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HANDWRITTEN KANNADA CHARACTER RECOGNITION IN AN UNCONSTRAINED ENVIRONMENT USING CONVOLUTIONAL NEURAL NETWORK TECHNIQUE : A SURVEY

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Abstract: Due to the wide variety of writing styles, the recognition of handwritten characters, particularly in Kannada, is a challenging area of study. In order to convert the handwritten text into an electronic format, this work focuses on deciphering handwritten Kannada characters utilizing deep learning algorithms and optical character recognition (OCR). Deep learning methods like recurrent neural networks (RNNs) and convolutional neural networks are the most renowned and widely used methods for handwriting recognition (CNNs). The paper examines the key algorithms for identifying and categorizing handwritten characters as well as the numerous approaches utilized for deciphering handwritten material. Towards the conclusion, the accuracy offered by various systems is contrasted. In general, technological developments have made life simpler, and the expanding interest in handwritten recognition in computer science follows this trend.

Keywords: Image Processing, CNN, deep learning, handwritten text, and classification.

I. INTRODUCTION

It might be difficult to identify handwritten kannada characters because of differences in writing style, legibility, and layout. Yet, handwritten text may now be converted into a computer-readable and programmable format thanks to the application of handwriting recognition models and deep learning techniques. The goal of these applications is to develop a practical symbol recognition system that enables the conversion of handwritten communications or notes into text that can be understood by computers. A broad variety of handwriting styles can be recognised by handwriting recognition systems, which have been developed as a result of advancements in machine learning and OCR technology. Handwriting recognition technology can be used to extract information from offline kannada text. There are a number of methods for creating a handwriting recognition system, such as utilizing machine learning algorithms to train a model on a sizable dataset of handwritten documents or using OCR to convert handwritten text into digital text and then processing it with NLP methods to extract meaning. Moreover, the ability to recognize written documents might offer extra services for robotics programs, mobile phones, and other devices for documentation and corroboration. Character identification of handwritten text is a challenging task that successfully combines a number of various approaches. To find features in a given image of a handwritten character, image processing techniques including edge detection, feature extraction, and pattern recognition can be employed. The character can then be recognized and classified using machine learning algorithms like neural networks and support vector machines. To increase recognition accuracy and speed, additional techniques like hidden Markov models and evolutionary algorithms are also applied. Accurate handwritten character recognition can be accomplished by combining several approaches and techniques.

II. CONVENTIONAL METHODS USED INHANDWRITTEN CHARACTER RECOGNITION

Several methods have been developed over time to conduct handwritten character recognition. Some of these approaches are:

2.1 CapsNets: One of the newest and most sophisticated neural network topologies is called a "capsule network," and it is thought that it is superior to the machine learning techniques now in use.

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In a convolutional block, the pooling layer is used to reduce the data dimension and achieve spatial invariance, which recognizes and categorizes the item wherever it is located in the image.

The loss of a significant amount of spatial information regarding the object's rotation, location, scale, and other positional features during pooling is one of the key drawbacks.

2.2 Multidimensional Recurrent NeuralNetworks (MDRNNs): RNN/LSTM (Long-ShortTerm Memory) only work with 1-D data, such as text, and deal with sequential data. As a result, they cannot be immediately extended to photos.

As many recurrent units as there are dimensions in the data can be utilised in multidimensional recurrent neural networks to substitute one recurrent link in a normal recurrent neural network (RNN).

In order to make the language model resilient to local distortions across all possible input dimensions (such as image rotations and shears, the ambiguity of strokes, and various handwriting styles), multidimensional recurrent neural networks were developed. This technology enables flexible multidimensional context modelling.

Connectionist Temporal Classification(CTC): Connectionist Temporal Classification (CTC) method handles tasks like speech and handwriting recognition, among others, by mapping all of the input data to the output class or text.

Mapping photographs to the appropriate text is a necessary step in the recognition of handwritten writing. We don't know how the characters and the patch of the image are aligned, though. Traditional methods fail without this knowledge.

To avoid having to know how a certain character is linked to an auditory or visual representation of a segment of speech, use Connectionist Temporal Classification (CTC). As each character requires a different amount of space when written by hand, simple heuristics like giving each character the same area won't work.

An image of handwritten text that has been vectorized is used as the algorithm's input. The representation of the characters as a series of pixels in the image is not exactly aligned with that. By adding up the likelihood of every potential alignment between them, CTC seeks to discover this mapping.

Recurrent Neural Networks (RNNs), which take into account context in the input, are commonly used by models trained with CTC to predict the per time-step probabilities. Each sequence element is given a character score, which is output as a matrix.

2.3 Transformer models: RNNs are the ideal choice for modelling textual data since they can account for their time component. The sequential pipelines preclude parallelization and memory restriction while processing longer sequence lengths, hence they also come at a cost in terms of training.

A distinct approach is used by transformer models, who use self-attention to memorize the entire sequence.
Transformer models can be used to approach handwriting in a non-recurrent manner.

2.4 ScrabbleGAN: As everyone has a different writing style, the potential for handwritten text recognition in training data is restricted. It is quite expensive to collect a diverse range of datasets, and it is difficult to annotate the text.

Semi-supervised learning is an effective way to reduce the requirement for data gathering and handwritten data annotation. To enhance the performance of the models, it combines samples of labeled and unlabeled data. It gains the ability to recognize more accurate characteristics and adjust to unseen images more effectively than fully supervised models.

III. RELATED WORK

***Handwritten Character Recognition (HCR) Using Neural Network* -** An Artificial Neural Network model-based method was introduced by Hitesh Mohapatra in 2009 to show how it may be used to recognize English alphabets written by hand. Binary glyphs are used to calculate the sum of each row and column values as features after the character has been segmented using an incremental model for character recognition [1].

