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MODI Lipi Handwritten character Recognition using CNN and Data Augmentation Techniques

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Abstract - *MODI is an old Indian script from Maharashtra. This script was popular for drafting official papers during the reign of Chhatrapati Shivaji Maharaj. Character recognition MODI is difficult due to its structural features and the lack of an image database. In this research, we created a CNN model for character recognition and used data augmentation techniques to expand the MODI script's dataset. Because the MODI script includes a limited image dataset of 4140 images, we applied data augmentation to the dataset and trained the CNN model on a produced dataset. The trained model recognizes Handwritten MODI characters with an accuracy of about 91.62%.*

Key Words: **Convolutional Neural Network, Data Augmentation, Deep Learning, Image Processing, Character Recognition.**

1. INTRODUCTION

MODI is a Brahmi-based script that is mostly used for writing Marathi. MODI Script was commonly used until 1950 when everyone switched to the Devanagari script. The MODI script was used to write official documents, cultural literature, and religious books. As a result, most old writings from the 12th century to the 19th century in Maharashtra State, India, are written in MODI Script. However, most individuals are unaware of the script. The study in this paper focused on handwritten character identification and transliteration to Marathi script.

The MODI script dates back to the 12th century and was used until the 20th century. Shivkalin and the Peshava Kalin Kingdom have both used MODI Script. Figure 1 depicts a letter written in MODI Script by Chh. Shivaji Maharaj.

As time passed, various changes were made to the forms of writing of MODI. In the 12th century, MODI Script was called "Adyakalin", and in the 13th century, it evolved as a new script known as "Yadavkalin". The "Bahamanikalin" of the 14th-16th centuries is the next phase of development, followed by the "Shivakalin" of the 17th century. MODI's ultimate stage is related to English rule and is known as "Anglakalin". From 1818 to 1952, this style of writing was in use. MODI was also used in elementary school textbooks published in the nineteenth and twentieth century. Then Devanagari Script began to replace MODI Script in the twentieth century. The Bombay Presidency decided on July 25, 1917, to replace the MODI script with the Balbodh style of Devanagari as the primary administration script for ease and consistency with the other areas of the presidency [1].

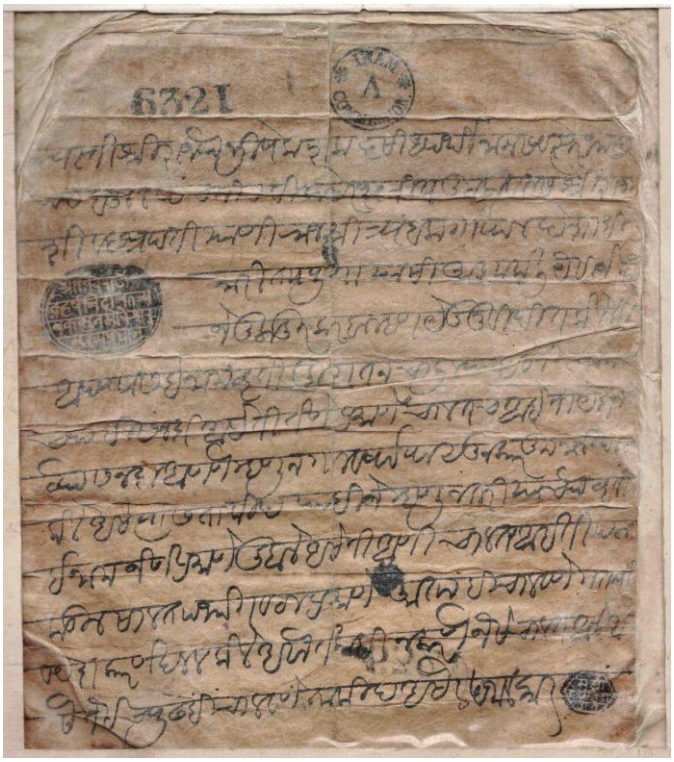

Fig-1: Letter Written by Chh. Shivaji Maharaj

2. IMPORTANCE OF MODI SCRIPT

Thousands of Modi documents have been saved in South Asia and Europe. Due to the presence of these Europeans in Tanjore, Pondicherry, and other South Asian places throughout the nineteenth century, the majority of these are stored in various archives in Maharashtra, although lesser collections are kept in Denmark and other nations. The earliest surviving Modi document is from the early 17th

century. While the majority of Modi papers are official letters, land registry, and other administrative documents, before the 1950s, the script was also applied in school, journalism, and other ordinary activities. Printing in Modi began in the early nineteenth century after Charles Wilkins cut the first metal script fonts in Calcutta [2].

