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Recognition of Hindi Handwritten Text using Deep Learning Technique (RHTDL)

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Abstract:

Handwritten Text Recognition (HTR) remains a challenging task due to the vast variability in writing styles, slant, and character formations. Deep learning techniques have a significant impact in handwritten text recognition in terms of accuracy. Optical Character Recognition (OCR) has witnessed significant advancements using deep learning techniques. For proposed work we used the Deep Feed Forward Neural network (DFFN) and Convolutional Neural Network (CNN) for Hindi handwritten text recognition. The Root Mean Square Propagation (RMSprop) optimizer for CNN and Adam optimizer with DFFN. Experimental results on a large dataset of handwritten Hindi characters demonstrate proposed method outperforms conventional recognition have efficient and more accurate results. This method provides a

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robust solution for recognizing complex scripts like Hindi, contributing to the broader scope of handwriting recognition systems.

Keywords: Deep learning, OCR, HTR, CNN, DFFN, RMSprop.

1.Introduction:

In current era, Optical Character Recognition (OCR) have significant research area due to the rise deep learning techniques. OCR systems aim to recognize and extract textual content from images, which has a applications area like document digitization, automated data entry, and assistance for the visually impaired, (Sai et.al 2023). While much of the research and application development has been centered around languages with a Roman alphabet, the recognition of text in languages with complex scripts, such as Hindi, presents unique challenges due to its rich set of characters, complex diacritical marks, and intricate word formations. Fig. 1 shows the basic handwritten characters of Hindi language.

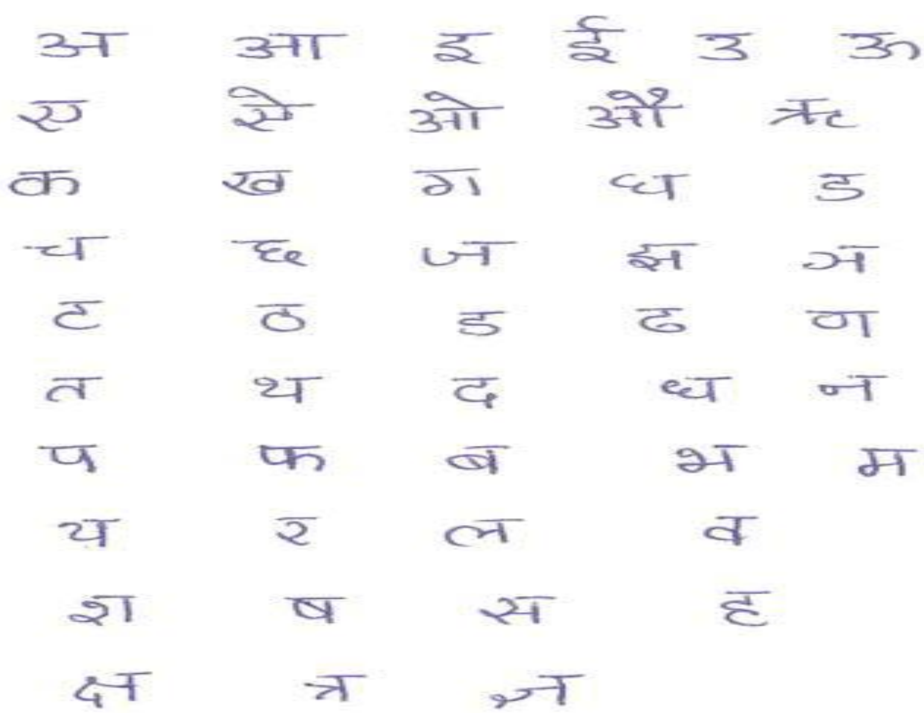

Fig. 1 Basic Character of Hindi languages

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Hindi is most spoken language in world, is written in the Devanagari script, which is highly cursive and possesses a variety of character variations, both in its isolated and contextual forms (Bhosle et.al. 2023). These challenges make it significantly more difficult to achieve accurate text recognition compared to Latin-based scripts. To address this, many deep learning as well as machine learning models have been proposed. Specially the CNN and DFFN, which are demonstrated remarkable success in handling such complex tasks because of automatically extraction of the features and patterns from the input data. Fig.2 shows the document analysis and recognition.

