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Handwritten Digit Recognition using CNN

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Abstract:- Digit Recognition is a noteworthy and important issue. As the manually written digits are not of a similar size, thickness, position and direction, in this manner, various difficulties must be considered to determine the issue of handwritten digit recognition. The uniqueness and assortment in the composition styles of various individuals additionally influence the example and presence of the digits. It is the strategy for perceiving and arranging transcribed digits. It has a wide range of applications, for example, programmed bank checks, postal locations and tax documents and so on.

The aim of this project is to implement a classificatio n algorithm to recognize the handwritten digits. The after effects of probably the most broadly utilized Machine Learning Algorithms like SVM, KNN and RFC and with Deep Learning calculation like multilayer CNN utilizing Keras with Theano and Tensorflow. Utilizing these, the accuracy of 98.70% utilizing CNN (Keras + Theano) when contrasted with 97.91% utilizing SVM, 96.67% utilizing KNN, 96.89% utilizing RFC was obtained.

Keywords:- *KNN, SVM, RFC, CNN.*

I. INTRODUCTION

Recognition is identifying or distinguishing a thing or an individual from the past experiences or learning. Similarly, Digit Recognition is nothing but recognizing or identifying the digits in any document. Digit recognition framework is simply the working of a machine to prepare itself or interpret the digits. Handwritten Digit Recognition is the capacity of a computer to interpret the manually written digits from various sources like messages, bank cheques, papers, pictures, and so forth and in various situations for web based handwriting recognition on PC tablets, identifying number plates of vehicles, handling bank cheques, digits entered in any forms etc.

Machine Learning provides various methods through which human efforts can be reduced in recognizing the manually written digits. Deep Learning is a machine learning method that trains computers to do what easily falls into place for people: learning through examples. With the utilization of deep learning methods, human attempts can be diminished in perceiving, learning, recognizing and in a lot more regions. Using deep learning, the computer learns to carry out classification works from pictures or contents from any document. Deep Learning models can accomplish state-of-art accuracy, beyond the human level performance. The digit recognition model uses large datasets in order to recognize digits from distinctive sources.

Handwriting recognition of characters has been around since the 1980s. The task of handwritten digit recognition, using a classifier, has extraordinary significance and use such as – online digit recognition on PC tablets, recognize zip codes on mail, processing bank check amounts, numeric sections in structures filled up by hand (for example - tax forms) and so on. There are diverse challenges faced while attempting to solve this problem. The handwritten digits are not always of the same size, thickness, or orientation and position relative to the margins. The main objective was to actualize a pattern characterization method to perceive the handwritten digits provided in the MINIST data set of images of handwritten digits (0-9).

II. LITERATURE SURVEY

Anuj Dutt in his paper demonstrated that utilizing Deep Learning systems, he had the capacity to get an extremely high measure of accuracy. By utilizing the convolutional Neural Network with Keras and Theano as backend, he was getting a accuracy of 98.72%. In addition, execution of CNN utilizing Tensorflow gives a stunningly better consequence of 99.70%. Despite the fact that the complication of the procedure and codes appears to be more when contrasted with typical Machine Learning algorithms yet the accuracy he got is increasingly obvious.

In a paper published by Saeed AL-Mansoori, Multilayer Perceptron (MLP) Neural Network was implemented to recognize and predict handwritten digits from 0 to 9.The proposed neural system was trained and tested on a dataset achieved from MNIST.

A. Existing System

These days, an ever-increasing number of individuals use pictures to transmit data. It is additionally main stream to separate critical data from pictures. Image Recognition is an imperative research area for its generally used applications. In general, the field of pattern recognition, one of the difficult undertakings is the precise computerized recognition of human handwriting. Without a doubt, this is a very difficult issue because there is an extensive diversity in handwriting from an individual to another individual. In spite of the fact that, this

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difference does not make any issues to people, yet, anyway it is increasingly hard to instruct computers to interpret general handwriting. For the image recognition issue, for example, handwritten classification, it is essential to make out how information is depicted onto images.

Handwritten Recognition from the MNIST dataset is well known among scientists as by utilizing different classifiers for various parameters, the error rate has been decreased, for example, from linear classifier (1-layer NN) with 12% to 0.23% by a board of 35 convolution neural systems. The scope of this is to implement a Handwritten Digit Recognition framework and think about the diverse classifiers and different techniques by concentrating on how to accomplish close to human performance. For an undertaking of composing diverse digits (0-9) for various people the general issue confronted would be of digit order issue and the closeness between the digits like 1 and 7, 5 and 6, 3 and 8, 9 and 8 and so forth.

