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AI-BASED KANNADA SCRIPT RECOGNITION FOR DIGITAL DOCUMENT PROCESSING

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ABSTRACT

The digitization of regional language documents is essential for preserving cultural heritage and enabling efficient information access. Kannada, a widely used Dravidian language, presents significant challenges for optical character recognition (OCR) due to its complex script structure, compound characters, and high intra-class variability. This paper proposes an AI-based Kannada script recognition system for effective digital document processing using deep learning techniques. The proposed framework employs convolutional neural networks (CNNs) for automatic feature extraction and classification of printed and handwritten Kannada characters. Image preprocessing techniques such as noise removal, normalization, and segmentation are applied to enhance recognition accuracy. The model is trained and evaluated on a benchmark Kannada character dataset, achieving high recognition accuracy and robustness against variations in font style, size, and writing patterns. Experimental results demonstrate that the AI-based approach significantly outperforms traditional machine learning methods in terms of accuracy and scalability. The developed system can be effectively integrated into digital archiving, e-governance, and document management applications, contributing to the advancement of regional language OCR and intelligent document processing systems.

KEYWORDS: Kannada Script Recognition, Optical Character Recognition (OCR), Artificial Intelligence, Deep Learning, Convolutional Neural Networks (CNN), Handwritten Character Recognition, Printed Text Recognition, Image Preprocessing, Document Digitization,

Regional Language OCR ,Kannada handwritten characters, CNN, Xception, InceptionV3, MobileNetV2, ResNet50V2.

INTRODUCTION

Native cultures are rapidly becoming diluted as a result of increased relocation brought on by jobs, education, facilities, and the impact of Western tendencies. The majority of cultures depend on the first language. Enhancing the language's adaptability so contributes significantly to mitigating the global threat. Being an IT (Information Technology) Hub provides refuge to individuals from many states and countries and leads to a progressive reduction in the utilization of the Kannada Language. This essay aims to provide free character recognition software for handwritten Kannada so that even non-Kannada speakers may rapidly identify handwritten text in the language. It does, however, only have a few alphabets, which, despite their similarities, differ, increasing trouble in accurately recognizing alphabetic characters. Additionally, the difficulti-`/+es double when handwritten alphabets are included. Since everyone has different handwriting.

The Kannada alphabet has more curvatures than the English alphabet, but it is very similar to other South Indian language characters. Unlike its straight-lined print, Handwritten Kannada's curvy characters inspired our eepearning model to decipher vowels and consonants easily. Curves rule in handwritten Kannada, making conventional recognition stumble. In every iteration, the deep learning technique methodically recognizes vowels and consonants.

Convolutional neural networks, the most widely used deep learning technology, are employed in this paper (CNN). CNN is an approach that came about as a result of machine learningtechniques and is built on numerous hidden layers. Deep learning is a suitable technique for recognizing handwritten characters. In day-to-day life, handwritten characters or digit recognition can be used for various purposes. It can be utilized for instructional purposes, to read cheques in banks, to evaluate a person's signature, etc. One kind of neural network that is built using convolution fully connected layers is the convolutional neural network.

A. Motivation

Convolutional Neural Networks (CNNs) for Kannada character recognition are highly motivated and significant in many ways. First of all, it is essential to the preservation and advancement of the rich Kannada language, helping it to adapt to the digital era. As the world becomes increasingly interconnected, automation of Kannada character recognition becomes crucial, enabling text processing, content indexing, and translation in Kannada, which, in turn, supports educational institutions, enhancing language learning and literacy rates. Moreover, in the business world, it streamlines data entry processes, especially for companies that need to handle Kannada text. This project isn't just about technology; it's about safeguarding cultural heritage, as it empowers the Kannada-speaking community to communicate, educate, and conduct business more effectively in their native language.

B. Objectives

The following are the objectives of the proposed work

1. Recognise the Kannada character for digitizing the handwritten documents
2. Compare CNN Architectures like MobileNet, ResNet50V2, InceptionV3, and Xception to determine the performance of Kannada character recognition applications.

