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**Dayananda Sagar University**

**School of Engineering**

**Devarakaggalahalli, Harohalli, Kanakapura Road, Ramanagara Dt., Bengaluru – 562 112**

**Department of**

**Computer Science & Technology**

**Mini Project-Report**

**On**

**Digit Recognition Using CNN**

**R For Data Analysis & Application Development**

**(22CT3507)**

By

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**Department of Computer Science & Technology**

**CERTIFICATE**

This is to certify that the work titled **“Digit Recognition using”** is carried out by **Danesh H M (ENG22CT0005), Lokesh J (ENG22CT0012) and Ahemad Talwar (ENG23CT1001)** Bonafide students of Bachelor of Technology in Computer Science and Technology at the School of Engineering, Dayananda Sagar University, Bangalore in partial fulfillment for the award of degree in Bachelor of Technology in Computer Science and Technology, during the year **2024-2025**.

**Dr. Santosh Kumar J Dr. M Shahina Parveen**

Associate Professor, Dept. of CST, Professor and Chairperson CST,

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**DECLARATION**

We, **Danesh H M (ENG22CT0005), Lokesh J (ENG22CT0012) and Ahemad Talwar (ENG23CT1001)** are students of the fifth semester B.Tech in Computer Science and Technology, at School of Engineering, Dayananda Sagar University, hereby declare that the project **“****Digit Recognition using Convolutional Neural Networks in R”** has been carried out by us and submitted in partial fulfillment for the award of degree in Bachelor of Technology in Computer Science and Technology during the academic year 2023-2024.

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**ABSTRACT**

The project focuses on digit recognition using convolutional neural networks (CNNs) implemented in R, addressing a significant challenge in the field of image-based machine learning. By leveraging advanced techniques and powerful libraries, this project automates the recognition of handwritten digits, providing a robust solution to tasks in diverse domains such as finance, logistics, and healthcare. The implementation explores various facets, including extensive data preprocessing, multi-stage model development, hyperparameter optimization, and detailed performance evaluation. With a foundation rooted in the MNIST dataset, a well-established benchmark in machine learning, this work exemplifies the application of CNNs to solve practical problems. The achieved accuracy of 85% highlights the system's capability and underlines its potential for broader applications. Moreover, this project sheds light on R’s versatility in executing complex machine learning workflows, offering a blueprint for future innovations.

**Keywords:** Digit recognition, convolutional neural networks, R programming, MNIST dataset, deep learning, machine learning, image classification.

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**CHAPTER 1**

**INTRODUCTION**

Recognition of digits is a problem which even though is basic but due to its numerous practical applications can prove to be rather complex for both pattern recognition and machine learning. It is concerned with the automatic recognition of one or more ary numeric alphanumeric or numeric characters as they appear in scanned or digitized images. This task requires robust algorithms that can handle different writing styles, images of different sizes and resolutions, and different noise levels. In this project, the challenges mentioned above are attacked using CNNs in R that classify handwritten digit from the MNIST database. The main aim is to develop a robust and high accurate system in order to automate bank check verification, automated mail sorting, and entering information contained in handwritten forms into the computer system. They are quite fit for this work due to their effectiveness in hierarchy feature extraction from image data. The project also integrates advanced capabilities of R and their application in real-world situations.

**Chapter 2**

**LITERATURE SURVEY**

**Background**

Digit recognition has long been a subject of extensive research, with traditional approaches such as template matching, statistical methods, and early machine learning techniques forming its foundation. However, with advancements in computational power and data availability, deep learning has emerged as the leading methodology for tackling complex image-based tasks. CNNs, in particular, have revolutionized the field by offering unparalleled performance in tasks requiring feature extraction and pattern recognition.

**Related Work**

* **CNN Architectures**: Over the years, several CNN architectures, including LeNet, AlexNet, and ResNet, have been developed and successfully applied to digit recognition tasks. LeNet, introduced by Yann LeCun, specifically targeted handwritten digit classification and laid the groundwork for subsequent advancements in deep learning.
* **MNIST Dataset**: The MNIST dataset is a standard benchmark in machine learning and deep learning research. Comprising 70,000 grayscale images of digits (60,000 for training and 10,000 for testing), it serves as a testing ground for evaluating the efficacy of models.
* **Applications of Digit Recognition**: Digit recognition is pivotal in various industries. For instance, financial systems use it for check processing, logistics rely on it for postal sorting, and healthcare applications leverage it for digitizing medical records.

**Tools and Libraries in R**

R provides an array of libraries, including caret, nnet, and mxnet, which facilitate machine learning and deep learning implementation. These libraries support data preprocessing, model building, evaluation, and visualization, enabling researchers to experiment with various methodologies efficiently. The versatility of R makes it an appealing choice for both beginners and advanced practitioners in the field.

**Chapter 3**

**REQUIREMENTS**

**3.1 Functional Requirements**

1. **Data Preprocessing:**
   * Import and normalize the MNIST dataset to ensure uniformity in data distribution.
   * Visualize sample images to identify patterns and verify data integrity.
   * Convert target labels into factor variables for seamless integration with classification algorithms.
2. **Model Development:**
   * Implement CNNs with a structured architecture comprising convolution, pooling, and fully connected layers.
   * Experiment with architectural variations to identify optimal configurations.
3. **Model Training and Evaluation:**
   * Train models using advanced optimization techniques like stochastic gradient descent.
   * Evaluate models based on comprehensive metrics, including accuracy, precision, recall, F1 score, and confusion matrices.
4. **Prediction Interface:**
   * Design an intuitive and user-friendly function to preprocess images and predict digits, enabling real-world applicability.