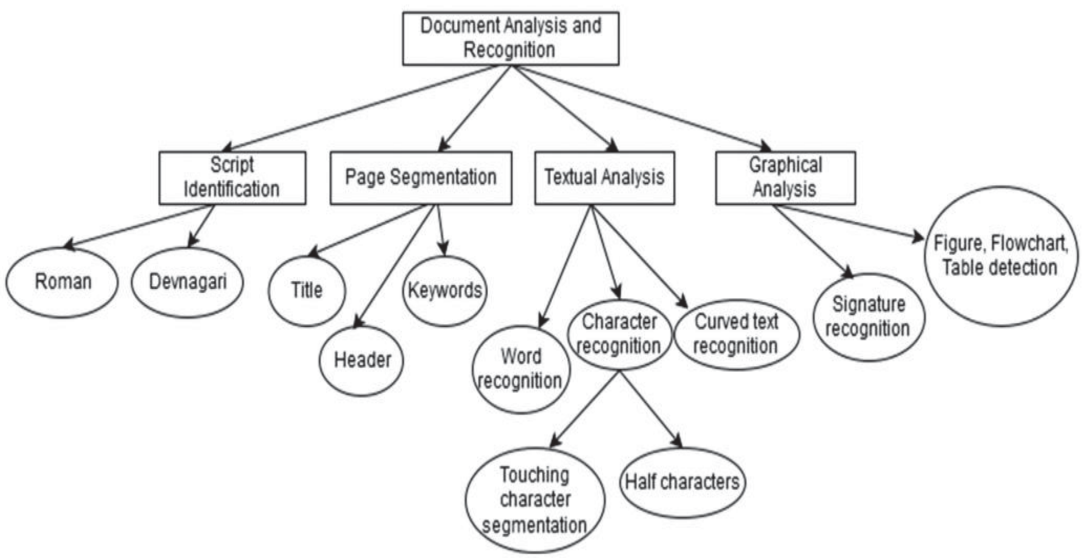

Fig. 2 Sub field of Document analysis and recognition

This research aims to explore the effectiveness of combining CNNs with DFFNs for Hindi text recognition, investigating how each model component contributes to improving recognition accuracy and efficiency. Specifically, we focus on how CNNs can be leveraged to extract robust spatial features from Hindi text images, followed by the use of DFFNs for the classification task, which provides high-level decision-making capabilities. Through a comprehensive analysis of various architecture configurations, the study aims to push the boundaries of current Hindi OCR systems and offer a more scalable, efficient solution for real-world applications.

2.Review of Literature Work:

Text recognition for Hindi language is challenging task for OCR System due to its complex nature of Devanagari scripting. This script encompasses various characters with contextual dependencies, diacritical marks, ligatures, and a range of handwritten and printed styles (Najam et.al 2023). Techniques have been planned to solve the problem, with deep learning emerging as a powerful tool.

Early Approaches in Hindi Text Recognition Early approaches in Hindi text recognition widely used deep learning and traditional OCR methods, including template matching and feature-based methods. These were based on manually designed features such as edges, strokes, and histograms (Reddy et al. 2019). Another method based on the segmentation of Devanagari characters was introduced, but such approaches failed to work with variations in handwriting and print styles. Further, HMM was used for recognition of Devanagari characters using methods such as Hidden Markov Models; however, manual feature engineering was highly intensive and did not provide flexibility or scalability (J. Memon et al., 2020).

Alwagdani et.al. 2023 proposed a deep learning model, CNN that began to gain prominence for its ability to learn feature hierarchies from pixel data. CNNs have proven exceptional performance in image recognition tasks and their application to OCR tasks, including Hindi text recognition, began to gain popularity in the last decade.

(Rathi et.al. 2016) proposed a combined hybrid model combining CNNs with LSTM network for Hindi text recognition. To handle the sequential nature of text, LSTM networks were integrated for robustness against varying font styles and distortions. However, the challenge was still in handling the large diversity of characters and ligatures present in the Devanagari script.

