**Handwritten character recognition using integrated machine learning**

**and deep learning approach**

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***Abstract***

Technology has revolutionized the world over the years. One such field is the field of character recognition, commonly known as Optical Character Recognition. Handwritten character recognition has been used in a variety of industries, including health care, banking, and other official documents. The purpose is to identify handwritten character using a neural network. Handwritten character recognition is challenging issue, researchers has been research into this area for so long especially in the recent years. Our objective is to recognize the character accurately from the MNIST dataset by using the deep learning approach methodology. To evaluate our proposed work, we will use the Accuracy, Precision, and recall metrics.

***Key words:*** *Optical character recognition, Mnist, Convolutional Neural Networks*

1. **Introduction**

OCR is a technology used to recognize any alphanumeric character of printed and handwritten text virtually which save a lot of time and man work. OCR is a combination of hardware (optical scanner) and software handles advance processing.

Working of OCR:

1. Using OCR software to scan a paper.
2. Identifying the document with OCR software.
3. Save the OCR-generated document in the format of your choice

It first converts the document into black-and-white color in which black color is recognized as the text need to recognize and white color recognized as background. OCR consists of two algorithms –Pattern recognition and feature analysis. So the characters are recognized using one of the two algorithms.

**Applications**

1.Banking

2.Healthcare

3.Education

4.Finance

5.Government agencies

TESSERRACT: Tesseract is an open- source OCR machine that retrieves textbook from filmland that have been published or written. It was originally created by Hewlett- Packard, but Google ultimately took over development. This is why it's now known as “ Google Tesseract OCR ”.

1. **Literature survey**

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| **TITLE** | **OBJECTIVE** | **REMARKS** |
| A Robust Model for Handwritten Digit Recognition using Machine and Deep Learning Technique[1] | 1.CNN technology on keras is used in this paper .  2. This study's key contribution is to enhance the convolutional layer using pooling and dropout, as well as to tweak the model utilising filter, kernel size, and amount of neurons. | * Training-97% and testing -98% accuracy * CNN is more effective than KNN and other algorithms . |
| An Enhanced Handwritten Digit Recognition Using  Convolutional Neural Network[2] | CNN is used in recognition of image classification in two different forms :voice and text form. | Due to two forms of output, performance of the system improves compared to other system. |
| Handwritten Character Recognition using Convolutional Neural Network[3] | English alphabet is recognize using CNN. | System is giving 97% accuracy  Future work- model will predict characters of other language. |
| An Empirical Comparison of Handwritten Character Recognition Using Machine Learning[4] | Comparison between various algorithm like- ANN, CNN, SVM, KNN. | The size of the training set influences recognition accuracy. |
| Handwritten Digit Recognition of MNIST dataset using Deep Learning state-of-the-art Artificial Neural Network (ANN) and Convolutional Neural Network (CNN)[5] | CNN and ANN are contrasted. On the MNIST dataset, models were trained using categorical cross-entropy loss and the ADAMoptimizer. Backpropagation and Gradient Descent are utilised to train the networks, as are reLU activations in the network that do automated feature extraction. | Average error occur in CNN IS LESS THAN ANN however  Time & power consumption in CNN is more than ANN.  For improved performance, we can use a GPU instead of a CPU. |
| Handwritten Digit Recognition using Convolution Neural Networks[6] | the suggested model's idea for digit recognition with higher accuracy by preprocessing data, as well as an ensemble of two or more models with distinct architectures and preprocessing. | The estimates of the two separate models are combined to obtain the final forecast, which yielded an efficient outcome.  Image segmentations are still challenging |
| Handwritten Character Recognition Using Histograms of Oriented Gradient Features in Deep Learning of Artificial Neural Network[7] | Two classifiers are used  1.”Deep-Learning Feedforward-Backpropagation Neural Network (DFBNN) “  2.”Extreme Learning Machine (ELM)” | Here the effects on classification in DFBNN and ELM with and without HOG is analyzed. |
| An effective digit recognition model using enhanced convolutional neural network based chaotic grey wolf optimization[8]. | With Orthogonal Learning Chaotic Grey Wolf Optimization (CNN-OLCGWO), an unique CNN has been developed to change the network topology. | CNN variants are used to avoid problems like over-fitting and computational complexity. |
| A Mobile Application for Offline Handwritten Character Recognition[9] | The suggested system's Android application is built with OpenCV and TensorFlow Lite. | Experiments are carried out using a local dataset gathered from elementary school kids. |

**Table 1:** Character recognition papers with identified remarks

1. **Methodology and Module Description**
   1. **Modules description**

**Figure 1:** Schematic representation of work flow

**1. Fetching data from MNIST**: Data is needed in order to train and test the model. The training and testing data are accessible in a dataset called MNIST dataset that is part of the Keras package. Python programming language is utilised and the built-in method load data() is used to retrieve the data from the dataset. Training and testing data are divided during data loading.

