IJIRCCE

e-ISSN: 2320-9801 | p-ISSN: 2320-9798

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN COMPUTER & COMMUNICATION ENGINEERING

Volume 10, Issue 7, July 2022

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 8.165

9940 572 462 | 6381 907 438 | ijircce@gmail.com | www.ijircce.com

International Journal of Innovative Research in Computer and Communication Engineering

| e-ISSN: 2320-9801, p-ISSN: 2320-9798| www.ijircce.com | |Impact Factor: 8.165

|| Volume 10, Issue 7, July 2022 ||

| DOI: 10.15680/IJIRCCE.2022.1007027 |

Compact NN Based Smart Pen

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ABSTRACT: The deep learning approaches are employed to predict the handwritten letters using the standard dataset for training and testing. The essential of handwritten recognition in various fields such as banks, college notifications, and government and non-governmental institutions to convert the handwritten documents into the digital format with a high predication rate. The research gap in this field is to predict the handwritten words or numeric values as everyone's handwriting style is different. The proposed framework addresses the above issues, the camera is attached to the pen and the signal is extracted by using the deep learning model using Natural Language Processing (NLP) to predict the words once the word is predicated it is passed through the dictionary application to predict the exact word if NLP fails to recognize the handwritten words.

KEYWORDS: NLP, Deep learning, handwritten predication, wrong predication correction.

I. INTRODUCTION

Handwritten digit string recognition, often known as HDSR, has seen significant advancements in recent years as a result of the development of deep learning [1–3]. An intuitive method for recognizing these handwriting strings is to first segment string images into pieces that correspond to single characters or parts of them, and then combine the recognition results of these pieces with path-search algorithms to get results that are optimal on a global scale. This method is described below. These techniques are together referred to as the over-segmentation approach. After binarization, the string image was converted into a series of primitive image segments by Wu et al. [1.] These image segments were then merged to construct candidate character patterns, which resulted in the formation of a segmentation candidate lattice. After that, a beam search technique was used in order to locate the most suitable route across the candidate lattice. This approach was awarded first place in the HDSR competition held at the ICFHR2014 [1]. In order to achieve high recognition rates, Saabni [3] employed a sliding window in conjunction with a deep neural network. Gattal et al. [2] used three different segmentation techniques to deal with handwritten digit strings. These segmentation methods were combined in different ways based on the configuration relationship between the digits. In reality, however, approaches of this sort presented several challenges, including a wide variety of handwriting styles, related characters, and environmental disturbances.

The capacity of a computer to identify the human handwritten text present in a variety of manual sources, such as images, papers, images, documents, and so on is referred to as "handwritten recognition." It is not difficult for a person to recognize the character based on the visual; nonetheless, the issue is whether or not it is feasible for a computer to reliably identify it. As a result, the notion of deep learning is put into practice.

The Convolutional Neural Network, one of the deep learning techniques, is used to recognize the alphabet, and a comparison of the architectures of the Convolutional Neural Network is performed in order to get the best possible results with the greatest possible accuracy and the least amount of data loss.

II. LITERATURE SURVEY

Many segmentation-based digit string recognition algorithms have been suggested and developed to identify digits in document pictures. A segmentation-based handwritten digit string recognition solution, for example, was presented by Kim et al. [9]. We used counter analysis, candidate breakpoint analysis, as well as ligature analysis to figure out where the separation points between two adjacent numbers in a handwritten string were. NIST SD19 database handwritten digits were used to test the approach, and findings demonstrate that the method is able to split two touching digits into