C. Scope

The problem statement in Kannada character recognition using Convolutional Neural Networks (CNNs) is vast and varied, embracing a variety of features that highlight the project's importance and usefulness.

To begin, the scope includes the creation of strong and adaptive machine-learning models and algorithms capable of properly recognizing and classifying Kannada characters. This comprises the development of a large dataset of Kannada characters, as well as pre-processing techniques and model training, all to achieve high accuracy and robustness.

Furthermore, the project handles the problem of multi- class character recognition by accepting a wide range of Kannada script characters, including consonants, vowels, and their combinations. The scope also includes handwritten character recognition, making it useful in real-world circumstances with a variety of writing styles.

LITERATURE REVIEW

In this literature survey, we have read numerous research papers regarding this topic. For our literature synthesis, we are referring to the paper published by MSRIT, which has an accuracy rate of 97%. They have created their dataset. They have classified both alphabets and numerals. 5 different types of writing styles have been used. Due to various writing styles, they had to use different techniques to identify, such as image processing (for thickening) and segmentation techniques (for edge detection).

The use of machine learning methods, including Support Vector Classifier (SVC), Convolutional Neural Networks (CNN), and Decision Trees (DT), is utilized in [1], which is used as a reference to categorize a range of 603 Kannada characters. This paper uses a handwritten MSRIT Kannada dataset. The machine learning algorithms achieved a 97.42% test accuracy using the decision tree method. Optical Character Recognition (OCR) is an excellent technique for classifying printed letters. Nevertheless, its effectiveness depends heavily on a large amount of training data as well as the application of several pre-processing, text-recognition, and post-processing techniques.

In [2], to identify and categorize Kannada alphabets, it focuses on pre-processing images and applying classification techniques like Decision Trees and Random Forests. The handwritten Kannada alphabets on sheets done by MSRIT students, written by various individuals in various styles, were the source of this dataset. Decision Trees and Random Forest Classifiers [ML] are utilized in this paper. For multi-class classification, the Random Forest Model's accuracy, consisting of an ensemble of 300 trees, was found to be between 72% and 76.7%.

In [3], the creation and application of Convolutional Neural Networks is the main emphasis of this approach. The Chars74K dataset is made up of a collection of pictures that are organized into more than 657 classes, each of which has 25 handwritten characters. This uses the Convolutional Neural Network (CNN) model [D.L], which has a 98% accuracy rate for non-overlapping character lines.

The main objective of the [4] is to recognize handwritten Kannada letters automatically. This technology can be used for many different things, such as reading Kannada literature, digitizing handwritten documents, and helping blind people see signs and boards. They collected the handwritten training set from NMAM Institute of Technology students and the Web, segmenting each letter. Tesseract tool and Convolutional Neural Network (CNN) was used. And have achieved 86% and 87% accuracy, respectively. The report also discusses previous studies on English character identification as well as cutting-edge text recognition methods. It draws attention to the difficulties in identifying handwritten scripts and the requirement for a particular method for Kannada language recognition.

In the paper [5], character recognition for Indic scripts is the subject of this research, which focuses on handwritten Kannada characters and uses the Char74k dataset for training and data pre-processing. The Random Forest Classifier (RFC), MultiNomial Naive Bayes Classifier (MNNBC), and Convolutional Neural Network (CNN) have all been used in this work. It has a 57% accuracy rate in identifying handwritten Kannada characters.

The authors in [6] discuss the theoretical foundation of SVM and the steps involved in the recognition algorithm, including size reduction, normalization, feature scaling, and conversion to CSV format. A customized dataset consisting of Kannada letters is used. All ten of MSRIT's font styles were used to write the Kannada letters, creating the dataset.

Support Vector Machine (SVM) algorithm was used and achieved efficiency on the pre-processed test at 96.77% and efficiency on the pre-processed as 89.16%. The paper starts with data acquisition, where samples of Kannada letters written in different handwriting styles are obtained. The paper then describes the pre-processing steps, including size reduction, normalization, and feature scaling, to prepare the images for classification.