Additionally, individuals compose a similar digit from various perspectives, the uniqueness and assortment in the handwriting of various people likewise impact the development and presence of the digits.

III. ARCHITECTURE

The reason behind this document is to look into the design possibilities of the proposed system, such as architecture design, block diagram, sequence diagram, data flow diagram and user interface design of the system in order to define the steps such as pre-processing, feature extraction, segmentation, classification and recognition of digits.

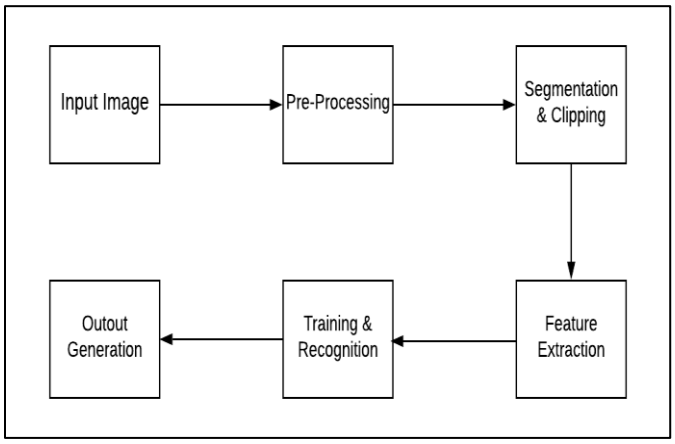

Fig 1:- Architecture of the Proposed System

The above Figure 1 illustrates the architecture diagram of the proposed system. The proposed model contains the four stages in order to classify and detect the digits:

A. Pre-processing
B. Segmentation
C. Feature Extraction
D. Classification and Recognition

A. Pre-Processing:

The role of the pre-processing step is it performs various tasks on the input image. It basically upgrades the image by making it reasonable for segmentation. The fundamental motivation behind pre-processing is to take off a fascinating example from the background. For the most part, noise filtering, smoothing and standardization are to be done in this stage. The pre-processing additionally characterizes a smaller portrayal of the example. Binarization changes over a gray scale image into a binary image.

The initial approach to the training set images that are to be processed in order to reduce the data, by thresholding them into a binary image. The Figure 2 shows a sample of images taken from the MNIST database.

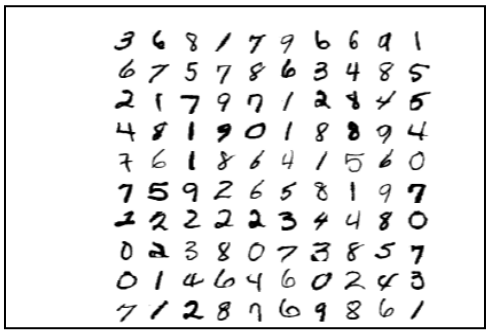

Fig 2:- Sample images taken from MNIST database

B. Segmentation:

Once the pre-processing of the input images is completed, sub-images of individual digits are formed from the sequence of images. Pre-processed digit images are segmented into a sub-image of individual digits, which are assigned a number to each digit. Each individual digit is resized into pixels. In this step an edge detection technique is being used for segmentation of dataset images.

C. Feature Extraction:

After the completion of pre-processing stage and segmentation stage, the pre-processed images are represented in the form of a matrix which contains pixels of the images that are of very large size. In this way it will be valuable to represent the digits in the images which contain the necessary information. This activity is called feature extraction. In the feature extraction stage redundancy from the data is removed.

