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From Pixels to Predictions Handwritten Digit Recognition using Deep Learning Techniques

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***Abstract:** Handwritten digit recognition is a fundamental problem in the field of deep learning, with applications ranging from postal services to finance. In this work, we explore the implementation of Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs) to predict and classify handwritten digits using the MNIST (Modified National Institute of Standards and Technologies) dataset, a well-known collection of handwritten digits. Our primary goal is to determine which of these methods offers higher accuracy in digit recognition. We started by preparing the MNIST dataset. Using this dataset, we construct two separate models: a CNN-based model and an RNN-based model. Both models were trained extensively to learn the intricate patterns and structures within the handwritten digits. This project lets us see which model works better, helping us make smarter choices when we want to predict numbers in different situations*

***Keywords:** Handwritten digit recognition, Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs), MNIST dataset, Accuracy.*

I. INTRODUCTION

In the realm of machine learning, accurately recognizing handwritten digits has broad applications, from security enhancements to data entry automation. In this project, we delve into digit recognition using Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs). Leveraging the MNIST dataset, a benchmark in this field, we aim to compare the effectiveness of CNNs and RNNs in digit classification. Through a process of data preprocessing, model development, training, and evaluation, we analyse the strengths of each neural network design. CNNs excel at capturing spatial patterns in images, while RNNs specialize in identifying sequential patterns in the strokes that form handwritten digits. By comparing these models, we gain valuable insights into their performance and practical applications. This research offers a concrete demonstration of CNN and RNN implementations in real-world scenarios, shedding light on their potential and their role in shaping the future of deep learning in digit recognition.

II. LITERATURE SURVEY

The study [1] used artificial neural networks (ANN) and convolutional neural networks (CNN) to tackle handwritten digit recognition, assessing their performance with the MNIST dataset. The research highlighted the importance of digit recognition in computer vision and employed techniques like backpropagation, gradient descent, and activation functions for model training. The conclusion favored CNNs over ANNs, demonstrating their superior performance in image classification. In summary, the study provided valuable insights into deep learning advancements in digit recognition. This study [2] explores teaching computers to recognize handwritten numerals using the K-Nearest Neighbors algorithm. The computer learns from a dataset of handwritten numeral images, identifying patterns to classify new images. The authors demonstrate its effectiveness through testing and anticipate future improvements for efficiency. Chao Zhang's team aimed to use a computer network to recognize handwritten numerals [3]. They trained the network on a large dataset of various writing styles. Testing with images of handwritten numbers achieved an impressive accuracy of about 97.3%. This technique holds promise for tasks like reading numbers on forms or documents. Researchers from Amity University in India used a CNN-based computer system for handwritten numeral recognition, utilizing the MNIST dataset [4]. Their system achieved remarkable accuracy, up to 99.89%, in recognizing digits from 0 to 9. Even with human-drawn images, the system performed exceptionally well. This highlights the effectiveness of CNNs in interpreting and recognizing handwritten numbers by computers.

III. PROPOSED WORK

The proposed method uses convolutional-neural-networks (CNNs) and recurrent-neural networks (RNNs) in effort to enhance the identification of handwritten numbers.

This project seeks to produce reliable and effective algorithms for classifying digits using the MNIST dataset as our base. The RNN model is suited to sequential data, capturing the temporal strokes of handwritten numbers, whereas the CNN model concentrates on spatial features, extracting complex patterns from photos. After thorough training and validation, a performance comparison of the CNN and RNN models reveals their respective advantages in digit recognition. The project's practical insights demonstrate the potential uses of precise digit recognition in sectors like postal services, finance, and security. By seamlessly integrating the power of CNNs and RNNs, our system paves the way for an improved digit recognition landscape. The project's outcome promises to offer valuable insights into the workings of neural network-based classification systems and their real-world applications.

IV. METHODOLOGY

In this project, we leverage Python's robust ecosystem, including key libraries like PyTorch, NumPy, Pandas, Scikit-Learn, and TorchVision, for data preprocessing and neural network construction. TensorFlow enhances computation with GPU acceleration. Vue.js creates an interactive user interface for digit input and predictions. Node.js hosts the interface, handling user requests and providing real-time model feedback. Our methodology focuses on supervised learning, training Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs) on labelled data for recognizing intricate patterns in handwritten digits. CNNs excel at image feature extraction, while RNNs capture digit stroke sequences, improving recognition of similar digits. The modules used here are:

A. Model Selection Module

This module empowers users to make a pivotal choice in selecting the suitable model for prediction. It facilitates an interactive platform where users can explore and decide between different deep learning models, such as Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs). Users can make an informed decision based on the system's performance metrics and their specific requirements. By enabling users to choose the model that aligns with their needs, this module enhances the flexibility and adaptability of the digit recognition system.

B. Image Upload Module

The Image Upload Module acts as a user-friendly gateway for inputting images into the system for digit recognition. Users can upload handwritten digit images, and the module processes and preprocesses them to match the model's requirements. This functionality facilitates user interaction with the system and bridges the gap between user data and model predictions, making it adaptable for various scenarios. After uploading, both the original and pre-processed images are displayed, offering users a visual representation and enhancing transparency in the preprocessing process.

