by decreasing eigenvalues and choose k eigenvectors with the largest eigenvalues, these becoming the principal components.
5) Derive the new axes by re-orientation of data points according to the principal components.

3.5.5.4 **Artificial Neural Network** (ANN)

An artificial neural network (ANN) is the piece of a computing system designed to simulate the way the human brain analyzes and processes information. It is the foundation of artificial intelligence(AI) and solves problems that would prove impossible or difficult by human orstatistical standards. ANNs have self-learning capabilities that enable them to produce better results as more data becomes available.

Artificial neural networks are built like the human brain, with neuron nodes interconnected like a web. The human brain has hundreds of billions of cells called neurons. Each neuron is made up of a cell body that is responsible for processing information by carrying information towards (inputs) and away (outputs) from the brain.

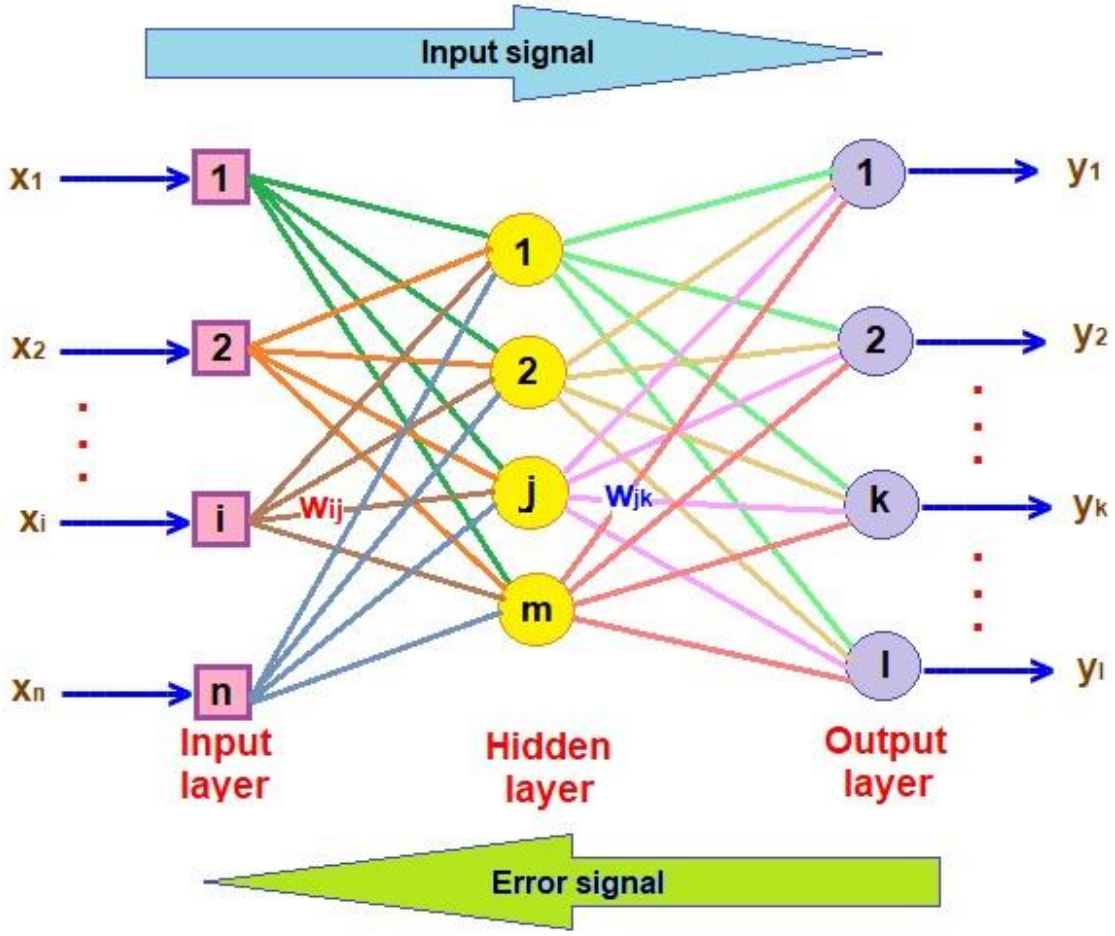


Figure 3.5: A typical feed-forward neural network architecture used in backpropagation.

- **Input Layers**

The input layer is the first layer of an ANN that receives the input information in the form of various texts, numbers, audio files, image pixels, etc.

- **Hidden Layers**

In the middle of the ANN model are the hidden layers. There can be a single hidden layer, as in the case of a perceptron or multiple hidden layers. These hidden layers perform various types of mathematical computation on the input data and recognize the patterns that are part of.

- **Output Layer**

In the output layer, we obtain the result that we obtain through rigorous computations performed by the middle layer.

CHAPTER 4: IMPLEMENTATION AND RESULTS

4.1 Introduction

This chapter will describe the classification experiments in more detail and present the results from three classification algorithms, namely CNN, ANN, and SVM. It is necessary to revisit the data set used in these experiments to benchmark our comparisons. Besides, implementation details such as the argument set-up will be described.

The final section of this chapter will compare the results of the three combinations and determine which combination can achieve an accuracy of more than 99%. Also in this section will present a detailed analysis in each section based on three classification algorithms, namely CNN, ANN, and SVM. Further, in order to evaluate the model, the confusion matrix, error rate, classification reports and some errors which are the difference between predicted labels and correct labels will be illustrated. the experiment implementation were accomplished using the programming language Python..

4.2 Dataset for Digits recognition

The MNIST database contains a total of 70,000 split photos, 60,000 for training and 10,000 for testing. Black and white photos are effectively stored in gray scale. The size of each image is length * width (28 x 28) pixels with pixel value 0-255 we convert it to range 0-1 and reshape images to 28 x 28 .