D. Classification and Recognition:

In the classification and recognition step the extracted feature vectors are taken as an individual input to each of the following classifiers. In order to showcase the working system model extracted features are combined and defined using following three classifiers:

- K-Nearest Neighbor
- Random Forest Classifier
- Support Vector Machine

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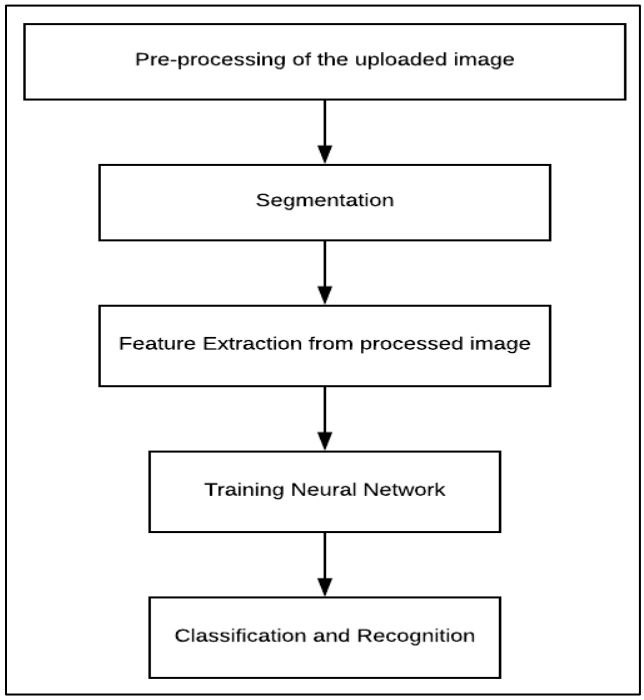

Fig 3:- Block Diagram of proposed model

1) K-Nearest Neighbor: KNN is an instance based learning algorithm. There are two main benefits of using KNN algorithm, that is, it is robust to noisy training data and it is very efficient if the data is very large in size. To perform admirably, this algorithm requires a set of training datasets which includes perfectly labeled data points. KNN is also a non-parametric classifier. The algorithm considers new data point as its input and performs classification by calculating distance between new and labeled data points using the Euclidean or Hamming distance formulas. The Euclidean distance is calculated using the following formula:

2) Random Forest Classifier: RFC is a supervised learning method. It infers that there is an immediate connection between the total number of trees and the result it gets: the bigger the number of trees, the more precise the outcome will be. This classifier can be used for regression as well as classification. For RFC algorithm if there are sufficient trees then the classifier will not over fit the model, instead it avoids the over fitting issues. This classifier can deal with the missing quantities. Once the training is done, predictions are taken from each individual tree and the average is calculated using the following formula:

3) Support Vector Machine: SVM is also a supervised learning method. It is also used for both classification and regression tasks. In this type of algorithm, there are data items which are considered as points in an n-dimensional space. This classifier finds the hyper plane by performing classifications between the two classes. One of the main advantages of this algorithm is that it provides a regularization parameter which avoids the over fitting problems. The block diagram shown below in the Figure 3 describes all these above steps.

IV. METHODOLOGY

Each research work needs some estimation, to measure the accuracy and performance of handwritten digits, MNIST dataset is being used for such reasons. MNIST is the most broadly utilized standard for handwritten digit recognition. MNIST is a huge and a standard database of handwritten digits. MNIST dataset has been commonly used as a standard for testing classification algorithms in handwritten digit recognition frameworks.

The initial step to be carried out is to place the dataset, which can be effectively done through the Keras programming interface. The images in the MNIST dataset are available in type of a cluster comprising of 28x28 values constituting to an image along with their labels. This is equivalent if there could be an occurrence of the testing images. The pixels are given as a variety of 784-d pixels and the range extends from 0 to 255 for example 0 implies Black and 255 implies White.