C. Live Prediction Module

The Live Prediction module enables real-time digit recognition by utilizing the selected model. Users can interact with the system's interface to draw or write a digit directly. The module processes the drawn digit through the chosen model and promptly provides the predicted classification. This immediate feedback allows users to observe the model's performance in action and witness its accuracy in predicting the handwritten digit. The Live Prediction module offers an interactive and engaging way to experience the system's capabilities in real time. The Live Prediction Module enables users to draw digits directly within the user interface. The module then presents both the original and pre-processed versions of the image, enhancing user interaction and visualization.

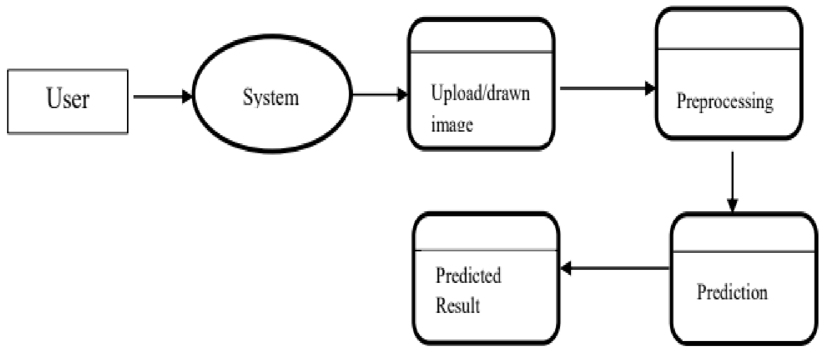

Fig. 1 Overview of the Proposed system

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V. RESULT ANALYSIS

The provided tables 1 & 2 and figures 2 & 3 depicts the accuracy and loss plotted against the number of epochs for both CNN and RNN model.

Table 1 Accuracy Comparison

SL No	Model	Accuracy
1	CNN	99.15%
2	RNN	98.74%

Table 2 Loss Comparison

SL No	Model	Loss
1	CNN	3.3127
2	RNN	3.8146

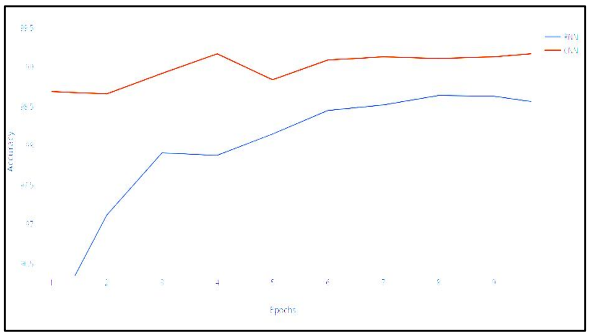

Fig 2 Accuracy Graph

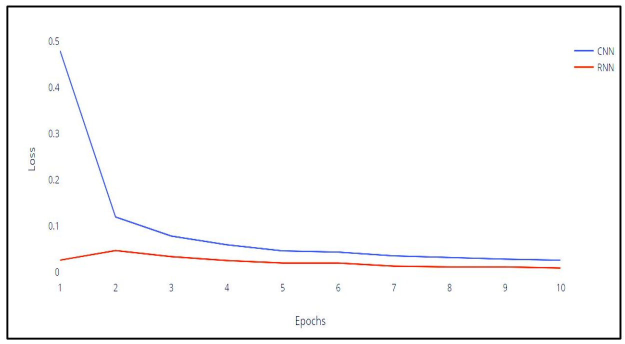

Fig 3 Loss Graph

Fig 4 illustrates the image upload process for the selected model, featuring the uploaded image, its pre-processed image, and the corresponding predicted result. Furthermore, Figure 2 presents a same scenario, highlighting the prediction of drawn images in real-time.