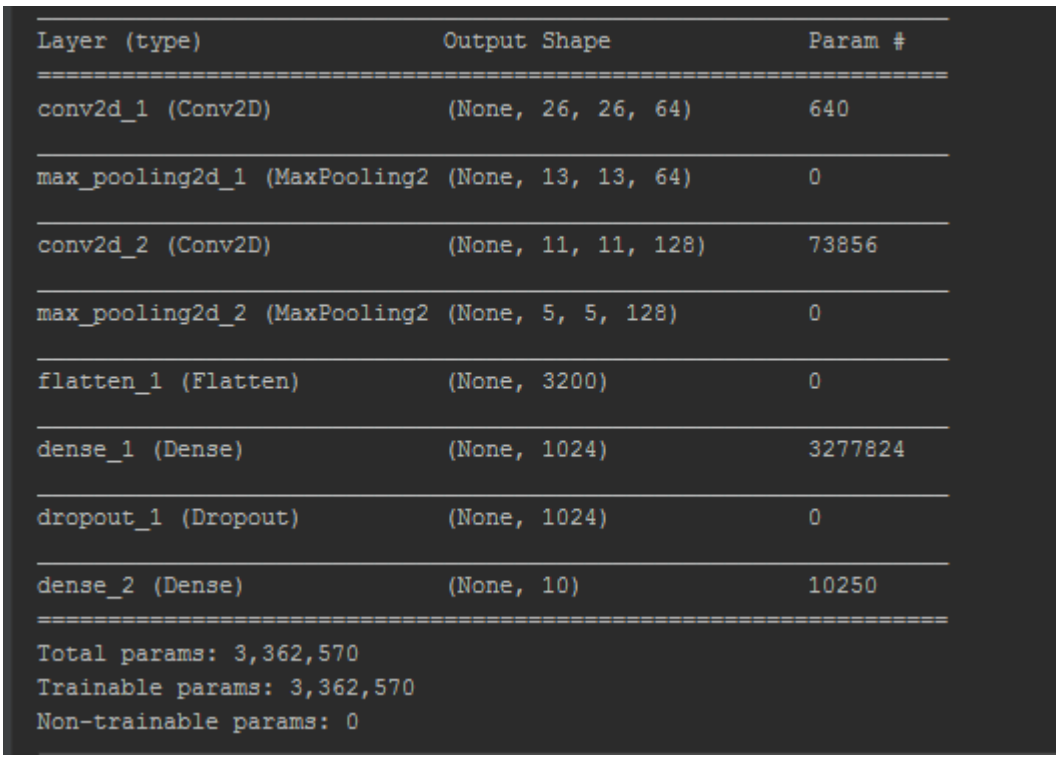
For the Arabic digits (MAD DBase) Arabic handwriting recognition dataset is used . It was brought together from various institutions to ensure the incorporation of multiple writing styles: engineering, medical colleges, law schools, open universities (whose graduates cover a variety of ages), secondary schools and government institutions. written By 700 writers. Where each writer wrote every ten times every number (0-9). To form more than one image in several ways it contains 60,000 training and 10,000 test pictures.

For connected digit TPdataset is used.This second version (V2.0), used in [Touching Digits – Laboratório Visão Robótica e Imagem], of the database holds 79,466 sections distributed into the 100 classes of touching pairs, which correspond to the possible combinations of two digits. Some of the classes involving the digit 1 still contain fewer samples than other classes. Owing to the American style of handwriting, the digit 1 is very often with the other digit in the pair.

4.3 The experiment with CNN

CNN is a multi-layer neural feed-forward network with a strongly supervised learning architecture that can be used as a two-part combination: an automated attribute extractor and a training classifier. In this chapter, pre-processing and CNN was used to achieve an optimal result.

First of all, the Keras Sequential () API was adopted to create the CNN model and its architecture includes: In -> Conv2D-> relu -> MaxPool2D -> Conv2D-> relu -> MaxPool2D -> Flatten ->Dense -> Dropout-> Dense -> Out as well as it is shown in Figure 4.2



Layer (type)	Output Shape	Param #
conv2d_1 (Conv2D)	(None, 26, 26, 64)	640
max_pooling2d_1 (MaxPooling2	(None, 13, 13, 64)	0
conv2d_2 (Conv2D)	(None, 11, 11, 128)	73856
max_pooling2d_2 (MaxPooling2	(None, 5, 5, 128)	0
flatten_1 (Flatten)	(None, 3200)	0
dense_1 (Dense)	(None, 1024)	3277824
dropout_1 (Dropout)	(None, 1024)	0
dense_2 (Dense)	(None, 10)	10250

Total params: 3,362,570
Trainable params: 3,362,570
Non-trainable params: 0

Figure 4.1 Architcure of CNN model

The first layer is the Conv2D layer, which is like a sequence of learning filters .A filter may be thought of as a representation of an image, and the kernel filter matrix is used for the whole image. Therefore, each filter transforms a portion of the image that determines the size of the kernel by adding the kernel filter.

The second core layer in CNN is the MaxPool2D layer, which is basically used as a down sampling filter. The aim of displaying and choosing the maximum value of two adjacent pixels is to minimize computing costs

Dropout is a regularization process in which the weight of each training sample is set to zero. It will spontaneously drop a portion of the nodes and cause the network to look at the features in a distributed manner.

After the model has been developed, the learning rate (LR) can be used to get the optimist closer to the minimum value of the loss function. Apparently, the greater the LR, the faster the convergence.

Overall, the choice of parameters has an effect on the efficiency of the CNN model. After several changes, the most efficient settings are Conv2D (15), Conv2D (13), Dropout (0.2), Dense (128), Dense (50) and Dense (10).

Finally, both the initial dataset and the preprocessed datasets were added to the previously generated CNN model with 15 epoch, and the result obtained is 99.88% in training and 99.15% in testing , as shown in figure 4.2

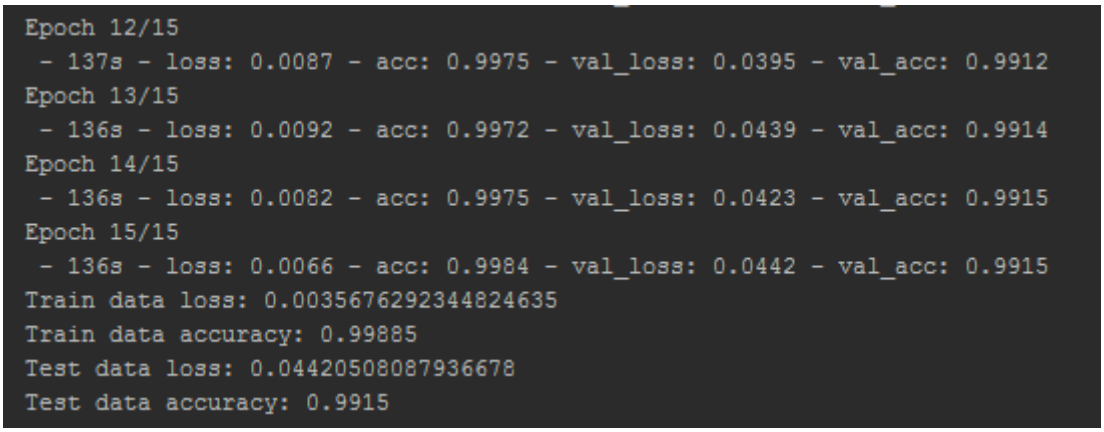


Figure 4.2: training and testing CNN model on mnist dataset

Using the pycharm editor to design and implemenet the user interface and linke to the python interpreter . The following is the main interface of the system as shown that contains several buttons and drop-down menus