A. Pseudocode

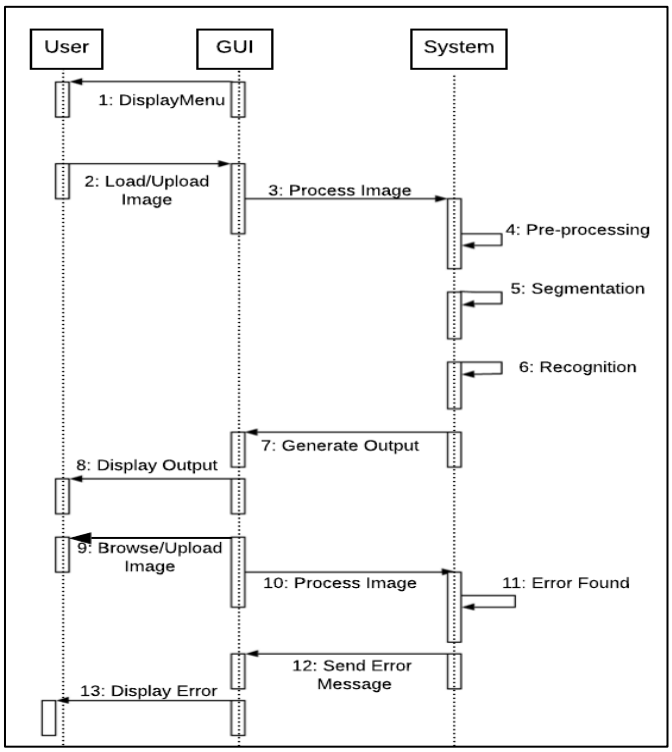

Fig 4:- Sequence Diagram of the System

The Figure 4 illustrates the sequence diagram of the system model. The figure describes the sequence of steps to be taken while performing execution. The CNN model works in the following sequence. User uploads a particular image of any digit which he wants to recognize. The image will be processed by the system. On running the system code the output is generated that shows which is the digit uploaded by the user and also displays the accuracy rate predicted by the model. On uploading image with different resolutions other

than the one mentioned in the code, the output generated shows error, and displays an error message to the user.

B. Algorithm Used

The following Figure 5 describes the Data flow diagram of the proposed system model. There are two ways to provide input to the system. The user can either upload the image of the digit he wants to detect or the data from the MNIST dataset. The input images are pre-processed. Using the different classifiers the recognized digits' accuracy is compared and the result is obtained. The results obtained are displayed along with the accuracy.

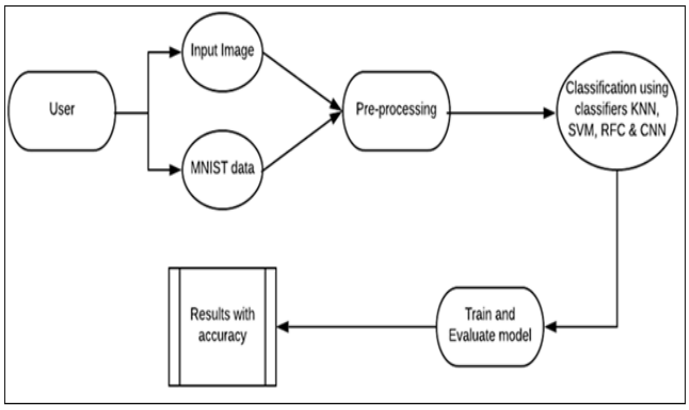

Fig 5:- Dataflow Diagram of the system model

V. IMPLEMENTATION

A. SOFTWARE PLATFORM

➢ *Tensorflow*

TensorFlow is an amazing information stream in machine learning library made by the Brain Team of Google and made open source in 2015.It is intended to ease the use and broadly relevant to both numeric and neural system issues just as different spaces. Fundamentally, TensorFlow is a low-level tool for doing entangled math and it targets specialists who recognize what they're doing to construct exploratory learning structures, to play around with them and to transform them into running programs. For the most, it can be considered as a programming framework in which one can entitle to calculations as graphs. Nodes in the graph speak the math activities, and the edges contain the multi-dimensional information clusters (tensors) related between them.

➢ *Python 3.7*

Python is broadly utilized universally and is a high-level programming language. It was primarily introduced for prominence on code, and its language structure enables software engineers to express ideas in fewer lines of code. Python is a programming language that gives you a chance to work rapidly and coordinate frameworks more effectively.

➢ *Anaconda3 5.3.1*

Anaconda is a free and open-source appropriation of the Python and R programming for logical figuring like information science, AI applications, large-scale information preparing, prescient investigation, and so forth. Anaconda accompanies in excess of 1,400 packages just as the Conda package and virtual environment director, called Anaconda Navigator, so it takes out the need to figure out how to introduce every library freely. Anaconda Navigator is a graphical UI (GUI) incorporated into Anaconda appropriation that enables clients to dispatch applications and oversee conda packages, conditions and channels without utilizing command-line directions.

B. HARDWARE PLATFORM

➢ *3.2.1 NVIDIA GeForce Graphic Card*

Nvidia Corporation more regularly specified to as Nvidia (adapted as NVIDIA), is an American innovation organization. It structures graphical processing units (GPUs) for the gaming and expert markets, just as a framework, system on a chip units (SoCs) for the versatile figuring and car showcase. It's essential GPU product is named as "GeForce". With outstanding GPU fabricating, Nvidia gives parallel processing capacities to analysts and researchers that enable them to effectively run superior applications.