Several studies have explored the use of CNNs for recognizing isolated Hindi characters. (Agarwal et. al. 2018) proposed deep CNN model on a large dataset of handwritten Hindi characters, achieving competitive performance in terms of accuracy.

(Verma et. al. 2019) studied on CNN for the recognition of Devanagari characters in natural scenes. They proposed a multi-level feature extraction strategy which enabled the model to recognize the printed as well as handwritten text more effectively through a combination of pre-processing techniques and various layers of CNN. Their results show the generalization potential of CNNs for the different styles of handwritten and printed Hindi text.

CNNs have also demonstrated robust performances in character-level recognition as well as full-word recognition. For example, (Jindal et al. 2023) applied DFFNs during the final classification, whereby CNN-drawn features extract their class and decide the final output of character and word identity. Their model accurately identifies text even in noisy backgrounds and hence outperforms traditional approaches.

A recent trend has been the combination of CNNs with DFFNs in a multi-stage pipeline. (Gupta et al. 2022) employed a CNN-based feature extractor for text regions followed by a DFFN-based classifier to recognize both characters and words in Hindi text. Their work highlighted the fact that although CNNs are very effective in capturing local features, DFFNs do a better job of making global decisions for the task of text recognition.

Challenges in Hindi Text Recognition, several challenges remain in Hindi text recognition, especially when dealing with complex scripts. One significant issue is the handling of contextual dependencies in the Devanagari script (AlKendi et. al 2024). Words in Hindi often exhibit ligatures and diacritical variations that are difficult to capture in standard CNN architectures. To address the issues, researchers have explored hybrid models that combine CNNs with sequence model of RNN and LSTMs, which can capture the sequential dependencies in text (Rathi et al., 2016).

Furthermore, the large annotated dataset for Hindi text recognition is limited to the development of deep learning models. There are several datasets available, such as the Hindi Character Dataset (Agarwal et al., 2018), which are not comprehensive and diverse in nature.

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Proposed work on CNN and DFFN of deep learning models, which have considerably better-quality the performance of Hindi text recognition system. The continued development of more sophisticated models promises to increased accuracy and scalability of OCR system for Hindi characters recognize. Exploration of hybrid architectures combining CNNs, DFFNs, and sequence models will likely play a key role in overcoming these challenges.

Proposed Methodology:

The proposed work is consisting of four phases. In the first phase, gather the Hindi character dataset from Kaggle and collect handwritten text image of various users. Second phase, gray scale image data will be preprocessing and checking the missing, and null values.

After that label the characters 0 to 39 coding for generate vector form of data. In third phase, deep learning techniques like CNN and DFFN for automatically feature extraction process. In final phase, optimizers like RMSprop and Adam estimation for relevant recognition of character. Fig. 3 shows the proposed block diagram.

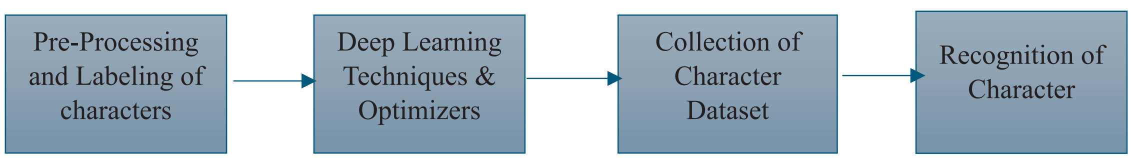

Fig. 3 Proposed Block Diagram

A. Convolutional Neural Network:

CNN is used for recognition task and their application to handwritten character recognition has gained significant attention. In the context of Hindi character recognition, CNNs can effectively handle the complexity of the Devanagari script, which includes over 40 characters and several modifiers. These networks excel in capturing spatial hierarchies' structure and local patterns for input image, making them well-suited for identifying handwritten Hindi characters (Moudgil et. Al 2023). Given the diverse styles of handwriting, CNNs' ability to generalize from large datasets makes them ideal for this task.