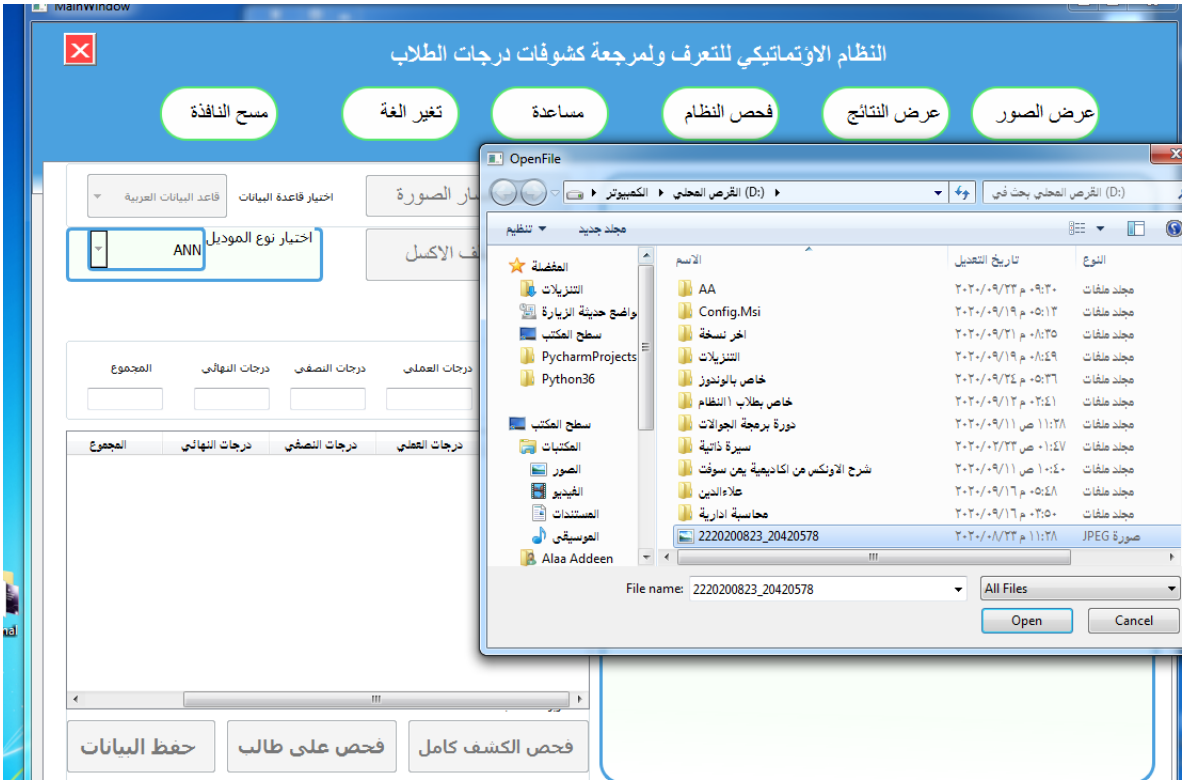


Figure 4.3 : fetch students grades image into the main interface

As shown above in Figure 4.3 , the main interface of the system, at the beginning, the user click on choose image pathy button to fetch the students grades image. After the user selects students grades image , the system displays it in the main interface as shown in Figure 4.4.

Figure 4.4 A main interface with students grades image

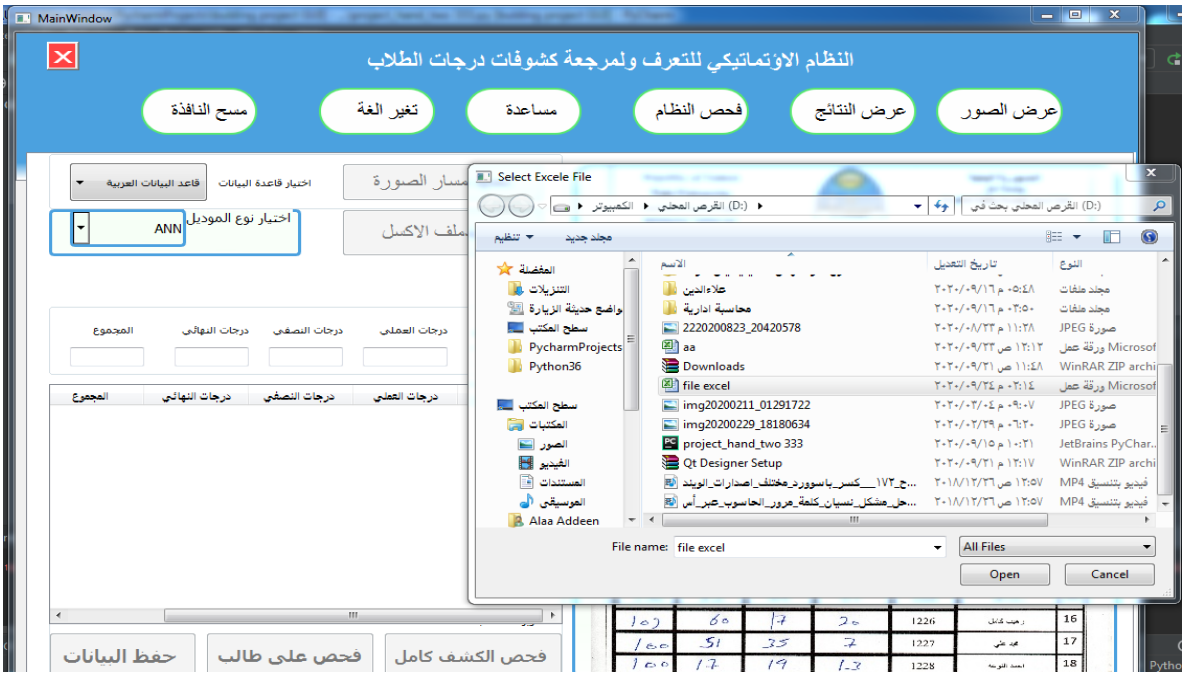


Figure 4.5 selects the excel file for saving students grades

after that the user choose type of model for example cnn model and type of dataset,alaso User selects the excel file for saving students 'grades after the process of reviewing students' grades as shown in Figure 4.5,and click on start testing the system .finally the user click on Check up on a student ,the system start to manipulate the student records. this mean that the system takes only one record from students records if the user click on check up on a student button , As shown in the figure4.6, the system reviewed the first three rows and entered them into the excel file.