C. RESULTS

The following Figure 6 shows the front-end design of the system output. There are four buttons for the four algorithms as shown in the figure.

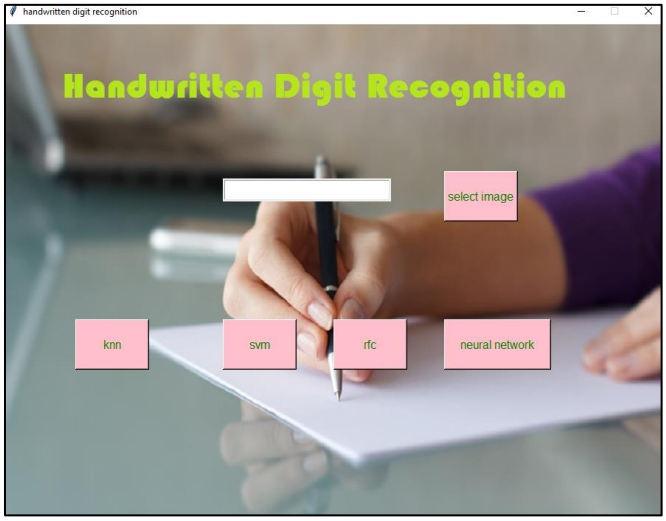

Fig 6:- Front-end design of the system output

The following figures show the sequence of steps to be carried out to obtain the required output. The Figure 7 shows the commands to run the code of classifiers.

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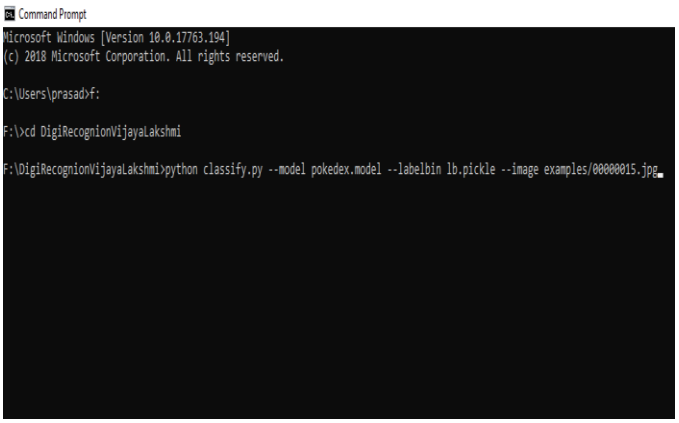

Fig 7:- Command to run the Classifying code

The Figure 8 shows the commands to run the code that trains the images.

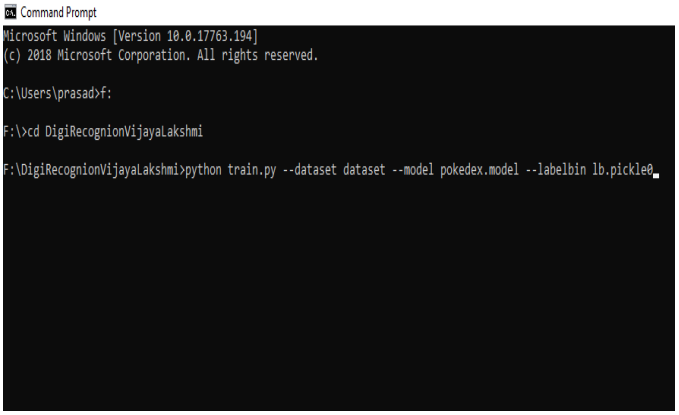

Fig 8:- Command to train the code

The Figure 9 shows the commands that are used to run the Tensorflow virtual environment.