The typical CNN architecture for Hindi character recognition includes multiple convolutional layers, pooling layers, and fully connected layers represent in fig. 4. The convolutional layers extract hierarchical features from the input image, such as edges and textures, pooling layers focus on dimensional reduction and focus on main information. Fully connected layers then classify the characters based on the extracted features.

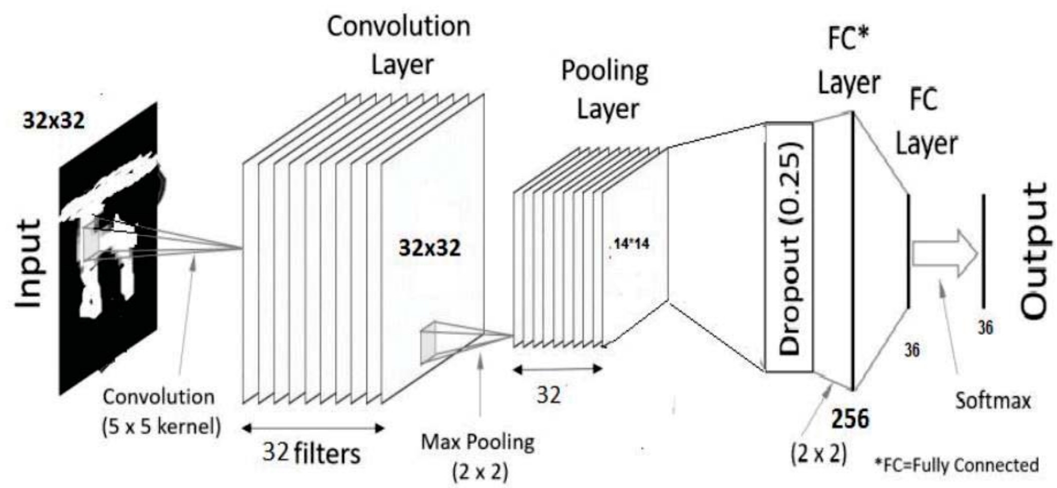

Fig. 4 Structure of CNN for proposed work system

B. RMSprop Optimizer:

The RMSprop is most commonly used adaptive learning optimization used for train deep neural networks including CNN for Hindi character recognition. RMSprop used for adjust each parameter learning rate during train, taking into account the regular of recent gradients, which used to steady training and improve convergence. The core update rule of RMSprop is given by:

$$S_{dw} = \beta s_{dW} + (1 - \beta)(\partial J/\partial W)^2 \quad (1)$$

$$W = W - \alpha \frac{\partial J/\partial W}{\sqrt{s_{dW}^{corrected} + \varepsilon}} \quad (2)$$

Where,

s - average exponential weight gradients of past,

$\partial J/\partial W$ - Present layer cost gradient weight,

W - Weight tensor,

α - learning rate,

β - hyperparameter tuned

ε - avoid divided by zero error.

C. Adam Estimator:

The Adam optimizer is most commonly used optimization algorithms for deep learning model like CNN for Hindi character recognition (Dayvid et. al 2024). Adam associations the advantages of both the RMSprop, and momentum methods, making it efficient in handling noisy gradients and sparse data, which is common in character recognition tasks. The algorithm computes each parameter for adaptive learning rates of gardients. The equation for Adam is as follows:

$$m_t = \beta_1 * m_{t-1} + (1-\beta_1) * g_t \qquad (3)$$

$$v_t = \beta_2 * v_{t-1} + (1-\beta_2) * g_t^2 \qquad (4)$$

Where m_t and v_t are the evaluations of the first, and second moments of gradients, β1 and β2 are the decay rates for these estimates, g_t and g_t^2 are the gradient at time step t.

D. Deep Feed Forword Neural Networks:

A DFFN for Hindi handwritten text recognition leverages multiple layers of neurons to automatically learns the intricate features and patterns present in handwritten Hindi characters (Putra et.al 2025). The network consists of an input layer, several hidden layers, and output layer as show in fig. 5. DFFN model is trained using a labeled dataset of Hindi handwritten characters, where the system learns to distinguish between various letters based on their pixel-level representations. With enough training, the network can generalize and recognize unseen handwritten Hindi text with high accuracy. This approach is highly effective for applications like optical character recognition (OCR), where reliable recognition of complex scripts like Hindi is essential for automated document processing.