The authors in [7] used unique feature extraction approaches and classifiers to advance OCR systems, especially for handwritten character recognition. Here, Curvelets via Wrapping Transform and Fast Discrete Curvelet Transforms (FDCTs) were used. And achieved a 90% accuracy. Principal component analysis was used. The Nearest Neighbor Classifier is used to identify the handwritten Kannada characters.

The authors in [8] have used Advancing OCR systems to efficiently recognize handwritten Kannada characters, contributing to Document Image Analysis, accessibility, automation in libraries & aiding the visually impaired. The K- Nearest Neighbor approach yielded an accuracy of 87.33% when wrapping-based Curvelet Transform, Principal Component Analysis (PCA), and Nearest Neighbor Classifier techniques were applied. This enhances handwritten Kannada character recognition through the development of an effective hybrid feature extraction technique. The approach leverages both local and global features, showcasing promising results and paving the way for future research in handling more complex handwritten Kannada characters.

Paper [9] uses handwritten Kannada characters for Optical Character Recognition (OCR). The study focuses on the recognition of Kannada vowels and number symbols utilizing shape-based characteristics like Fourier descriptors and chain codes. A dataset of handwritten Kannada vowels, consonants, and numerals has been produced by them. The Support Vector Machines (SVM) approach was used for classification. For the number of characters, the recommended approach yielded an overall recognition accuracy of 98.65%. The average recognition accuracy for vowels was 93.92%. The use of shape-based features is justified in the research due to its capacity to handle the variation of handwritten character samples in both the frequency and spatial domains. The shape's overall characteristics are captured by the Fourier descriptors.

The research in [10] applies to the field of Handwritten Character Recognition (HCR), which has several uses, including automated data entry, bank check reading, automated document classification, and reading forms filled out by customers. The researchers themselves generated the dataset that was used in this work. SVM is used for classification problems, such as the recognition of handwritten Kannada letters using a multi-class SVM classifier. For the Kannada character set, an average recognition accuracy of 87.24% was attained. The splits between the foreground and background pixels are represented by a series of straight-line segments that are used to encode the character's boundaries. This technique does not require thinning and is unaffected by the handwritten characters' size.

TABLE I. YEAR-WISE CLASSIFICATION OF PAPERS ON KANNADA CHARACTERS

Year	Algorithm	Accuracy	References	Limitation
2011	Optical Character Recognition (OCR)	93.92%	[9]	Variation of Handwritten characters
2013	K-Nearest Neighbor technique (KNN)	87.33%	[8]	Sensitivity of the noise
2013	Support Vector Machines (SVM)	87.24%	[10]	The Time Complexity of this was high.
2015	Fast Discrete Curvelet Transforms (FDCTs)	90.01%	[7]	Not enough data to support the detailed features
2018	Convolutional Neural Network (CNN) model	98.08%	[3]	-
2019	Convolutional Neural Network (CNN)	87.01%	[11]	The training phase was slow for all the Kannada characters
2019	Convolutional Neural Network (CNN)	57.35%	[5]	The drawback is that it takes a considerable amount of time for classification.
2020	Decision Tree & Random Forest Classifiers	40.6% - 47.01% 72.01% – 76.7%	[2]	Overfitting the training data, small variation in the data
2021	Support Vector Machine (SVM) algorithm	90.77%	[6]	Takes more training time
2022	Decision Tree (DT)	97.42%	[1]	Overfit the training data

The [11] focuses on the application of Convolutional Neural Networks (CNNs) for Kannada handwritten character recognition. The system architecture involves data division, data preparation, classification, and result analysis. Convolutional Neural Networks (CNNs) were used and achieved For the consolidated dataset as 93.2% and for the raw dataset, the accuracy achieved is 78.73%. Traditional OCR techniques are less effective in handling Kannada characters, making deep learning approaches like CNNs a promising solution. The system architecture of the proposed method involves data division, data preparation, classification, and result analysis.

