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A State of Art Comparison of Models Used in Kannada Hand-Written Digit Classification

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Abstract

Benchmark datasets play a crucial role in the constantly changing field of handwritten digit recognition. This review paper acknowledges the current lack of standardized datasets for Indian languages, especially Kannada, while anticipating the evolving landscape. It will review the state of the art with a specific focus on Kannada handwriting digit categorization, meticulously examining datasets from established sources like NIST and MNIST to the unveiling of the Kannada Handwritten Digits dataset (KHTD). The analysis will span the range of accessible resources. Traditional machine learning methods and state-of-the-art deep learning architectures will be thoroughly compared, providing insightful information for both experienced researchers and practitioners. This paper aims to be a valuable resource that will fill a vacuum in standardized datasets and pave the way for future research in the field of Kannada handwritten digit categorization. It is positioned to encourage advances in Kannada OCR systems.

Keywords: Character Recognition, Kannada Character Recognition, Deep learning, Machine Learning, Classification, Image Classification

Introduction

In the realm of handwritten digit recognition, the significance of benchmark datasets cannot be overstated. These datasets serve as invaluable tools for researchers to evaluate and compare the performance of various classification models. While numerous benchmark datasets exist for several languages, the scenario is markedly different in the context of Indian languages, particularly Kannada.

Even though India is a multilingual, multi script country, there are still few standard datasets available for handwritten character identification in Indian languages. The majority of existing datasets are devoted to languages like Bangla, Devanagari, or Gurumukhi, which leaves a clear gap in the benchmark datasets for text-pages of Indian languages, particularly Kannada.

One of the major Dravidian languages, Kannada, has a separate set of characters, including numerals, and a unique script. Because Kannada script is so complex and individual writing styles are so different, it might be difficult to recognize Kannada numerals in their handwritten form. Researchers have suggested and constructed a number of models utilizing state-of-the-art methods in deep learning, neural networks, and image processing to address this difficulty.

Current datasets such as NIST, MNIST, CENPARMI, and CEDAR are primarily designed for use with English databases; they include large sets of delimited characters, words, and text pages. But the lack of benchmark datasets for handwritten text-lines in Indian languages, Kannada included—has hampered the advancement of OCR (Optical Character Recognition) systems that are suited to the subcontinent's diverse linguistic landscape.

In recent years, the field of image classification has witnessed unprecedented advancements, owing to the rapid evolution of machine learning and artificial intelligence. Amidst this progress, the specific domain of handwritten digit classification has garnered significant attention, given its applications in diverse fields such as optical character recognition, document analysis, and digit-based language processing. This paper delves into the nuanced realm of Kannada handwritten digit classification, focusing on the exploration and comparative analysis of state-of-the-art models.