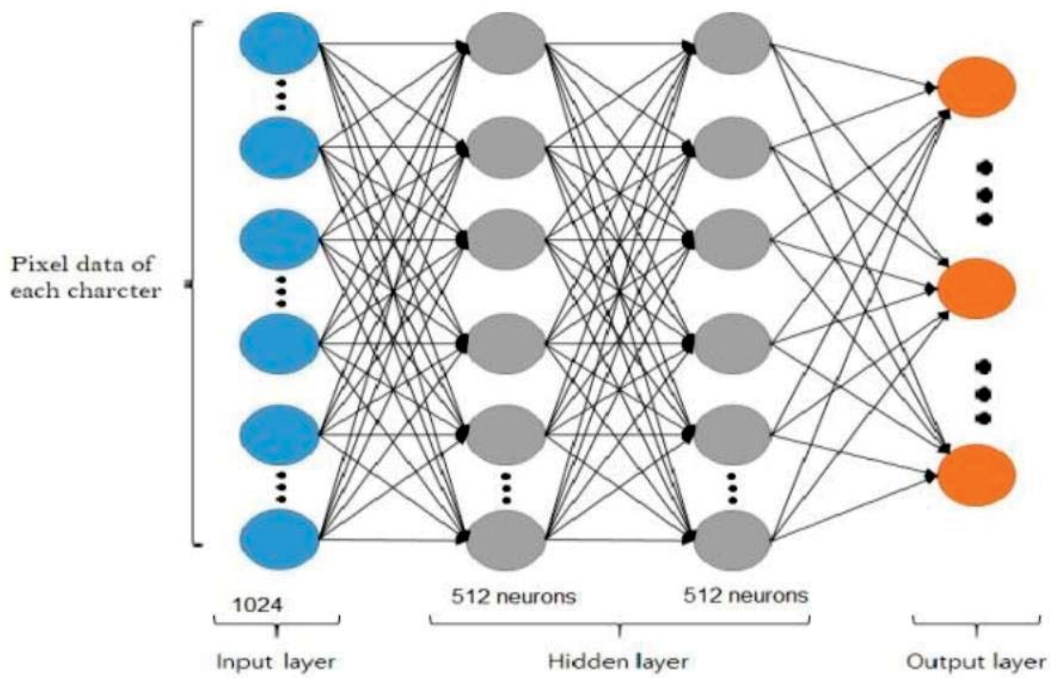

Fig. 5 Structure of DFFN for proposed work system

3. Results and Analysis:

The DFFN deep learning model is having 2 hidden layer and each layer is contains of large amount of neurons i.e.512 and multiplied with different random weight. Deep network we got accurate results. Table 1 shows, labeling of character using DFFN with Adam optimizer with accuracy of 97.15%.

Table 1. Data Labeling using DFFN and Adam Optimizer

Layers	Operation of Layer	Feature maps	Size of feature map	Size of Window	Total Parameter
Conv	Convolutional	32	32*32	5*5	832
MP	Max pooling	32	32*32	2*2	0
FL	Flatten	6272	1*1	N/A	0
FC1	Fully Connected 1	256	1*1	N/A	1605988
FC2	Fully Connected 2	36	1*1	N/A	9509

Table 2 shows, test phase where we used five layers of CNN with RMSprop optimizer. One convolutional layer, one max pooling, one flat layer which convert 2D to 1D array. The classification task is performed by fully connected layers with recognition accuracy of 98.33%.

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Table 2. Data Labeling using CNN and Adam RMSprop Optimizer

Layers	Operations of layers	Feature maps	Size of feature map	Size of Window	Total Parameter
Conv	Conv2D	32	32*32	5*5	832
MP	Max pooling	32	32*32	2*2	0
FL	Flatten	8192	1*1	N/A	0
FC1	Fully Connected 1	256	1*1	N/A	2096408
FC2	Fully Connected 2	36	1*1	N/A	9252

Fig.6 shows, the characters are stated for Convolutional neural network with RMSprop optimizer.