**3.2 Non-Functional Requirements**

1. **Performance**:
   * Ensure the system achieves an accuracy exceeding 80% on unseen test data.
   * Optimize computational efficiency to reduce training and inference times.
2. **Scalability**:
   * Build a system capable of handling larger datasets or more complex character recognition tasks without significant performance degradation.
3. **Usability**:
   * Provide well-structured, documented scripts to facilitate replication and adaptation.
   * Ensure modular code design, enabling easy integration into broader systems.

The project requirement specification outlines a comprehensive roadmap for the development of a robust digit recognition system. By clearly defining functional and non-functional requirements, the project ensures a structured approach that balances performance, scalability, and usability. The emphasis on data preprocessing, model development, and user-centric design underpins the success of the project, laying the groundwork for future advancements and adaptations in the domain of image-based machine learning.

**Chapter 4**

**PROBLEM DEFINITION**

The objective is to develop a robust and scalable digit recognition system using CNNs in R. The system aims to classify handwritten digits from the MNIST dataset accurately, addressing challenges such as varying handwriting styles, image noise, and resolution disparities.

**Vision**

To create an innovative and accessible digit recognition solution that simplifies and automates tasks requiring numeric data processing, enhancing efficiency across industries and benefiting society at large.

**Mission**

To leverage cutting-edge convolutional neural networks and the R programming environment to develop a reliable, scalable, and user-friendly digit recognition system that meets real-world needs and promotes technological progress.

**Relevance of the Problem**

Digit recognition plays a crucial role in automating tasks that involve numeric data entry. By minimizing human error and streamlining workflows, it enhances operational efficiency across industries. Applications like bank check processing, postal sorting, and automated form entry highlight its practical significance. This project contributes to advancing machine learning techniques for digit recognition, leveraging R as a powerful tool for statistical and computational analyses.

**Problem Validation**

The validation of the problem lies in the wide adoption of digit recognition systems across industries and their proven impact on operational efficiency. Studies and benchmarks using the MNIST dataset have consistently demonstrated the importance of accurate digit classification in streamlining workflows. Furthermore, real-world use cases such as postal sorting systems and check processing illustrate the tangible benefits of implementing robust digit recognition models. This project, by addressing challenges like data variability and noise, ensures that the developed system aligns with industry standards and meets practical needs effectively.

**Chapter 5**

**RESULT AND DISCUSSION**

This project implemented and evaluated multiple machine learning models, including logistic regression, single-layer neural networks, and CNNs. The results reveal significant insights:

1. **Logistic Regression**:
   * Achieved a baseline accuracy of approximately 60%.
   * Exposed limitations in handling high-dimensional image data, emphasizing the need for more sophisticated models.
2. **Single-Layer Neural Networks**:
   * Improved accuracy to around 75%, demonstrating the potential of neural networks in learning patterns from data.
   * Highlighted the importance of hidden layers in enhancing model capacity.
3. **Convolutional Neural Networks**:
   * Achieved the highest accuracy of 85%.
   * Demonstrated exceptional ability in extracting spatial hierarchies and robust patterns from image data.

The CNN model incorporated techniques like dropout regularization and batch normalization to prevent overfitting and ensure generalization. Feature map visualizations revealed the model’s capability to focus on critical aspects of handwritten digits, further validating its design. The evaluation metrics confirmed the superiority of CNNs over other models in this context.

**Chapter 6**

**CONCLUSION AND FUTURE WORK**

This project successfully developed a digit recognition system using CNNs in R, achieving an accuracy of 85% on the MNIST test dataset. The findings underscore the effectiveness of CNNs in image classification and highlight the potential of R as a viable platform for implementing deep learning models.

**Future Work**

1. **Enhanced Architectures**: Explore advanced architectures such as ResNet, DenseNet, or transformers to improve accuracy and robustness.
2. **Broader Datasets**: Extend the system to recognize alphabets, symbols, or multi-digit sequences, making it more versatile.
3. **Real-World Integration**: Develop mobile or web-based applications for real-time digit recognition, integrating the system into practical use cases.
4. **Optimization**: Investigate methods to reduce computational costs, enabling deployment on resource-constrained devices.

**REFERENCES**

1. **"An Introduction to Statistical Learning with Applications in R"** by Gareth James, Daniela Witten, Trevor Hastie, and Robert Tibshirani  
   Provides a gentle introduction to statistical modeling in R.  
   link = https://www.statlearning.com/
2. **"Machine Learning with R"** by Brett Lantz  
   Teaches machine learning algorithms and their implementation in R.  
   Link = <https://community.alteryx.com/t5/Data-Science/Book-Review-Machine-Learning-with-R/ba-p/438366>
3. **"Applied Predictive Modeling"** by Max Kuhn and Kjell Johnson  
   Comprehensive guide to predictive modeling techniques using R.  
   Link = <https://link.springer.com/book/10.1007/978-1-4614-6849-3>
4. **"R for Data Science"** by Hadley Wickham and Garrett Grolemund  
   Focuses on data analysis and visualization using R.

Link = <https://digitallibrary.tsu.ge/book/2019/september/books/R-for-Data-Science.pdf>

1. **"The Art of R Programming: A Tour of Statistical Software Design"** by Norman Matloff  
   Covers the fundamentals and programming aspects of R.

Link= https://www.researchgate.net/publication/254296013\_The\_Art\_of\_R\_Programming\_A\_Tour\_of\_Statistical\_Software\_Design\_by\_Norman\_Matloff

1. **"Artificial Intelligence: A Modern Approach"** by Stuart Russell and Peter Norvig  
   A foundational book covering a wide range of AI topics, including machine learning.

Link = https://people.engr.tamu.edu/guni/csce421/files/AI\_Russell\_Norvig.pdf