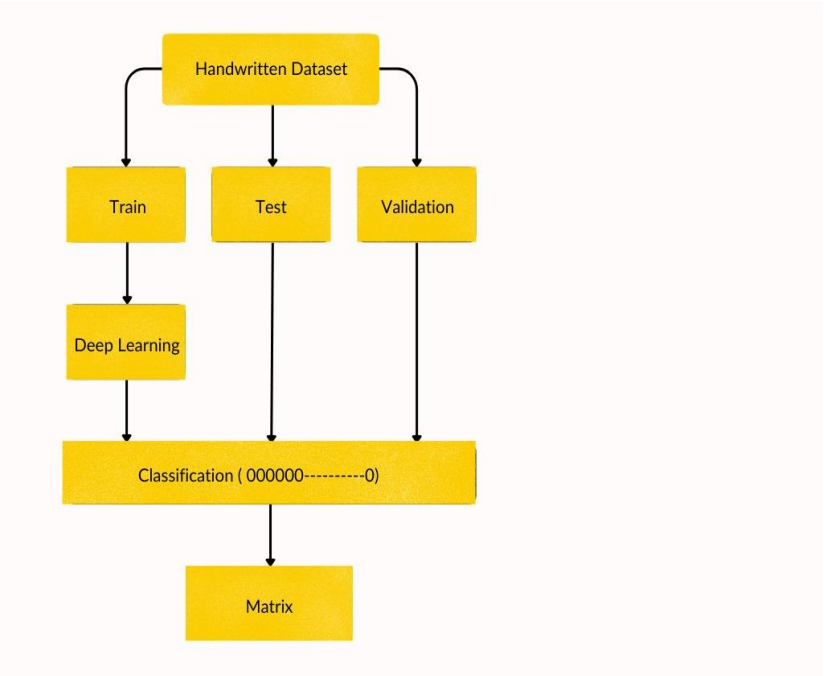

Fig 1. Flow Diagram of Handwritten Digit Classification

Fig 1 depicts the flow of classification of handwritten digits. This review study starts with an extensive investigation of the most popular models used for the categorization of handwritten Kannada numbers. The aim is to furnish scholars, professionals, and amateurs with a comprehensive comprehension of the current state of affairs, so they can select a model that best suits their own needs. Traditional machine learning algorithms and cutting-edge deep learning architectures are among the models under examination; each has advantages and

disadvantages of its own.

1. Machine Learning In Character Recognition

1.1 What is Machine Learning?

Machine Learning is a subfield of computer science and artificial intelligence (AI) which focuses on, using data and algorithms to simulate human learning processes and progressively increase their accuracy

In the science of artificial intelligence, machine learning (ML) is the study and creation of statistical algorithms that can recognize patterns in data, extrapolate those patterns to new data, and carry out tasks without explicit guidance. A lot of earlier methods have been surpassed in performance by generative artificial neural networks recently.

When developing algorithms to accomplish the necessary tasks would be too expensive, machine learning techniques have been used in fields like email filtering, audio recognition, computer vision, huge language models, agriculture, and medicine. Predictive analytics, a term that refers to ML's use in solving various business challenges, Computational statistics serves as a major source of approaches in machine learning, even though the subject is not entirely reliant on statistics.

A crucial element of the developing study of data science is machine learning. Statistical techniques are used to train algorithms to identify relevant information in data mining projects and to generate predictions or classifications. These insights then guide decisions on applications and business, which ideally have an impact on critical growth indicators. Data scientists will be in greater demand as big data continues to grow and flourish.

1.2 Classification of Hand Written Characters:

The classification of handwritten characters is a fundamental task in the field of pattern recognition and computer vision. Handwritten characters exhibit a high degree of variability due to individual writing styles, making this task inherently challenging. The goal of handwritten character classification is to develop models that can accurately identify and categorize individual characters based on their visual representations.

One of the primary applications of handwritten character classification is in Optical Character Recognition (OCR) systems, where the task involves converting handwritten or printed text into machine-encoded text. This process finds widespread use in document analysis, digitization of historical manuscripts, automatic form processing, and various other domains**.**

1.3 Models:

Machine learning plays a crucial role in digit classification, where the goal is to develop models that can accurately recognize and classify handwritten or printed digits. Various machine learning models have been employed for digit classification, each with its own strengths and characteristics. Here are some of the main models used in digit classification:

3.3.1 Support Vector Machines (SVM),

3.3.2 K-Nearest Neighbors (KNN),

3.3.3 Decision Trees,

3.3.4 Neural Networks,
3.3.5 Logistic Regression,
3.3.6 Ensemble Methods,
3.3.7 Naive Bayes,
3.3.8 Principal Component Analysis (PCA),
3.3.9 Autoencoders,
3.3.10 Extreme Learning Machines (ELM).

2. Related Work

Character Recognition in Natural Images paper [1] introduced a database of images of street scenes taken in Bangalore, India and showed that even commercial OCR systems are not well suited for reading text in such images. This paper tackled the problem of recognizing characters in images of natural scenes.

Character recognition in natural scene images using Rank-1 tensor decomposition [2] work proposed solution to the problem of natural scene character recognition that avoids dependency on local features. For each training/testing image, a 3-mode tensor of rotated instances of the image is formed. Then decomposed that tensor using rank-1 Tucker decomposition. 12CDML framework is used for classification purpose.

Various feature extraction and classification techniques used for recognition of handwritten Indic scripts. The lack of good benchmark and quality of the dataset is one of the basic issues in several Indic scripts. This obtained by [3] Offline recognition of handwritten Indic scripts.

In [4], A database of handwritten text-pages of Kannada that contains 204 handwritten text-pages. It has also two different ground truths based on pixels and text-content information.

The capsule network and CNN is used for classification of off-line Kannada handwritten letters [5]. By this we can able to handle raw images, saving preprocessing time, to preserve positional information of entities, which helps in the recognition of not only letters but words, owing to the complex letter formation style in the language.