MODI Script users are currently publishing books and publications in the script on a regular basis. Several organizations currently provide Modi tutorials, ranging from weekend workshops held by the Maharashtra State Department of Archives to official courses offered by Bharat Itihas Samshodhak Mandal (BISM) in Pune. Some colleges also provide Modi certifications that are recognized by the Maharashtra government. The rebirth of Modi coincides with an increasing demand for Modi experts to categorize and handle the massive archives of Modi documentation at BISM and other locations. The Indian government has set aside cash for the indexing of these archives, which is being carried out by teams freshly trained as Modi experts [2].

Modi users have created computer assistance for the script, particularly in the form of digitized typefaces. However, due to the absence of a character-encoding standard for the script, users rely on outdated encodings or are linked to Unicode blocks such as Devanagari [2].

3. WRITING IN MODI LANGUAGE

The MODI script was written with a bamboo pen that had to be lifted and dipped in an inkpot every few seconds. The MODI script contains 46 distinct letters, 36 of which are consonants & 10 of which are vowels. Devanagari, on the other hand, has 48 distinct letters, 12 of which are vowels & 36 of which are consonants [3].

When we write in MODI, we start by drawing a horizontal line from the left margin to the right margin of the page. And because of the curves in letters, we don't have to raise a pen to write the following letter. Figures 2–4 depict the vowels, consonants, numbers, and punctuation in MODI Script.

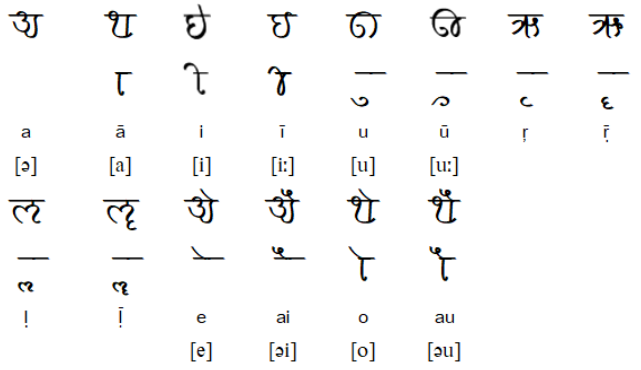

Fig-2: Vowels and Diacritics in MODI Script

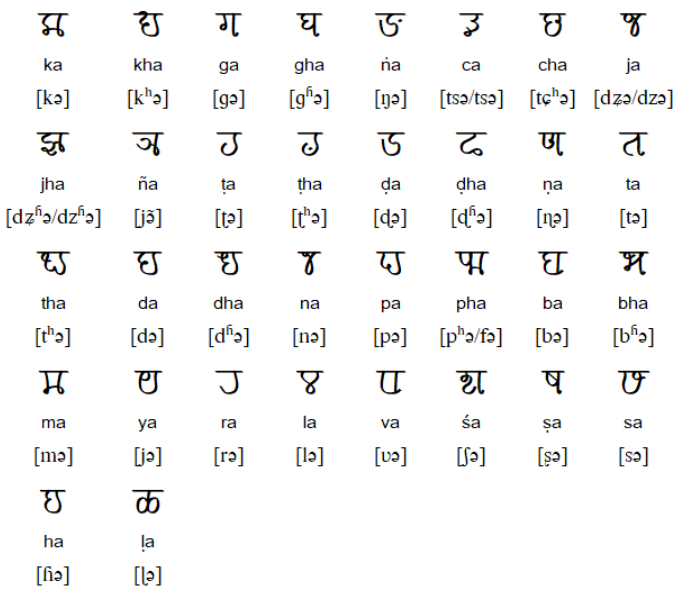

Fig-3: Consonants in MODI Script

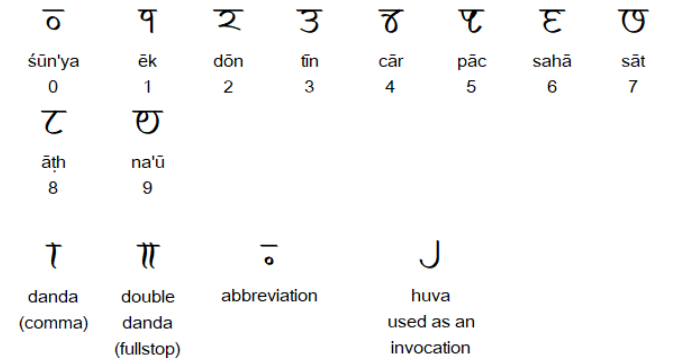

Fig-4: Numbers and Punctuation in MODI Script

4. MODI SCRIPT IMAGE DATA

Data gathered from multiple sources includes nearly 4140 photos that are inefficient for accuracy. As a result, we used several data augmentation techniques to expand the data as needed for training. Then, using the 80-20 rule, we separated our collected dataset into training and testing sets.