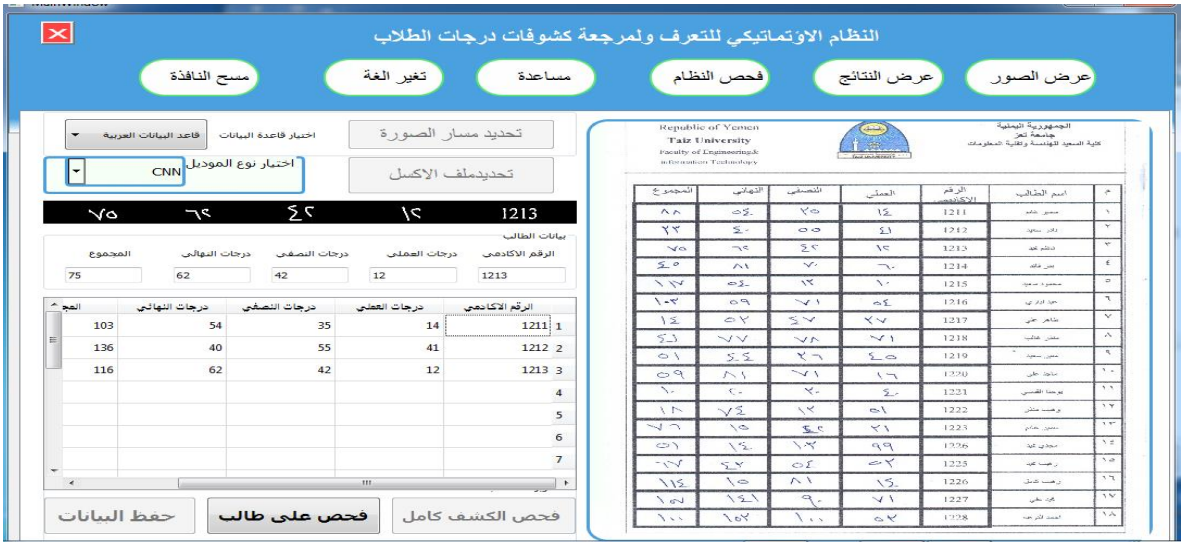


Figure 4.6 reviewed the first three records

4.4 The experiment with PCA and SVM

The Support Vector Machine (SVM) method is an efficient discriminant classifier that has been successfully applied to many pattern recognition or classification problems and has produced favorable performance.

in this experiment the PCA and SVM based supervision scheme can determine patterns in the recognition system. for this experiment the PCA is used for feature extraction and SVM for classification. Additionally, the optimal number of PCs to use, the preprocessed data was dimension reduced by applying the PCA (n_components=200), and pca.fit_transform () functions as well.

The following stage is to build an SVM classification model by the Linear(SVC) function, where SVM comes with numerous built-in parameters. To optimize the efficiency of this

model, the settings for these variables include C=1.0, gamma='auto', kernel='rbf' and so on. The results obtained from this experiment is 98%, as shown in figure 4.7

classification_report :			precision	recall	f1-score	support
0	0.98	0.98	0.98	1000		
1	0.98	0.99	0.99	1000		
2	0.97	0.98	0.97	1000		
3	0.99	0.99	0.99	1000		
4	0.99	0.98	0.99	1000		
5	0.97	0.97	0.97	1000		
6	0.99	0.99	0.99	1000		
7	0.99	0.99	0.99	1000		
8	0.99	0.99	0.99	1000		
9	0.98	0.98	0.98	1000		
accuracy			0.98	10000		
macro avg	0.98	0.98	0.98	10000		
weighted avg	0.98	0.98	0.98	10000		

Figure 4.7: The classification reports for SVM

With the same steps mentioned in the CNN section, for example in this section, there is no need to repeat the steps for fetching the image and choosing an excel file, With the same steps mentioned in the CNN section. When the user selects the SVM model to make recognition , As shown in the figure4.8, the system reviewed the first tow rows and entered them into the excel file.

Figure 4.8: reviewed the first three records

4.5 The experiment with ANN

ANN was employed as a classifier to construct a classification model. Two (2) parameters were provided to ANN. The first indicates the number of classes in the dataset (which is 10 classes in our dataset, one for each type of digit) for isolated digit and (100 classes for connected digit) ,and The second parameter informs the classier about the number of features that have been used. ANN is designed to train the database and evaluate the test performance of the network. It is implemented by using python language**.** First of all, the Keras Sequential () API was adopted to create the ANN model and its architecture As shown in the figure4.9. three hidden layers with 128 neurons was taken, which found to give the best performance for the proposed system. The neurons of output layer are10 as the proposed system have 10 class (0- 9).

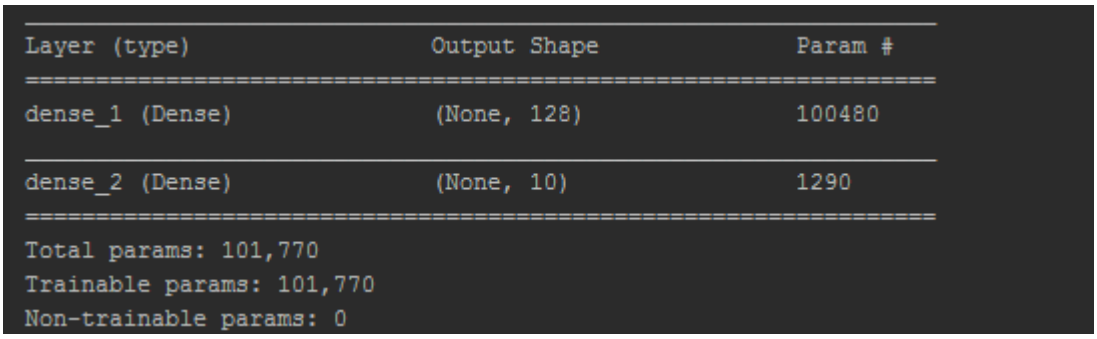


figure4.9: ANN architecture

This proposed method used the image pixels for its features extraction process. ANN carried out the classification, and the overall classification accuracy above 99%.