An exhaustive review of the state of the art for both, the MNIST and EMNIST databases is obtained by a Survey [6]. The MNIST database of handwritten digits was used to validate computer vision algorithms, also as a benchmark to test different convolutional neural networks architectures and approaches.

Provided details of structure, statistics, ground truth information and the tasks supported for each databases. These databases usually focus on one or more of the activities related to segmentation, recognition, and preprocessing. This obtained by [7] the survey of handwritten document benchmarks: structure, usage and evaluation.

The various techniques/methods which are used for Handwritten Character Recognition are obtained [8]. And also discussed, how a system can be designed to recognize different handwritings and some useful datasets like EMNIST, IAM.

3. Summary

Rf. no	Author	Methodology/ Algorithm	Works
[1]	Teofilo de Campos, Bodla Rakesh Babu, Manik Varma	Nearest neighbour (NN), support vector machines (SVM), multiple kernel learning (MKL).	Enhancing character recognition in street scene photos, especially in Bangalore, India, is the main goal of this work. In addition to introducing a database and highlighting the shortcomings of commercial OCR systems.
[2]	Muhammad Ali and Hassan Foroosh	Image-to-Class Distance Metric Learning (I2CDML), Tensor Representation and rank-1 Decomposition.	Using 3-mode tensor decomposition and a 12CDML framework to capture shape and font variations, the research presents a unique strategy for natural scene character recognition that outperforms baseline methods and achieves enhanced recognition performance using leave-random-one-out cross-validation.
[3]	Reya Sharma, Baijnath Kaushik	Particle Swarm Optimization (PSO), Convolutional Neural Network (CNN)	In addition to highlighting the significance of dataset size and quality, the paper offers a thorough survey of feature extraction and classification techniques for handwritten Indic script recognition. It also proposes a novel framework based on an improved PSO algorithm for optimal CNN architecture.
[4]	Alireza Alaei, P. Nagabhushan, Umapada Pal	Potential Piece-wise Separation Line (PPSL), Text-line segmentation technique.	This paper introduces the Kannada Handwritten Text Database (KHTD), comprising 204 handwritten text-pages with two ground truths based on pixels and text content, facilitating evaluation of algorithms in various document image processing tasks for Kannada language.
[5]	Ramesh. G, J. Manoj Balaji, Ganesh. N. Sharma, Champa H.N	Capsule Network technology.	This paper utilizes Capsule Networks and CNNs for off-line Kannada handwritten letter classification, demonstrating superior performance over conventional techniques by preserving positional information for recognizing complex letter formations and words.

[6]	Alejandro Baldominos, Yago Saez, Pedro Isasi	Tensor Flow, K-NN k-nearest neighbors, BFGS Broyden-Fletcher-Goldfarb-Shanno algorithm.	This paper extensively reviews the state of the art in computer vision, focusing on the MNIST and EMNIST databases, evaluating the evolution of techniques over two decades, highlighting the role of convolutional neural networks, data augmentation, and hardware advancements in achieving competitive results.
[7]	Raashid Hussain, Ahsen Raza, Imran Siddiqi, Khurram Khurshid, Chawki Djeddi	Comparison of Datasets	In order to help researchers select relevant datasets for assessing suggested systems, the study offers an extensive assessment of databases in handwriting recognition over the last 20 years, describing their architecture, statistics, ground truth data, and supported activities.
[8]	B M Vinjit, Mohit Kumar Bhojak, Sujit Kumar, Gitanjali Chalak	Edge-detection, skew detection, Back propagation algorithms.	The paper reviews techniques for Handwritten Character Recognition, emphasizing the importance of feature extraction and classification methods, and highlights the significance of quality data and neural network design for improved recognition systems.

Table 1. Summary of Algorithms Used

4. Conclusion

In conclusion, this review paper illuminates the critical importance of benchmark datasets in the realm of handwritten digit recognition, emphasizing the existing gap in standardized datasets for Indian languages, particularly Kannada. Through an extensive exploration and comparative analysis of state-of-the-art models, ranging from traditional machine learning algorithms to cutting-edge deep learning architectures, the review provides valuable insights for researchers, professionals, and enthusiasts. This endeavor not only contributes to the field by bridging the gap in available resources for Kannada but also sets the stage for future research endeavors in Kannada OCR systems. Overall, the comprehensive exploration, analysis, collectively position this review as a significant and foundational resource in the advancement of Kannada handwritten digit classification.

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