In the paper [12], a stroke-based technique for text- independent writer identification in Indic scripts, with an emphasis on Telugu and Kannada languages, is presented in this work. On the Kannada dataset, the suggested method obtains 100% writer identification accuracy, demonstrating its excellent accuracy. To identify the document, the strokes from handwritten documents are extracted, clustered, and then their distribution is used to generate a stroke alphabet. Support Vector Machines, are employed in classification. The technique offers a simple and efficient algorithm for identifying a writer's handwriting style. However, it could need a lot of training data, and it might have trouble telling different writers with similar handwriting styles apart. The usefulness of the suggested strategy in the context of Indian scripts is demonstrated in the paper through experimental analysis using handwritten datasets of Telugu and Kannada scripts.

The [13] uses a collection of scanned images of printed Kannada text and this study focuses on Kannada character recognition. The font independence and training database reduction is achieved via the k-means clustering algorithm. The suggested method achieves an accuracy of about 95%. The recommended method's advantages include faster recognition and font independence; its disadvantage is that it becomes more susceptible to font changes as the number of clusters employed grows.

In [16], a method for identifying handwritten Kannada characters and turning them into speech is presented. Then 3 million images of simple handwritten Kannada characters, such as Swaras and Vyanjanas, are included in the dataset for classification, and the instance-based learning method K- Nearest Neighbor (K-NN) is applied. 84.72% recognition accuracy is attained when just specific moments in the test image samples' features are taken into account. By turning recognized characters into speech, the system has the potential to help kids with learning difficulties like dyslexia. The low recognition accuracy, which would require more development for some applications, could be a drawback.

In [19], the primary goals of the paper are the creation of a dataset for handwritten Kannada characters and the use of machine learning models to evaluate its resilience. The dataset consists of 130,981 samples for 85 classes divided into upper, lower, and intermediate zones. The authors used unsupervised approaches, K-means clustering, and hand annotation to generate the dataset. To identify the characters, they used convolutional neural network (CNN) and support vector machine (SVM) models, achieving accuracies of 92.2%, 88.6%, and 99.0% for the bottom, middle, and upper zones, respectively. High recognition accuracies and the use of unsupervised learning for dataset annotation are two advantages of the strategy. The authors did point out that some classes were unbalanced, necessitating the use of oversampling and under sampling techniques.

In [20] using deep learning and image preparation techniques presents an effective solution for Kannada handwritten character recognition. The experimental dataset is made up of an assortment of pictures from different sources. Deep Neural Networks (DNN) are used by the suggested approach to extract features and classify them. 95.11% accuracy was attained during training, while 86% accuracy was attained during testing. The suggested approach has the benefits of bridging the gap between humans and technology, facilitating the easy accessibility of ancient handwritten records, and being practical in government and medical settings. Reduced accuracy resulting from handwriting variances and the requirement for a GPU to increase processing speed are the drawbacks.

The [22], explores the application of Convolutional Neural Networks (CNNs), a kind of deep learning method, to the identification of handwritten Kannada characters. The study's dataset consists of handwritten Kannada characters, and feature extraction and classification are accomplished via the CNN technique. The model shows its effectiveness in recognizing Kannada characters by achieving an accuracy of 95.11% throughout training. The study does, however, also draw attention to the difficulties of obtaining real-time handwritten data, which could result in decreased accuracy because handwriting styles vary widely. Notwithstanding this drawback, the suggested paradigm offers a great benefit in terms of bridging the gap between people and computers, especially when it comes to government sectors and the replication of historical Kannada documents. It is also suggested that there is room for improvement by creating a hybrid algorithm that combines K-NN, CNN, and ANN to increase the accuracy and performance of the model.

In [24], the identification of Kannada characters from images is the main topic of the study. The dataset presented in the article consists of Kannada characters, and the suggested method leverages the Support Vector Machine (SVM) as the classifier. For printed characters, the accuracy is 100%, while for handwritten characters, it is 99%. The system's potential sensitivity to changes in handwriting styles is one drawback. The advantage is that it can identify printed and handwritten Kannada characters with a high degree of precision.