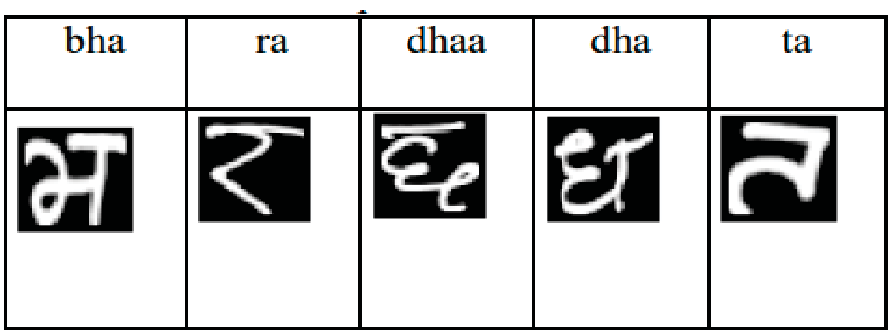

Fig.6 Characters for CNN with RMSprop optimizer

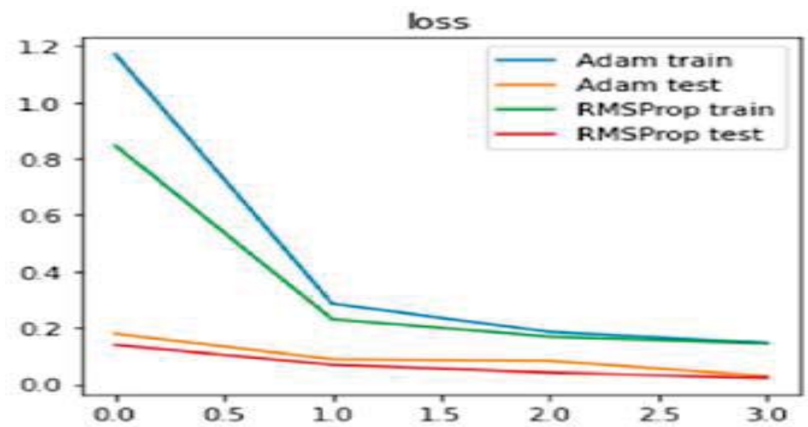

Fig.7 Loss funcation for Adam and RMSprop optimizer

The fig. 7 shows the comparsion of loss funcation for Adam and RMSprop optimizer for hindi handwritten characters. As its clearly indicating the RMSprop test is having less loss values compared with adam optimizer.

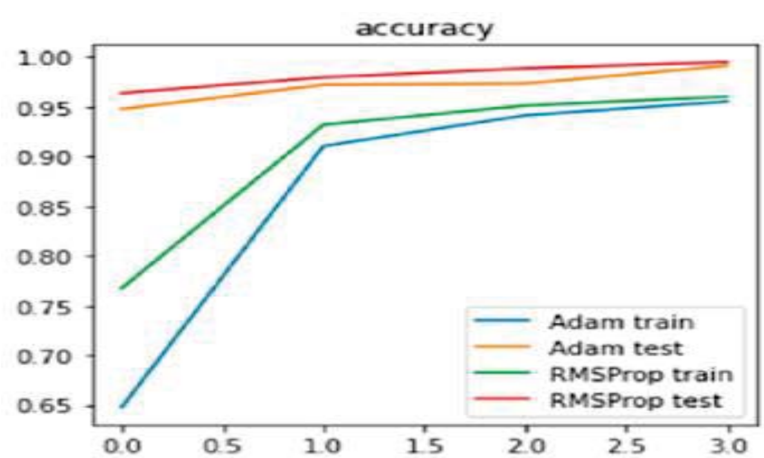

Fig. 8 Compasion accuracy for Adam and RMSprop optimizer

The fig. 8 indicating comparsion accuracies for Adam and RMSprop optimizer for hindi handwritten characters. As its clearly indicating the RMSprop optimizer is having greater accuracy values compared with adam optimizer. The accuracy of CNN with RMSprop optimizer for hindi handwritten characters is 98.33% .