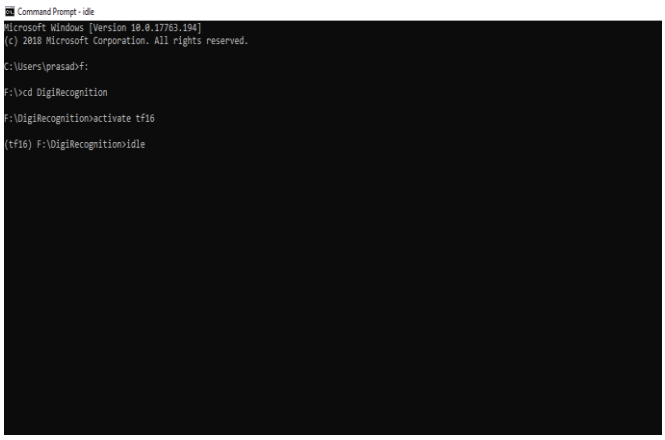

Fig 9:- Commands to create virtual environment to run the code

The Figure 10 shows the output generated by running the KNN algorithm.

```
training data points: 1212
validation data points: 135
testing data points: 450
EVALUATION ON TESTING DATA
              precision    recall  f1-score   support

           0       1.00      1.00      1.00        43
           1       0.95      1.00      0.97        37
           2       1.00      1.00      1.00        38
           3       0.98      0.98      0.98        46
           4       0.98      0.98      0.98        55
           5       0.98      1.00      0.99        59
           6       1.00      1.00      1.00        45
           7       1.00      0.98      0.99        41
           8       0.97      0.95      0.96        38
           9       0.96      0.94      0.95        48

   micro avg       0.98      0.98      0.98       450
   macro avg       0.98      0.98      0.98       450
weighted avg       0.98      0.98      0.98       450

Digit is: 4
```

Fig 10:- Output generated by KNN

The following Figure 11 describes the digit recognized by SVM algorithm. The confusion matrix is demonstrated using a matrix where each row shows the examples in a predicted class, while each column shows them in an actual class.

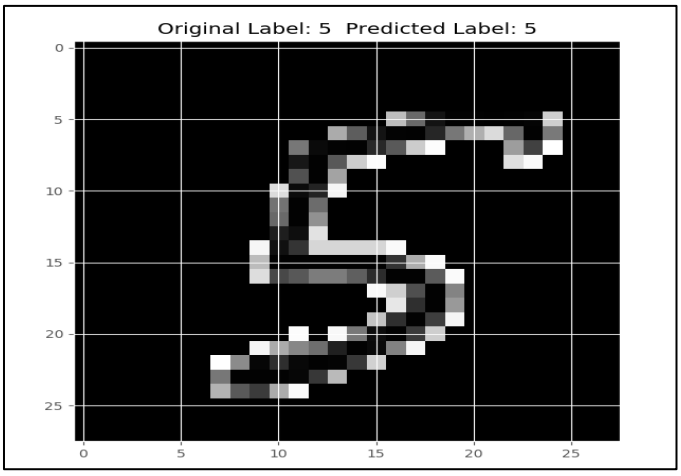

Fig 11:- Digit Recognized by SVM algorithm

The Figure 12 shows the output generated by training CNN.

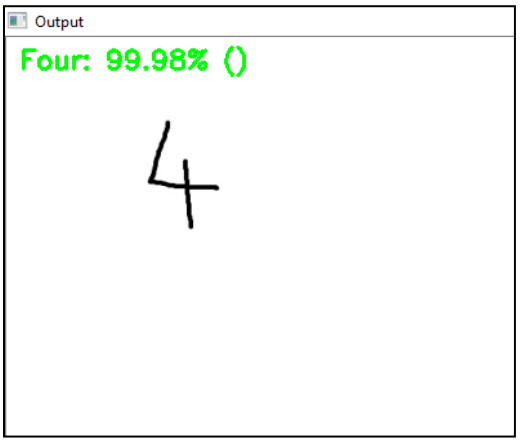

Fig 12:- Output generated by CNN

VI. CONCLUSION

In this paper, the Handwritten Digit Recognition using Deep learning methods has been implemented. The most widely used Machine learning algorithms, KNN, SVM, RFC and CNN have been trained and tested on the same data in order acquire the comparison between the classifiers. Utilising these deep learning techniques, a high amount of accuracy can be obtained. Compared to other research methods, this method focuses on which classifier works better by improving the accuracy of classification models by more than 99%. Using Keras as backend and Tensorflow as the software, a CNN model is able to give accuracy of about 98.72%. In this initial experiment, CNN gives an accuracy of 98.72%, while KNN gives an accuracy of 96.67%, while RFC and SVM are not that outstanding.

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