In [25], using the English and Kannada datasets as a primary emphasis, the report discusses research on character identification in natural photographs. According to the findings, the multiple kernel learning (MKL) approach produced the greatest results, with an accuracy of 55.26% after 15 photos per class were used for training. Character recognition accuracy in natural photos can be improved, as this technology proved when it outperformed the commercial OCR system ABBYY FineReader. A compositional or hierarchical approach is recommended because of the document's emphasis on the difficulties in identifying Kannada characters and the abundance of visually diverse classes.

In [26], the classification of handwritten Kannada characters using several image processing methods and machine learning models is covered. Chars74K and PSCube, a custom dataset, were the datasets used. The ML/DL techniques used are Support Vector Machines (SVM), K Nearest Neighbors (k-NN), Convolutional Neural Networks (CNN), and Inception V3. Test accuracy is the performance metric employed, and CNN obtained 99.84% accuracy on the Chars74K dataset. OpenCV, Keras, and TensorFlow are some of the hardware and software utilized. The paper's main conclusions are that CNN is good at identifying Kannada characters and that augmentation and pre-processing methods are crucial for raising classifier accuracy.

In [28], using transfer learning from a Devanagari recognition system, the paper focuses on handwritten Kannada character recognition. In addition to 92000 instances of Devanagari characters belonging to 46 classes, the dataset employed comprises 188 classes of the Kannada alphabetical set with 31654 training and 9401 test cases. The deep convolutional neural network architecture VGG19NET is the Machine learning technique that is being employed. With a verified accuracy of 73.51% and a loss of 16.01%, accuracy is the performance metric that is employed. To achieve better results, VGG19 was used to conduct the trials. Nothing in the snippets provided specifically mentions the hardware or software used.

The main insight from the paper is that handwritten Kannada characters can be accurately recognized through the successful application of transfer learning from a larger dataset of Devanagari characters. This shows how transfer learning can be used to address issues related to limited data availability in certain realms.

In [30], the study focuses on recognizing handwritten Kannada characters by applying deep learning and machine learning methods. The dataset under investigation has 1,225 images that include vowels, consonants, and gunitaksharas. There are 49 classes in the dataset, and each class has 25 pictures. Two machine learning algorithms that are utilized for recognition are KNN and SVM. CNN is a deep learning method that is separated into parts for feature extraction and classification. Accuracy is the performance metric used, and the KNN algorithm achieves about

72% accuracy with a k value of 5. The accuracy of the CNN algorithm was the highest; however, the precise value is not given, and the accuracy of the SVM algorithm is not specifically noted. The software and hardware utilized for the research are not specifically mentioned in the report. All things considered, the study offers insightful information about handwritten Kannada character recognition, highlighting the importance of feature extraction, data pre-processing, and algorithm selection in obtaining high accuracy. Because of it's higher accuracy, the CNN algorithm is used for Kannada character recognition.

METHODOLOGY

The methods used in this paper are covered in this section. It covers everything from data collection to model operation. The procedure used in the paper is shown visually in Fig. 2. proposed method.

Fig. 1. Char74k Dataset.

A. Dataset

For the experiment, the Kannada Handwritten character dataset was collected. The collection includes several images of Kannada characters. And have utilized random characters in place of vowels and consonants. There are 51 classes in all, and each class has 50 images. Every class has fifty distinct images, one for each vowel or consonant in the Kannada alphabet. This dataset is divided between 20% validation sets and 80% training sets. The model's resilience has been enhanced through the application of multiple data augmentation techniques.

B. Pre Processing

The ImageDataGenerator object divides each pixel value by 255 to rescale the image values to the range of 0-1. The rotation range parameter indicates the range of degrees that will be used to rotate the images randomly while they are being trained. The range is 20 degrees in this instance. The images won't be flipped horizontally during training because the horizontal flip parameter is set to False. The shear range parameter indicates the extent to which the training images underwent shearing modifications. The range is set to 0.2 in this instance. The fill mode parameter designates the process for filling in recently formed pixels that might emerge following a shift or rotation. In this case, the mode is set to 'nearest.' The validation split parameter specifies the fraction of the data to be used for validation. In this case, 20% of the data is used for validation. The percentage of the data to be utilized for validation is specified by the validation split option. In this instance, the validation process uses 20% of the data.