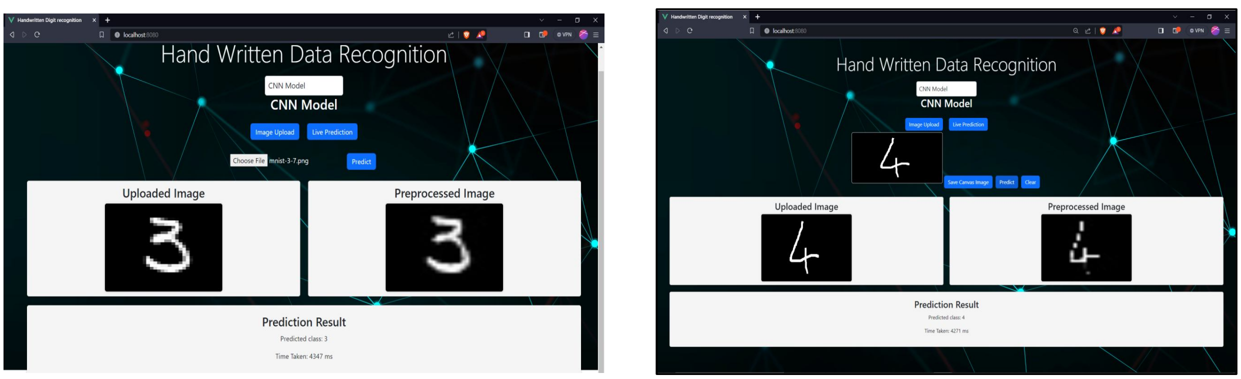

Fig 5 Live Prediction

VI. CONCLUSION

In this study, convolutional-neural-networks (CNNs) and recurrent neural networks (RNNs) are used in the application of handwritten digit recognition. By using these structures independently based on user preference, exact algorithms for digit categorization and prediction are made possible. Model selection, image upload, real-time prediction, and comprehensive evaluation are all parts of the procedure. In industries including banking, security, education, and postal services, accurate digit identification is important. This study enhances digit identification technology and demonstrates how CNN and RNN models differ in their application to actual problems.

It highlights the significance of personalized model selection to satisfy particular job needs while also highlighting the larger significance of machine learning. Finally, my project provides users with the option of CNN or RNN models for digit prediction, demonstrating the influence of various neural network designs on realworld applications.

VII. ACKNOLWDGEMENT

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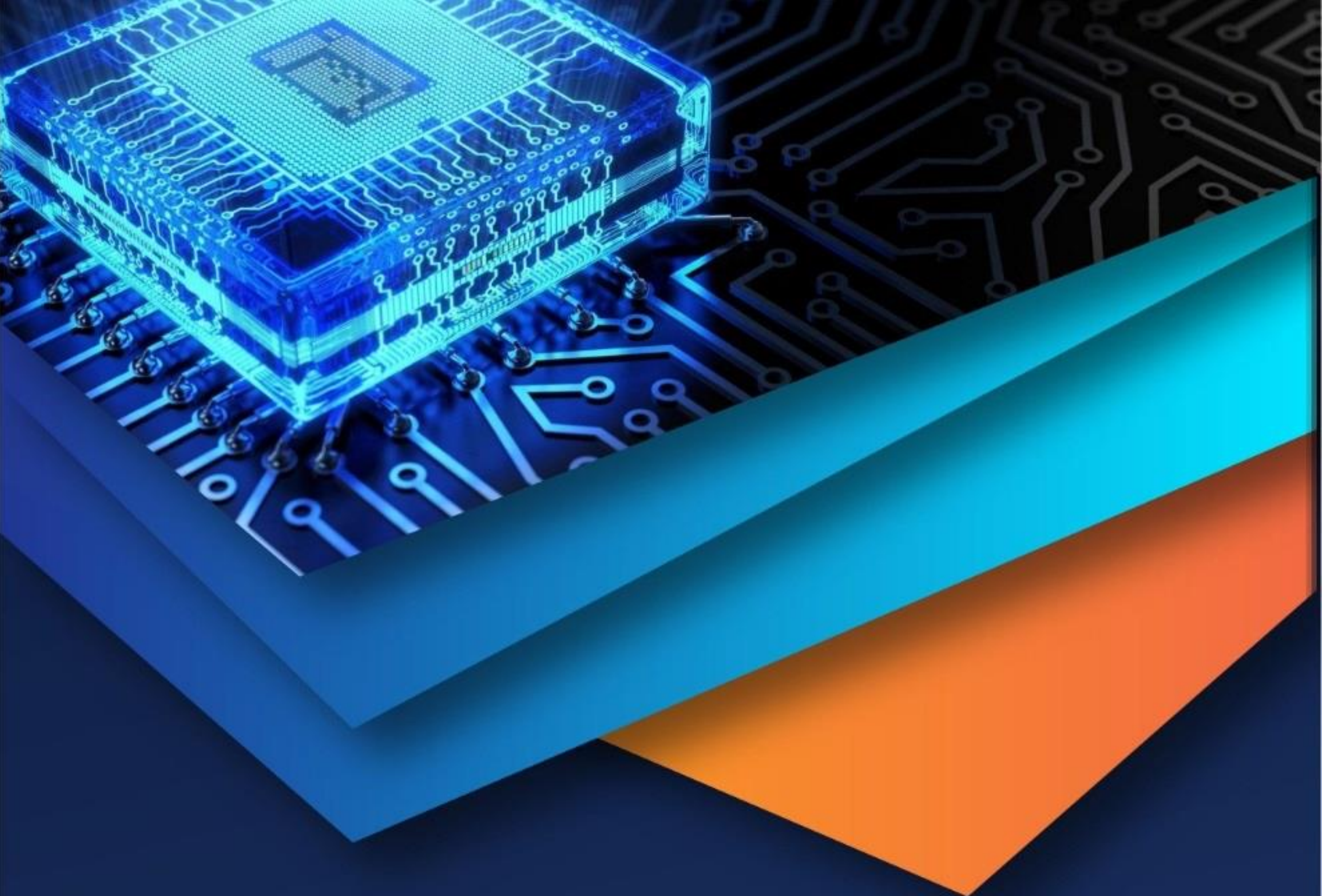

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