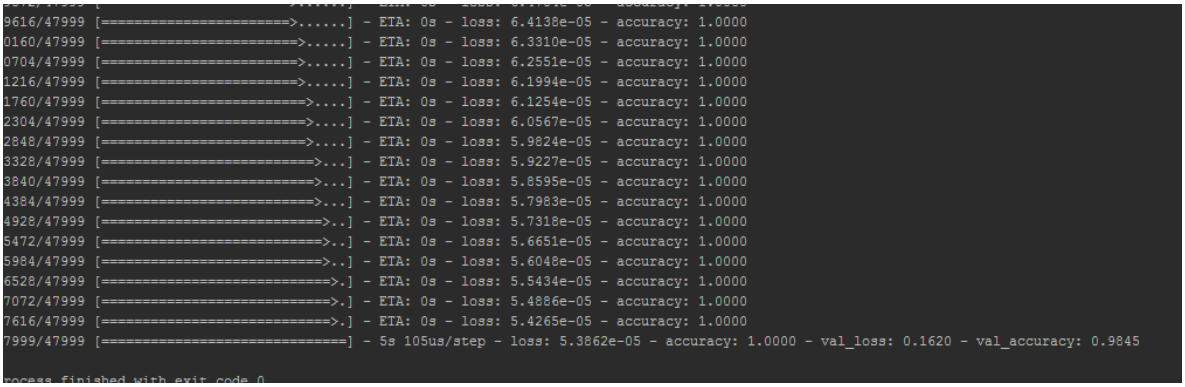


figure4.10: training and testing ANN model on mnist dataset

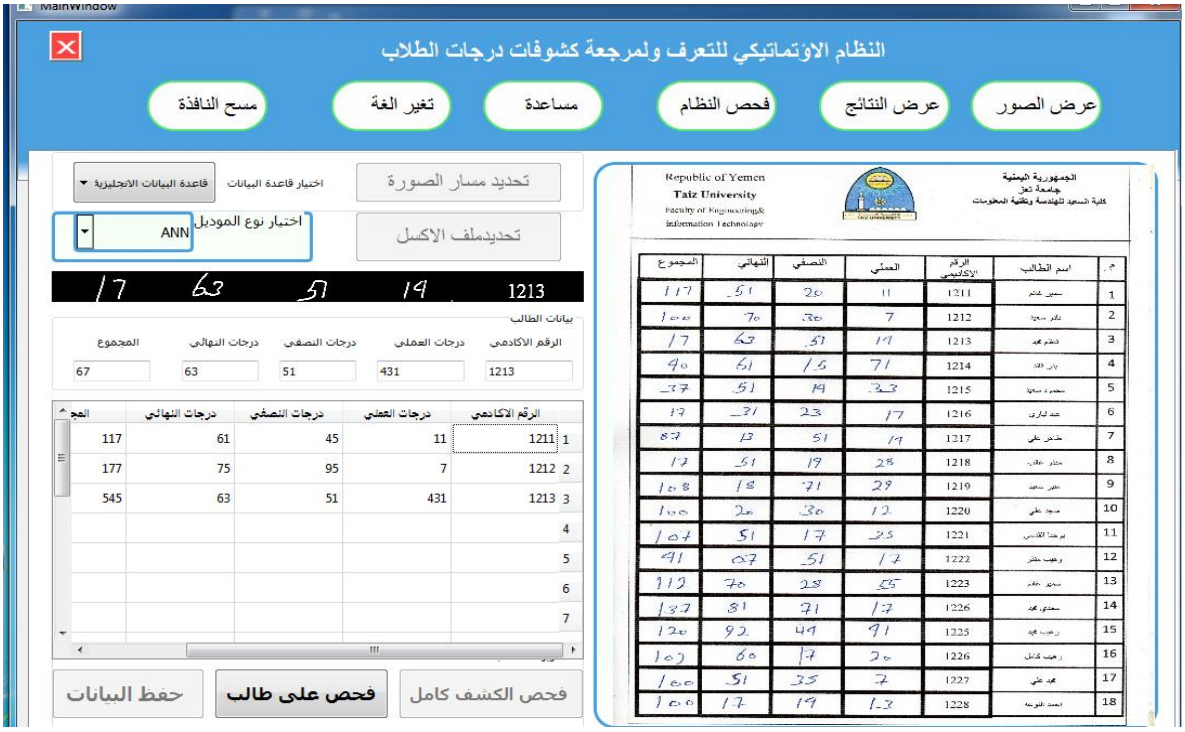


figure4.10: reviewed the first three records with ANN model

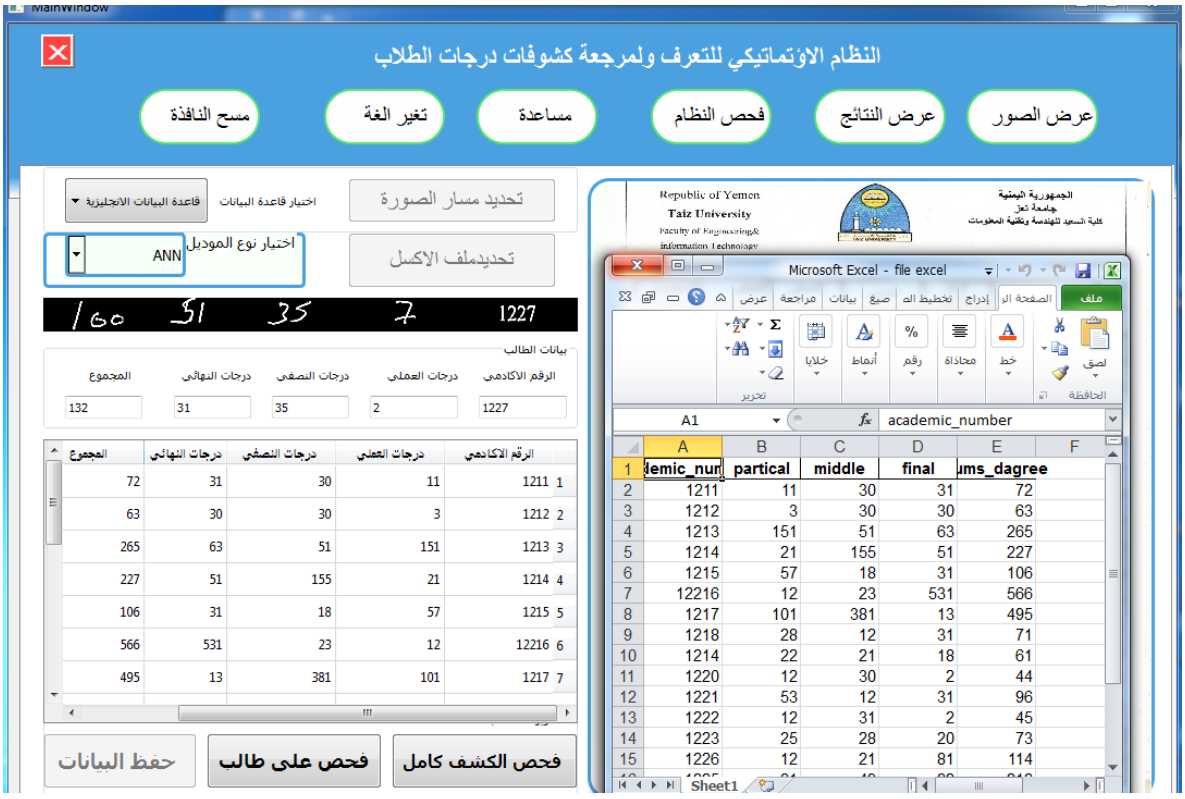


figure4.11: review the students grades

4.6 results

This section provides a detailed analysis of each section based on three classification algorithms, namely CNN, ANN and SVM.