5. DATA AUGMENTATION THEORY

When given a large amount of data, a machine learning model always performs well. In general, more the data we have, the higher the model's performance. Image augmentation is typically necessary to increase the performance of the machine models when building an effective image classifier with very little training data. We used image augmentation techniques [4].

Image augmentation builds training images artificially by using various processing methods or a mix of numerous processing methods, such as randomized rotation, shifting, shearing and flipping, and so on. Fig-5 shows some

augmented images from created dataset. The image on the left is the original, while the others were created using augmentation techniques. We don't have to acquire these photographs manually because they are created from training data. If the training data is insufficient, this strategy increases it.

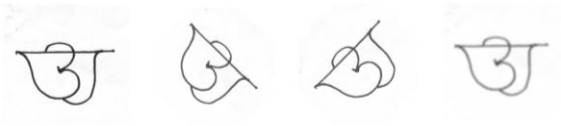

Fig-5: Some images from the dataset.

The following are some image augmentation techniques:

5.1 Rotation

Rotation is the most widely utilized method for image augmentation. Rotating the images has no effect on the data contained in them. As a result, we could use this strategy to expand our dataset. Figure 6 depicts the rotation approach applied to a character image [4].

Fig-6: Generated new image using rotation

5.2 Flipping

This approach allows us to flip photos in any orientation we desire, including left-to-right and up-to-down. Figure 7 depicts image flipping.

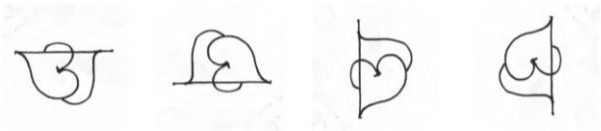

Fig-7: Generated new images using flipping

5.3 Noising

We add fake noise to the photos via this technique. Using this method, we can teach our model to distinguish between noise and picture data. This technique might also make your model more resistant to alterations in the image [4]. Fig-8 shows the noising of the image.

Fig-8: Noising of image

5.4 Blurring

When we collect data from multiple sources, it is not required for all of the images to be of the same quality. Some photographs may be of extremely high quality, while others may be of very low quality. In this case, we can distort the original photos, which makes our model more resistant to changes in image quality [4]. Fig-9 Depicts the blurring of images.

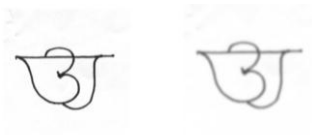

Fig-9: Blurring images

In Fig-9 left image is the original image and the right image is the blurred image generated from the original image.

6. THE MODI HANDWRITTEN CHARACTER RECOGNITION

We have used the convolutional neural network for the recognition of MODI Script Handwritten characters. In recent years CNN has evolved very much in the character recognition field.

6.1 Convolutional Neural Network (CNN)

It is a deep learning system that takes an image as input, assigns priority to distinct items in the image, and can distinguish between them. In contrast to other algorithms that require pre-processed pictures for further processing, CNN accomplishes the majority of the pre-processing itself.

CNN's design is inspired by the organization of the visual cortex and is identical to the connectivity pattern of nerve cells in the brain. Fig-10 shows the architecture of the convolutional neural network.

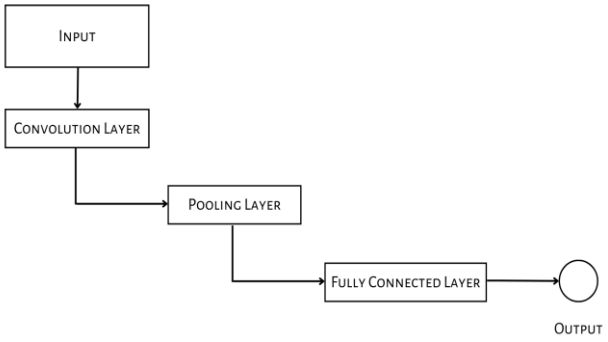

Fig-10: Architecture of Convolutional Neural Network.

6.2 The Proposed Model

Traditional Convolutional Neural Networks serve as the foundation for the suggested model. Because the MODI Script dataset is too small for training any network, we applied data augmentation/image augmentation techniques like rotation, flipping, noising, and blurring to enlarge the MODI Script dataset. The dataset was then divided into 80:20 training and test sets. We used the ReLU activation function to immediately output a 1 if true, otherwise a zero.