**2. Data Preprocessing:** Data input for both training and testing the Convolutional Neural Network model should be given as it is being developed. However, because both data sets are 28\*28 pixels, they cannot be sent to CNN's input layer. Since the first layer of CNN is a flattening layer, the data set must follow this pattern in order to pass. Flattening the dataset is therefore considered data preparation.

**3. Creating CNN model:** The CNN model is needed to generate predictions using the handwritten characters. The CNN model is built sequentially to ensure that it is built in an organized way. . CNN’s consists of 4 layers –first input layer followed by two hidden layers and last output layer. First layer is input layer also called flattening layer which takes flatten data as input followed by two hidden layers which consist of 128 neurons and relu which is the activation function. And then the final layer is the output layer of CNN which contains 10 neurons.

**4. Train the model:** The MNIST dataset contains specific data, referred to as the training data, that may be used to train the model. The constructed model may be trained to produce predictions for the test data using the training data.By continues training for CNN the neurons of the network get practiced to recognize any digit correctly. Continuous training of the neurons is called as ‘epoch’ which defines how many times the training needs to be done.

**5. Present the projected result:** Following the creation of the model, the model is trained using the MNIST dataset's training dataset. When the model has been trained, the prediction phase may begin. During the prediction phase, the model predicts the test dataset of the MNIST dataset using the Keras package.

* 1. **Algorithm implemented for character recognition**

**Input:** MNIST dataset in which each image is 28 pixels in height and 28 pixels in width, for a total of 784 pixels in total. Each pixel value between 0 to 255.

**Output:** Recognized character

**Begin**

1. Import TensorFlow, keras, matplot, NumPy packages
2. Divide training and testing data
3. Build the feed forward neural network model that contain layers
   1. Input later with shape 28\*28
   2. Define Hidden and output layers with activation functions ReLu and SoftMax
4. Compile the model Adam optimizer, loss function, and metrics
5. Train the model with train and test with 10 Epochs
6. Evaluate the model then print the accuracy

**End**

Import the data source

Reshaping the processing the data

Build the model and define the specifications of it

Compiling and fitting the model

Output and Prediction on test

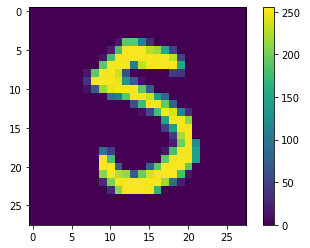
Predicted results assessing

**Figure 2:** Detailed working methodological process

* 1. **Performance analysis**

In the proposed system the handwritten characters are recognized using convolutional neural network firstly MNIST dataset is loaded from the keras library usingmnist.load\_data()function since the data is in 28\*28 pixels it needs to get flatten and this can be done by dividing the training and testing data by 255.0 .We did this because after dividing the values will get small & model can easily give result on the smaller values as the first layer of CNN accepts only flattening data this process is called as data preprocessing . This model represents a feed-forward neural network (one that passes values from left to right).Here keras API ,the high-level API of TensorFlow is implemented. After that building and compilation process is completed by using build\_model\_with\_functional() and model.compile() function.Training of model is done by using epoch value as 10.

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| **Figure 3**: recognizing the digit 3 | **Figure 4**: recognizing the digit 0 |



**Figure 5**: recognizing the character S

1. **Conclusion**

The concept of OCR technology used in many sensitive areas such as document verification in banking sector, health care, government sector as well. Hence, we worked on the concept of character recognition methodological process. The objective is to recognize the character accurately from the dataset by using the deep learning approach methodology. To evaluate our proposed work, we will use the deep learning model. Then for the performance analysis evaluation we will use the Accuracy, Precision, and recall metrics.

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