Firstly, the performance of the three classification models such as CNN, ANN and SVM was evaluated on the original MNIST and MADBase data Table 4.1 indicates a comparison of the three classifiers regarding error rates (ER) and accuracy. It can be seen from this table that the ER of CNN in this experiment is the lowest at 0.21% compared with the other three classifiers, and the ER of SVM is up to 1.4%

Table 4.1 : The comparison of three classifiers in terms of ER and Accuracy

Model	CNN	ANN	SVM
ER	.21%	1.7%	0.0168%
Accuracy	99.88%	99%	98.32%

Confusion matrices concentrate on the predictive potential of the model instead of the speed of the model. Executes the classification. One of the benefits of this performance assessment approach Is that the data mining analyzer will easily find whether the model is confusing several or two classes.

As seen in Fig4.12, the CNN performs with just a few numbers substantially well missions and the data set scale contains 10000 images. However, it appears the CNN has some small problems with the '7' images. The '1' or '3' was misclassified. It is difficult to capture the handwriting habits variable in the curve from '1' to '3' and '7' .The classification report is often used to monitor the quality of the predictions of classification models. picture. 4.16 show how precise, recall score are the main classification metrics on the basis of every class. The following are described as:

1. True Negative(TN): both case and predicted were negative
2. True Positive(TP): both case and predicted were positive
3. False Negative(FN): the case was positive but predicted negative
4. False Positive(FP): the case was negative but predicted positive