C. CNN Architectures

Convolutional neural networks (CNNs) are deep learning algorithms that are composed of one or more convolutional layers, one or more subsampling layers, and one or more fully connected layers on top. The convolutional layer's job is to go over the input data and identify features. Pooling layers come after convolutional layers and are used to organize the data that the former generates. The last layer in the CNN model is called the fully connected layer. Its task is to use the output of the convolution or pooling layer to classify the image into an output label.

The study mainly focuses on the following four prominent CNN architectures:

1) Xception

Xception is a deep convolutional neural network design that includes depthwise separable convolutions. It is an expansion of the Inception architecture, which extracts varying degrees of feature from the input image by splitting up the convolutional filter into many parallel branches. Xception flips the order of the Inception module by combining the depthwise convolutions that are applied to each input channel with 1x1 convolutions. As a result, the network's accuracy increases, and there are fewer parameters and computational expenses.

2) ResNet50V2

A popular deep-learning CNN architecture in machine learning for face recognition, object identification, picture classification, and other applications is ResNet50V2. ResNet, an acronym for "residual network," is a technique that adds information from earlier layers to the output of subsequent levels using skip links or shortcuts. ResNet50V2 may be trained on a big dataset of handwritten Kannada characters to recognize Kannada characters. It can then be used to predict the class of a new image.

3) MobileNetV2

For mobile and embedded applications, it is a lightweight, efficient type of convolutional neural network (CNN). In contrast to conventional convolutions, it makes use of depthwise separable convolutions, which require less computations and parameters. It is a lightweight architecture designed for efficiency in terms of memory and computational resources. MobileNet can be used for Kannada character recognition by applying transfer learning; it is a technique that uses the knowledge learned from one domain (such as ImageNet) to another domain (such as Kannada characters). By fine-tuning the MobileNet model on a Kannada character dataset, the model can learn to recognize the Kannada characters with high accuracy.

4) InceptionV3

It is a type of CNN Architecture also known as GoogLeNet; it uses multiple parallel branches of different types of convolution filters to capture different levels of features from input images and to lower the number of parameters and computational expense; bottleneck layers are also used. Furthermore, the architecture can accommodate a wide range of inputs, including those with varying resolutions, aspect ratios, and orientations. Character recognition applications, where characters may appear in a variety of typefaces and sizes, benefit greatly from this versatility.

D. Proposed model

As the pre-trained model, MobileNetV2 can be utilized for the classification of Kannada characters. A new layer that has been trained on a dataset of Kannada characters to categorize them replaces the model's last dense layer. The higher, fully connected layers of the MobileNetV2 model are retrained on the current task, while the lower, convolutional layers keep their learned features and weights. To finish the classification more precisely, the model modifies the weights of the top, fully linked layers, and the custom dense layer during the training phase. The model can be used to predict the Kannada characters once training is over.

The proposed model for this research is inspired by the paper "Classification of Maturity stages of Coconuts using Deep Learning on Embedded Platforms".

I. EXPERIMENTATION

Intel Core i5-10210U, 8 GB RAM, and Google Collaboration on Microsoft Windows 11 are features of the laptop utilized for the Kannada character recognition training. To facilitate training and validation, the dataset is split 80/20. Learning rate, batch size, and other hyperparameters are fine- tuned for optimal outcomes.

Pre-trained models like Xception, ResNet50V2, MobileNetV2, and InceptionV3 have been used to classify Kannada characters. Stochastic gradient descent (SGD) is used as the optimizer, accuracy is the metric, and categorical cross-entropy is the loss function in the compilation of the models. The use of dropout layers addresses overfitting. The validation accuracy was continuously monitored during training periods consisting of 25 epochs. Data augmentation is utilized to introduce a variety of character examples to the models.