4. Conclusion:

This research study compared two deep learning models for Hindi handwritten character recognition DFFN optimized using the Adam optimizer, and a CNN optimized using the RMSprop optimizer. The DFFN with the Adam optimizer achieved an accuracy of 97.15%, while the CNN model with the RMSprop optimizer outperformed it with an accuracy of 98.33%. The results demonstrate that the CNN architecture, with its ability to capture automatic features through convolutional layers, provides greater performance for image recognition tasks, especially when combined with the RMSprop optimizer, which adapts the learning rate and helps achieve faster convergence. The accuracy of the CNN, indicating that feature extraction is crucial for achieving high performance in character recognition tasks. Overall, the CNN-based model with RMSprop optimizer is a more effective approach for Hindi handwritten character recognition, achieving higher accuracy. Further work can explore additional improvements in data augmentation and model tuning to push accuracy levels even higher.

References:

[1] Agarwal, S., Jain, A., (2018). Deep convolutional neural network for handwritten Hindi character recognition. Proceedings of the 2018 International Conference on Computing, Communication, and Networking Technologies (ICCCNT), 1-6.

[2] Gupta, V., & Yadav, P. (2022). A hybrid model of CNN and DFFN for Hindi text recognition. International Journal of Machine Learning and Computing, 12(1), 45-53.

[3] Vijaya Reddy and Ravi Babu et.al (2019). Handwritten Hindi Character Recognition using Deep Learning Techniques, International Journal of Computer Sciences and Engineering 7(2):1-7 DOI:10.26438/ijcse/v7i2.17

[4] Rathi, A., & Choudhary, A. (2016). Hybrid model for handwritten Devanagari script recognition using CNN-LSTM. International Journal of Advanced Research in Computer Science, 7(4), 25-30.

[5] Sai Prashanth Duddela (2023). Analysis on Classification of Handwritten Devanagari Characters Using Deep Learning Models, Applications and Techniques in Information Security, 10.1007/978-981-99-2264-2_18, 227-240.

[6] Najam, R., & Faizullah, S. (2023). Analysis of recent deep learning techniques for Arabic handwritten-text OCR and post-OCR correction. Applied Sciences, 13(13), 7568.

[7] AlKendi, Wissam, Gechter, (2024). Advancements and Challenges in Handwritten Text Recognition: A Comprehensive Survey" Journal of Imaging 10, no. 1: 18. https://doi.org/10.3390/jimaging10010018

[8] Moudgil, A., Singh, S., (2023). Handwritten devanagari manuscript characters recognition using capsnet. *International Journal of Cognitive Computing in Engineering*, *4*, 47-54.

[9] J. Memon, M. Sami, (2020). Handwritten Optical Character Recognition (OCR): A Comprehensive Systematic Literature Review (SLR)," in IEEE Access, vol. 8, pp. 142642-142668, doi: 10.1109/ACCESS.2020.3012542. 1-6.

[10] Verma, A., & Gupta, R. (2019). Robust CNN-based Hindi text recognition from natural images. Proceedings of the 2019 IEEE International Conference on Imaging Systems and Techniques (IST), 68-74.

[11] Dayvid Castro, Byron Leite (2024). An End-to-End Approach for Handwriting Recognition: From Handwritten Text Lines to Complete Pages. Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR) Workshops, pp. 264-273

[12] Bhosle, K., & Musande, V. (2023). Evaluation of deep learning CNN model for recognition of devanagari digit. In *Artificial intelligence and applications* (Vol. 1, No. 2, pp. 114-118).

[13] Alwagdani, M. S., & Jaha, E. S. (2023). Deep learning-based child handwritten Arabic character recognition and handwriting discrimination. Sensors, 23(15), 6774.

[14] Putra, E. D., Ermatita, E., & Abdiansah, A. (2025). Handwritten Kaganga script classification using deep learning and image fusion. *Bulletin of Electrical Engineering and Informatics*, *14*(2), 1290-1297.

[15] Jindal, A., & Ghosh, R. (2023). An optimized CNN system to recognize handwritten characters in ancient documents in Grantha script. *International Journal of Information Technology*, *15*(4), 1975-1983.