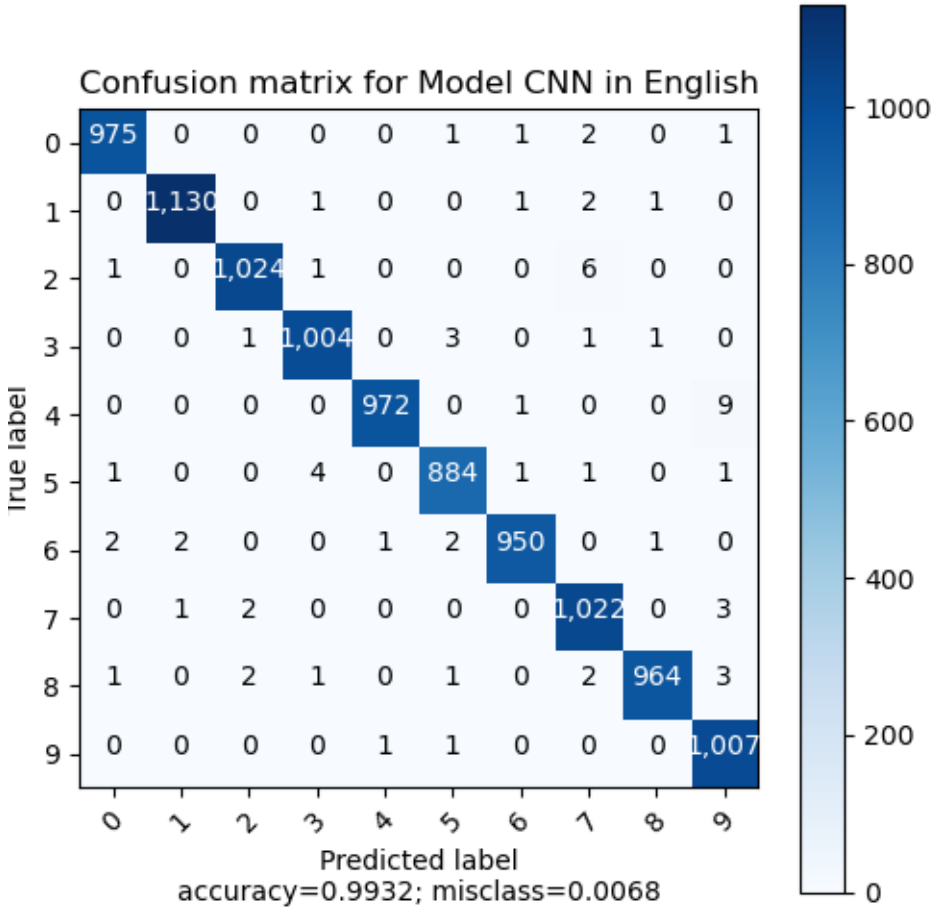


Figure 4.12 The confusion matrices for CNN

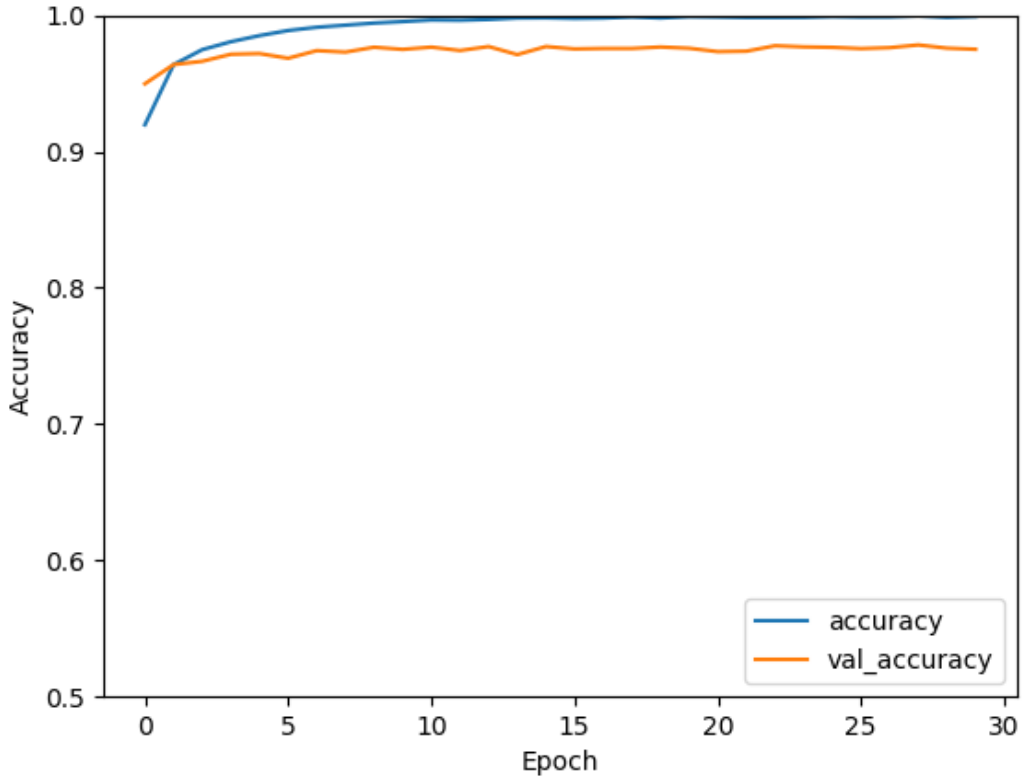


Figure 4.13: The result accuracy for ANN model

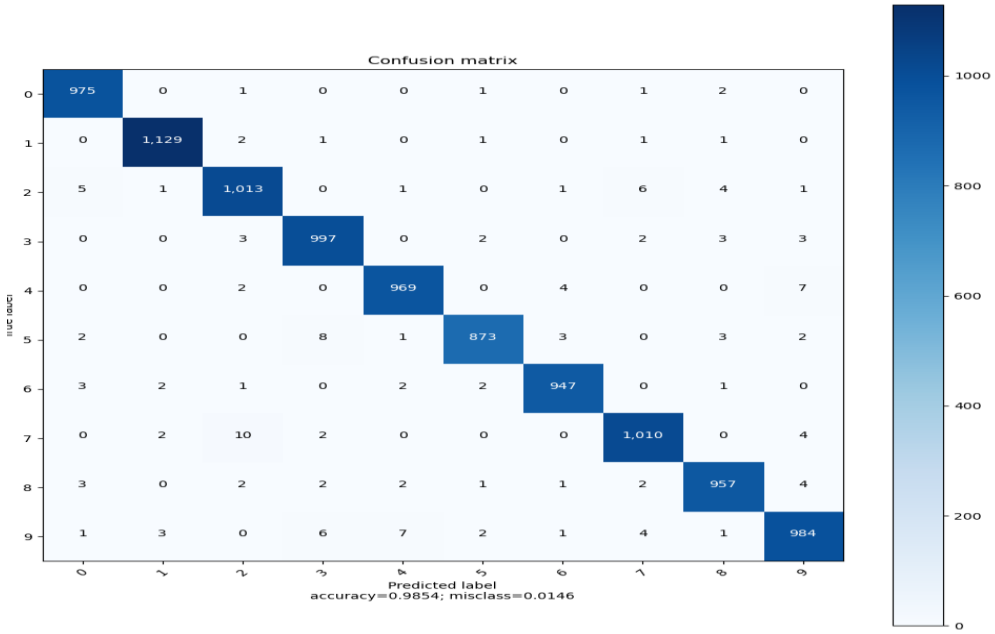


Figure 4.14: The confusion matrix for ANN

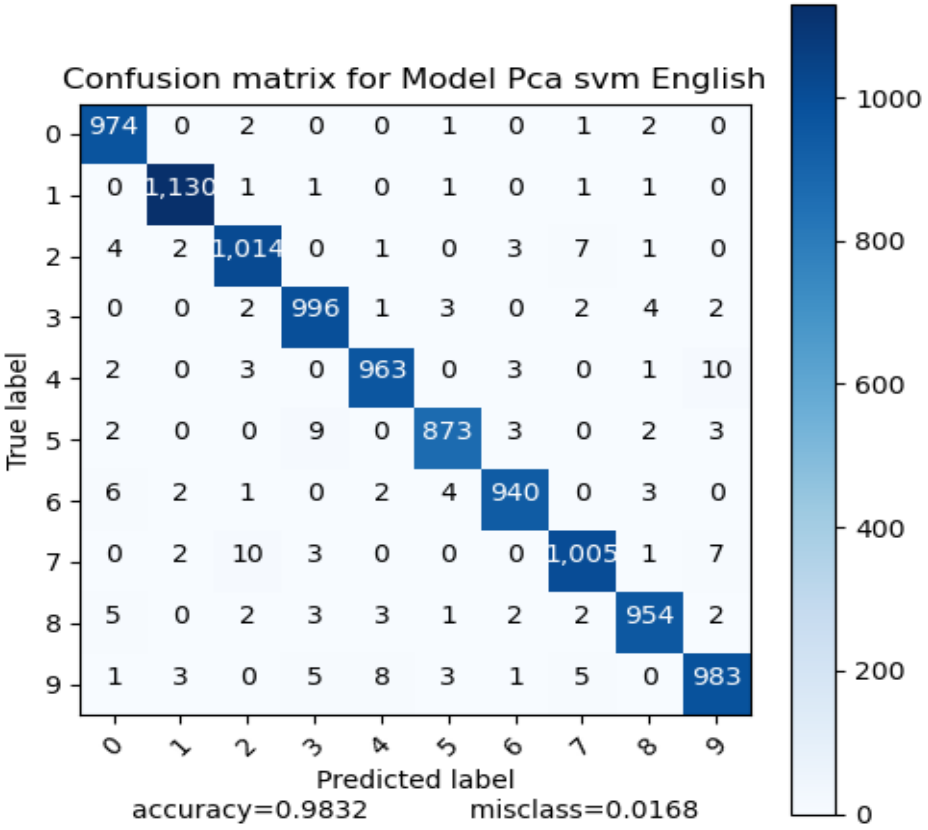


Figure 4.15: The confusion matrix for SVM

The final ANN and SVM classification reports are described in Fig.4.16, Fig.4.17 Whichever classification criterion, the SVM classification efficiency is greater than the classifier of ANN. The precision of the '8' number in particular was 99% While only 98% was obtained for the SVM model, ANN classification report.