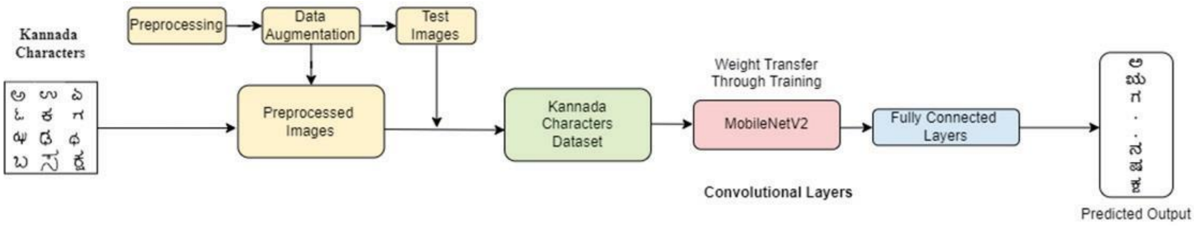

Fig. 2. Pipeline used for Kannada Character Recognition.

Firstly, the dataset was prepared using the ImageDataGenerator class to arrange the training and validation sets. The techniques were used like rescaling, rotation, and shear, and resized the images to the standard size of (224,224) pixels. After that, a custom model was created by combining pre-trained ResNet50V2, MobileNetV2, Xception, and InceptionV3 architectures with ImageNet weights.

To accommodate the task of Kannada characters, we modified the uppermost levels. The categorical cross-entropy loss function, accuracy as a metric, and the stochastic gradient descent (SGD) optimizer were used to set up the model. Next, we trained the model using the fit method, including callbacks like ReduceLROnPlateau and EarlyStopping to adjust the learning rate and stop early if needed. Using the evaluation approach, which provided parameters like loss, accuracy, and classification report, the trained model was assessed. Ultimately, the model was saved for subsequent application.

This research compares different CNN architectures for Kannada character recognition, exhibiting the higher performance of MobileNet. Character recognition technology has advanced significantly as a result of the authors' rigorous testing, data analysis, and wise recommendations for additional study.

RESULTS AND DISCUSSION

The following section of the paper compares the CNN architectures for the application of Kannada character recognition

A. Analyzing the Results

This work shows that MobileNetV2, in conjunction with transfer learning, performs admirably for image classification tasks; moreover, when training the model using this strategy instead of starting from scratch, performance was significantly better. Using this technique, the model can use its prior knowledge to tackle a new problem, in this case, identifying Kannada characters. When recognizing the Kannada letters in the test dataset, 95.49% accuracy was obtained.

Several CNN architectures, including Xception, ResNet50V2, and InceptionV3, are tested with 51-class Kannada letter images to compare the real-time accuracy with MobileNetV2. The results show that the MobileNetV2 model produced results of 96.52% accuracy and a loss of 0.1323, and 95.49% accuracy and a loss of 0.1599 for the test data.

The accuracy v/s epoch graph and loss v/s epoch graph of the various CNN architectures that were implemented are displayed in Figures 3 and 4

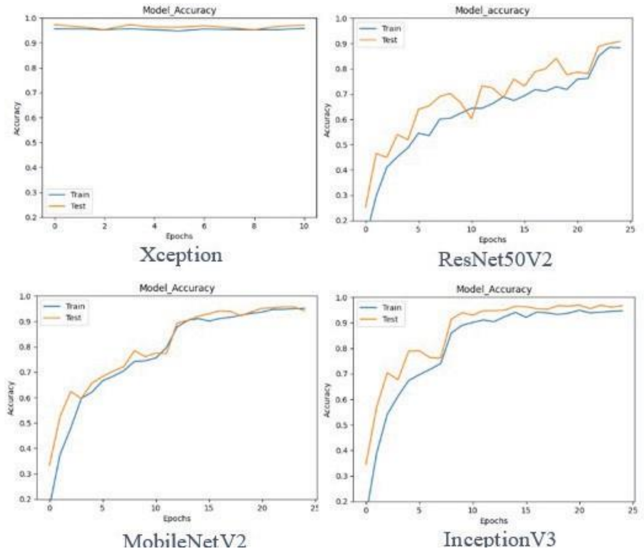

Fig. 3. Accuracy of Different CNN Architectures.