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independent digits with high accuracy. Segmentation of linked handwritten digits based on feature extraction is presented by Lacerda et al. [11]. Skeletonization and self-organizing maps are used in this strategy to provide two distinct characteristics. Topological and geometric characteristics are extracted from digit pictures using the first feature extraction method, whilst touching area features are extracted using the second method. The findings reveal that the approach is able to handle a variety of different sorts of digits. In the case of handwritten document image analysis, however, these two approaches only take segmentation of touching digits into account. Unknown-length handwritten digit strings have been the subject of a segmentation and recognition system [12]. The digits have been segmented using contour analysis, sliding window Radon transform, and histogram of vertical projection. The final segmentation results are the product of a combination of all three procedures. SVM classifiers are used to identify the segmented digits in this step. Handwritten linked digit segmentation and recognition were suggested by Merabti et al. [13] for unconstrained handwritten numerals. Cutting points of linked digits may be found using the method's two structural properties. The Fuzzy-Artificial Immune System is used to test the segmentation approach's effectiveness in recognizing digits (Fuzzy-AIS). The technique is tested using the NIST SD19 handwritten digit database [10]. In recent document pictures, segmentation-based digit recognition systems often only identify and/or recognize touching digits, broken digits, and unknown-length handwritten digit strings. Even yet, historical handwritten document photographs present a number of additional issues, including considerable changes in paper texture, document aging, handwriting style, digit thickness, orientation, and digit appearance along with ink bleed-through and stains, as well as fading inks. In addition, handwritten digit instances in document pictures are commonly found close together, making it impossible to distinguish them using current approaches. The figure highlights some of these problematic challenges. Moreover, state-of-the-art approaches have been applying image processing techniques to identify the digits and this strategy makes the automated handwritten digit string identification methods not efficient and not dependable. Therefore, it is required to employ a learning-based strategy to identify the digits.

III. PROPOSED ALGORITHM

The below flow provides the general flow diagram for every machine learning model which were employed to design models in it.

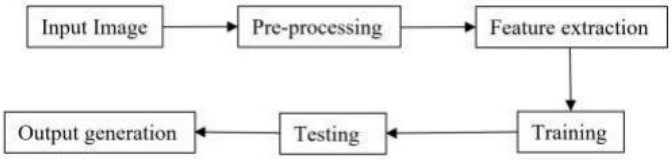

Figure 1: General flow diagram of the model design in machine learning.

Dataset: For the implementation had employed the two dataset first one is IAM handwriting dataset and another is RIMES dataset

IAM handwriting dataset: It is possible to train and test handwritten text recognizers and execute writer identification and verification tests using the IAM Handwriting Database's handwritten English text samples. The database was initially presented at the ICDAR in 1999 when it was published for the first time. A handwritten sentence recognition system based on HMM was built and presented in [2] at the ICPR 2000 using this resource. According to [3] and published in the ICPR 2002, the segmentation technique utilized in the second database version is described. As of October 2002, the IAM database may be found in [4]. For more information on how we make use of the database in our own work, please read our published papers.

The database comprises forms of unconstrained handwritten text, which were scanned at a resolution of 300dpi and exported as PNG images with 256 grey levels. An example of a completed form, a text line, and some extracted words are shown in the image below.

The 12723 pages were allowed by the volunteers to write the words. [6]

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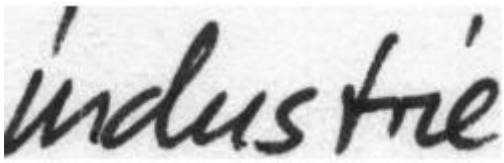

Figure 2: Instance of the IAM dataset

For preparing this dataset the 657 writers were employed to write the words in 1539 pages [1] and generated the sentences as shown in below table,

Table 1: IAM dataset details

Type of word	Details
Sentences	5685 labelled sentences
Text lines	13353 lines of words
Words	115320 labelled data

The RIMES dataset is created in such a way that it can be used for automatic recognition systems which are collected by posting or by faxing the mail to the 1300 volunteers. The gifts were given to write the volunteers in return. The five scenarios with respect to bank transactions were given to writers.

Pre-processing is the method employed to refine, clean, or parse and can also tokenize the words captured from the pen.

The smart pen is a family of low-cost, low-power microcontrollers featuring Wi-Fi and dual-mode Bluetooth. In the ESP32 series, the processors are Tensilica Xtensa LX6 or LX7 with twin or single cores and integrated antenna switches, RF baluns, power amplifiers, and low-noise receive amplifiers, filters, and power management modules. The image detected is uploaded to the server by using the wifi module. The server returns the detected characters to the program. The detected words are displayed and feature extraction is going to happen if any of the words are wrongly detected it is corrected by employing the dictionary method.