Classification Report for Model svm with Pca Arabic

	precision	recall	f1-score	support
0	0.97	0.98	0.98	1000
1	0.98	0.99	0.98	1000
2	0.97	0.97	0.97	1000
3	0.99	0.98	0.99	1000
4	0.98	0.98	0.98	1000
5	0.98	0.96	0.97	1000
6	0.99	0.99	0.99	1000
7	0.99	0.99	0.99	1000
8	0.99	0.99	0.99	1000
9	0.98	0.98	0.98	1000
accuracy			0.98	10000
macro avg	0.98	0.98	0.98	10000
weighted avg	0.98	0.98	0.98	10000

Figure 4.16: The classification reports for SVM

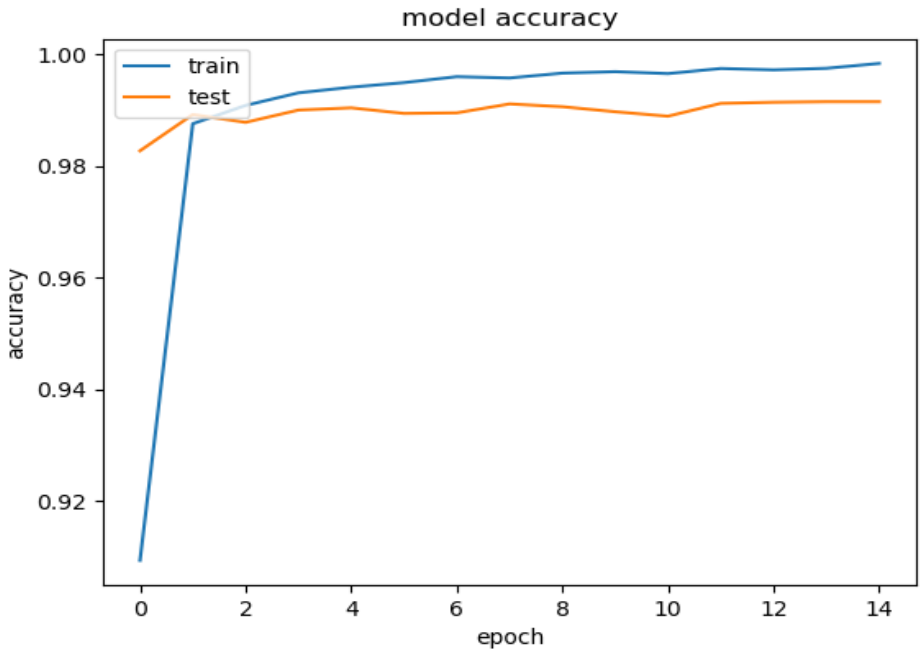


Figure 4.18 : The result for CNN model accuracy

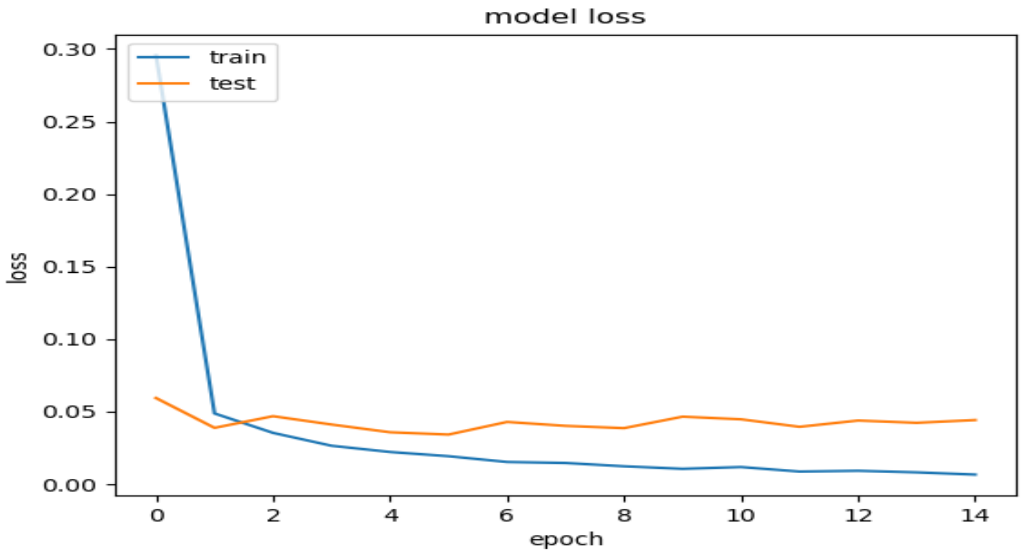


Figure 4.19 : The result for CNN model lose

4.7 Summary

This chapter has revisited the data sets adopted in this experiment, three combinations were selected for implementation, namely CNN, ANN, and SVM. Furthermore, the implementation details of the three combinations such as the adjustment of the parameters have been analyzed. In addition, some evaluation techniques such as Confusion matrices, error rates, classification reports and error cases were adopted and illustrated .

CHAPTER 5: CONCLUSION AND FUTURE IMPROVEMENTS

5.1 Conclusion

In this project, I used a combination of existing techniques that are simple to implement and versatile. For field extraction, Field extraction refers to the extraction of region of interest, which in this case, is the students grade field. Since the location of students grades field is about the same in all image. I used the morphological and binary operation techniques to detect border black pixels in the specified area.

For the case of segmentation two types of techniques were used ,first one is split disjoint numbers This step utilises OpenCV library to find the contour points of the region of black pixels, which are characters in this case. Using OpenCV function findContours, the points which are the edge of each character are stored in vector form .It effectively split disjoint numbers from the image, but could not split if two or more numbers are connected or touching each other.For the case of connected components, no splitting procedure is used to segment the touching numerals.I made the classifier learn to recognise connected numerals as a whole to avoid segmentation errors. By this technique the computation time is also greatly reduced.

In order to extract the feature, two types of techniques were used, namely Statistical feature and Structural feature, for Statistical feature ,I used PCA for feature extraction, for Structural feature The length of a digit is used for recognition. After fitting the bounding

box on each digit , height and width are computed. Then the extracted features is fed into the trained model for recognition. Some post-processing conditioning is applied to the product of the recognition and the final output is generated.

5.2 Future Improvement

Future work may concentrate on the implementation of the following techniques

5.2.1 Image Acquisition

The scanner that fetches the image to the system is only fetching an image each time. In other words, fetching one image at a time is not ideal. The future development of this project is the necessity to find an automatic scanner that has the ability to fetch more than one image in a short period of time.

5.2.2 Segmentation

A better segmentation technique that can cater for single and multiple digits is sliding window segmentation with Hidden Markov Model. By determining the best segmentation path through the search on all possible paths, it is believed that the processing process would become simpler and faster.

5.3 References

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