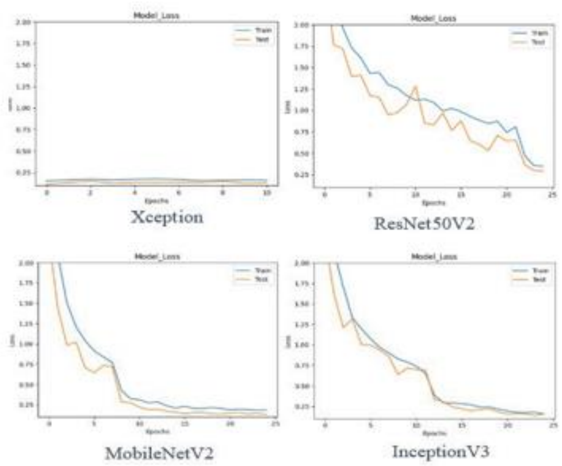

Fig.4. Accuracy of Different CNN Architectures.

In comparison to other designs, MobileNetV2 exhibits the smallest model size and fastest execution, as can be seen.

The table below shows the MobileNetV2 detection results for other CNN architectures that were trained using our data.

TABLE II. CNN ARCHITECTURES RESULT

Architecture	Test accuracy	loss	model size
Xception	94.27%	.1656	88.68 MB
ResNet50V2	92.75%	0.2552	98.99MB
MobileNetV2	95.49%	0.1599	14.78 MB
InceptionV3	94.08%	0.1609	92.27MB

In the future, multimodal approaches for accurate text identification can be emphasized in Kannada character recognition via CNN architectures, supporting language technology. While domain-specific adaptations improve accuracy, continuous learning ensures flexibility. To promote innovation, accessibility, and Kannada digitization while preserving linguistic uniqueness and cultural legacy is necessary.

The result table provides a thorough comparison of the performance of various CNN architectures for Kannada character recognition. The table gives a comprehensive overview of the model's performance in identifying Kannada characters: Xception, ResNet50V2, MobileNetV2, and InceptionV3. It shows metrics for test accuracy, loss, and model size. MobileNetV2 outperforms other models with a test accuracy of 95.49% and a low loss of 0.1599, showcasing its excellent capability to accurately detect Kannada letters while lowering errors. Another feature that sets MobileNetV2 apart from other designs is its modest model size of 14.78 MB, which emphasizes how effectively it uses memory and computing resources. The results show that MobileNetV2 performs well when it comes to Kannada character recognition

B. Model Performance

Detailed results are presented, including accuracy and loss for each architecture. The comparative analysis shows the strengths and weaknesses of each model.

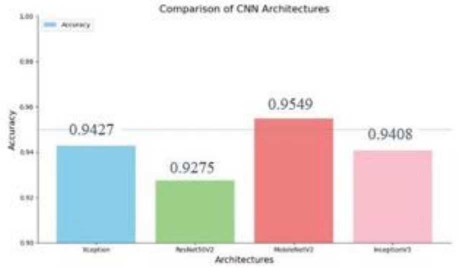

Fig.5. Comparison of CNN Architecture

CONCLUSION

This paper presented an AI-based approach for Kannada script recognition aimed at improving the accuracy and efficiency of digital document processing. By leveraging convolutional neural networks, the proposed system effectively learns discriminative features directly from character images, overcoming the limitations of traditional handcrafted feature–based methods. The integration of preprocessing techniques such as noise reduction, normalization, and segmentation further enhanced recognition performance across diverse document conditions. Experimental evaluation demonstrated that the model achieves reliable and consistent accuracy for both printed and handwritten Kannada characters, even in the presence of variations in font styles, sizes, and writing patterns.The results confirm that deep learning–based OCR systems offer a scalable and robust solution for regional language digitization. The proposed framework can be effectively deployed in applications such as digital archiving, e-governance, document automation, and multilingual information retrieval. Future work will focus on extending the system to recognize compound characters and full-word recognition, incorporating attention-based and transformer models, and optimizing the framework for real-time and mobile deployment. Overall, this study contributes to the advancement of intelligent document processing for Kannada and other Indian language scripts

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