The proposed methodology for handwrittenword recognition is as shown in the below figure,

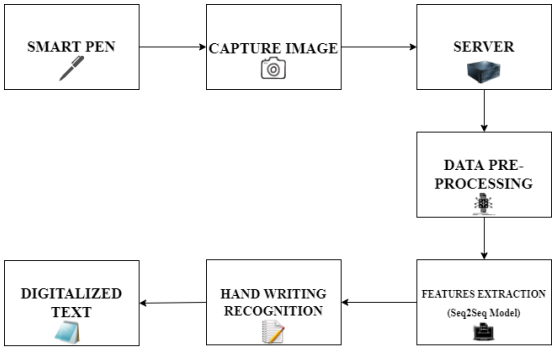

Figure 3: Proposed model for handwritten recognition

Design of the model:

The CNN model is employed to predict handwritten recognition. The architecture of the proposed methodology is as shown in the below figure,

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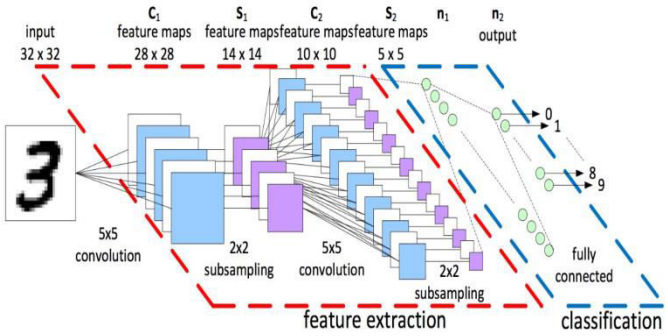

Figure 4: Architecture of the proposed CNN model.

The CNN model is implemented in python by using the Keras library which has the input layer followed by the series of convolutional layer, max-pooling, and batch normalization. The use of the convolutional layer is to reduce the dimensions of the image and as well as extracting the features.

Once the training data of about 70% of the total dataset is passed through every layer of the designed model then the model is ready for the testing process. Once the model is trained the testing images are provided to evaluate the accuracy of the model. The model is able to predict the words accurately as per the analysis of the results. The predicted word is passed through the text blob method to identify any wrong spelling in the predication.

Textblob is the library for handling data that is textual in nature. It offers a straightforward application programming interface (API) for digging into natural language processing (NLP) activities including part-of-speech tagging, noun phrase extraction, sentiment analysis, classification, and translation.

IV. RESULT AND DISCUSSION

The model is trained using the IAM and RIMES dataset, both the dataset contains hand-written sentences written on pages by the volunteer. To capture the testing images the smart pen is employed where the camera is attached to the pen to fetch the character and send it to the server for predicting the letters. The dataset is trained by using the CNN model. The model predicts the sentences. If by chance there is a wrong predication then the dictionary library called textblob is employed to correct misspelled letters in the predicated sentences. Some of the screenshots are shown below,

The various cases of implemented results are

The word written in the image is coming soon the input and output word predicated is

Figure 5: Input to the model

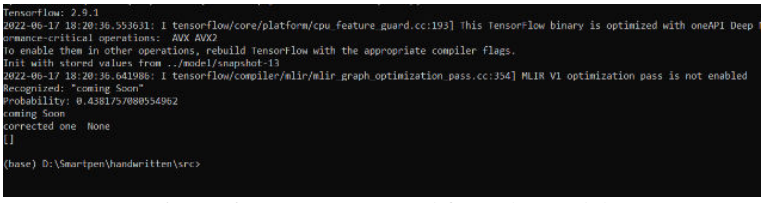

Figure 6: Output generated from the model.

The word written in the image is oxford college of engineering and the results are shown below,

Figure 7: Input image for the model

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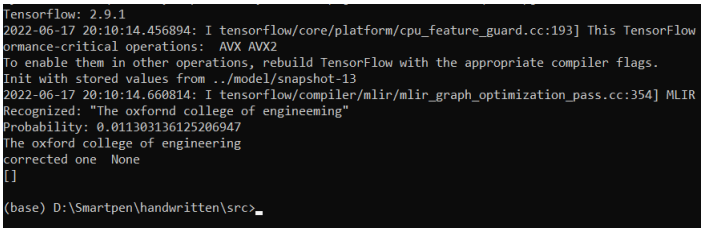

Figure 8: Output generated for the word.

V. CONCLUSION

The IAM and RIMES datasets are used to train the model. Both of these datasets comprise the hand-written phrases that were produced by volunteers on pages. For the purpose of capturing the testing images, a smart pen is used. This pen has a camera connected to it, so it can retrieve the character and transmit it to the server so that it can be used to forecast the letters. In the event that an erroneous predication was made, the dictionary library known as textblob is used to rectify any misspelled letters in the sentences that were made using the incorrect predication.

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