When an image is submitted to CNN, it undergoes a variety of modifications. First, a convolution layer is applied to the image array, followed by a pooling layer, and these two layers are applied every two times. It is then forwarded to the fully connected layer.

The suggested CNN model was then trained on the original MODI dataset, and the MODI dataset was constructed via image augmentation. This training took nearly 1 hour and 8 minutes to complete. The model's performance is evaluated using accuracy rate as the effectiveness metric. Hyperparameter adjustment is used to get optimal performance. Following training on the dataset, the model was tested on the original data. Then it was tested with our own handwritten MODI characters, and it correctly predicted or classified with 99% confidence.

Fig-11 shows the model for training using the MODI training dataset, fig-12 shows the model testing using MODI testing dataset and Fig-13 shows the Predicting handwritten character using the trained model on the training dataset.

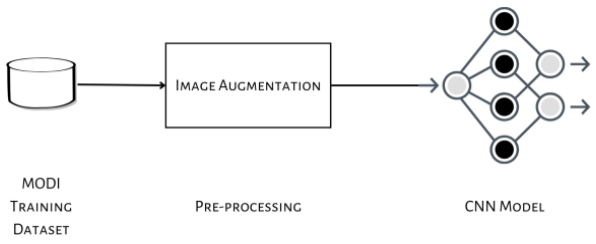

Fig-11: Training the CNN Model

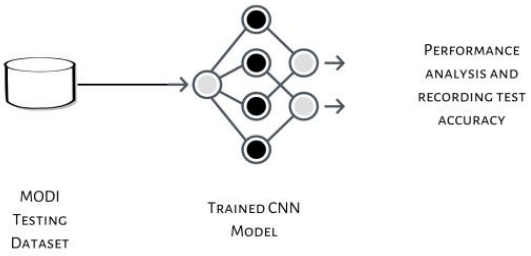

Fig-12: Testing the Trained CNN Model

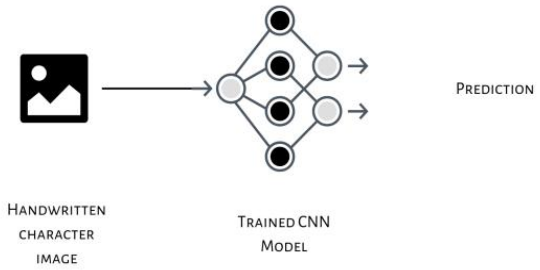

Fig-13: Predicting Handwritten character.

7. EXPERIMENTS AND RESULT ANALYSES

The suggested model's performance has been tested for detection of all letters in MODI Script, which totals 46 characters. The suggested model's performance is measured using classification accuracy. We optimized the CNN hyperparameters such as learning rate, batch size, epochs, optimizer, and the activation function to improve the results. The suggested model has a batch size of 50 and uses the ReLU activation function. The model's optimizer is called 'adam'. The model was trained on the original MODI script dataset before being trained on the produced dataset via image augmentation. The suggested model took nearly 1 hour and 8 minutes to finish the training procedure.

The model's performance in comparison to the current study, that is the work presented in [3] used Zernike moments for MODI character identification and achieved 76.74 percent accuracy. Then it was renovated with Zoning and received 82.61 percent. In addition, the study indicated in [6] employed GoogleNet and AlexNet pre-trained networks for recognition and achieved an accuracy of 95.86%. We achieved about 91.62% accuracy for MODI character identification using a simple conv2d method, a standard CNN algorithm, and some data augmentation techniques in the proposed study. Fig-14 shows the prediction accuracy of some MODI characters in percentage.

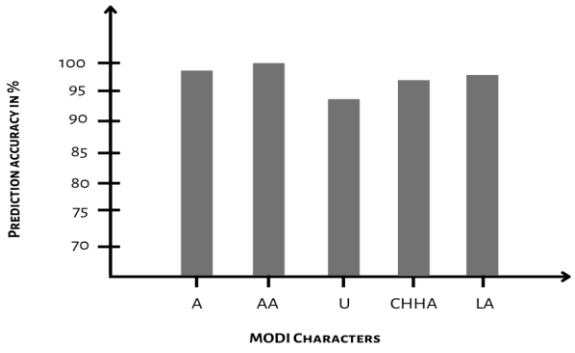

Fig-14: Prediction accuracy graph of handwritten MODI character recognition.

8. CONCLUSION

The model in this research is a conventional Convolutional Neural Network for Handwritten MODI character recognition. Using the standard CNN technique, the highest accuracy achieved is 91.62 percent. The algorithm is also analyzed for various picture modifications. This work can be expanded in the future to distinguish very noisy and unclear images from copperplates, stones, or old papers.

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