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Spatial Features for Handwritten Kannada andEnglish Character Recognition - A K-Nearest Neighbor method for Spatial Characteristics for Handwritten Kannada and English Character Recognition was put up by B V Dhandra, Mallikarjun Hangarge, and Gururaj Mukarambhi in 2010 [2].

Handwritten character segmentation for Kannada scripts - Unrestricted handwritten Kannada character segmentation was carried out in 2012 by Naveena Chikkaguddaiah and Manjunath Aradhya using a Connected Component Analysis (CCA) Algorithm. This method produced accuracy of 85.5%[3].

Handwritten Kannada Character Recognitionusing Wavelet Transform and Structural.

Features - In 2015, Saleem Pasha and M. C. Padma developed a technique for handwritten Kannada character recognition utilizing Wavelet Transform and Structural Features, Artificial Neural Network Classifier (ANN). As structural features, features including aspect ratio, quadrant density, corner detection, correlation, and width feature extraction are used. For characters in kannada, this method produced 91% accuracy.

Kannada Handwritten Word Conversion to Electronic Textual Format Using HMM Mode - In 2016, Sushma A. and Veena. G. S. introduced the Hidden Markov Model (HMM) to detect off-line words of the handwritten kannada language, with an average accuracy of 55%.

Script Identification from Handwritten Documents using SIFT Method - Scale invariant Feature Transformation (SIFT) approach was proposed in 2017 [6] by G G Rajput and Suryakant Baburao Ummapure. Rotation and Scale Invariant Feature Transformation (SIFT) was a useful technique for script identification that worked well for Kannada, Hindi, and English scripts and had an accuracy rate of 96.71% for characters written in both the English script and the Hindi script.

Online Kannada Character Recognition usingSVM Classifier - A Support Vector Machine (SVM) classifier approach was presented in 2017 [7] by Rajni Kumari Sah and Dr. K Indira to identify handwritten kannada characters. Dataset is created using pen-based handwriting character recognition.

Kannada Handwritten Document Recognition using Convolutional Neural Network - In 2018 [8], Asha K and Krishnappa H K developed a Convolution Neural Network (CNN)-based method for Kannada handwritten document identification for non-overlapping lines of characters.

Deep Learning Network Architecture based Kannada Handwritten Character Recognition -
A Deep Neural Network Architecture for Recognizing Handwritten Kannada Characters Using Transfer Learning from Devanagari Handwritten Recognition System was presented by N. Shobha Rani, Subramani A C, Akshay Kumar P, and Pushpa B R in 2020 [9].

Handwritten Character Recognition of KannadaLanguage Using Convolutional Neural Networks and Transfer Learning - In 2021 [10], Parikshith Hegde, S M Naga Rajath, D Shwetha, C M Sindhu, and P Ravi developed a Convolutional Neural Network (CNN) and transfer learning based technique for Character Recognition from the Images Consisting of Handwritten Characters in Kannada.

IV. WHY CONVOLUTIONAL NEURALNETWORK FOR HANDWRITTEN CHARACTER RECOGNITION

Convolutional neural networks (CNNs), a subset of deep learning neural networks, are particularly effective at recognizing images. They are employed for handwritten character identification because, despite changes in the characters' appearance, they can pick out the underlying patterns and qualities of the writing. Moreover, CNNs have a fast processing speed for handling massive datasets, enabling them to process enormous amounts of handwritten data with precision. Also, CNNs are excellent for reading handwritten characters because they can spot intricate relationships and patterns in data. Moreover, handwritten character recognition using the Convolutional Neural Network architecture has shown outstanding results on a variety of benchmarks. The CNN architecture is ideal for recognizing handwritten characters for a number of reasons:

Easy to detect patterns: Character recognition uses CNNs (Convolutional Neural Networks), which can recognize patterns in photos. Several layers of neurons make up CNNs, which process, evaluate, and extract characteristics from the input image. Convoluting the image with a set of filters—basically, tiny matrices of integers that each stand for a certain feature—accomplishes this. The attributes linked with the characters are then extracted from the image using the filters to find patterns in the image.

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4.1 Efficiency: CNNs also include a pooling layer, which combines the characteristics from various filters to cut down on the amount of network parameters. The network becomes more effective as a result of the decrease in computation needed to process the image.

4.2 Process large and complex datasets: Because CNNs can swiftly process massive datasets, they can process enormous volumes of handwritten data with great accuracy. In addition, CNNs can spot intricate relationships and patterns in the data, which makes them perfect for reading handwritten characters.

4.3 Classification is easier: To classify the characters, the convolutional layer output is finally routed via a fully connected layer. The convolutional layers' retrieved characteristics are used in this layer, which is in charge of classifying the characters using those features.

4.4 In conclusion, because CNNs can extract features from images and utilize them to classify characters, they are employed for character recognition. They are also effective because they use a pooling layer to cut down on the number of network parameters.

Table - 1: Comparative Study on Various methods applied for handwritten character recognition.

Title	Authors	Method	Purpose	Drawbacks
HandwrittenCharacter Recognition (HCR) Using Neural Network Sep 2009 [1]	Hitesh Mohapatra	Artificial Neural Network approach	Recognition of English characters	HCR for various tongues
Spatial Features for Handwritten Kannada and English CharacterRecognition Nov 2010 [2]	B V Dhandra, Mallikarjun Hangarge, Gururaj Mukarambhi	K- NearestNeighborClassifiers	With regard to handwritten Kannada and English characters, directional spatial aspects demonstrated pretty encouraging performance.	Only kannada vowels and digits are recognized
Handwrittencharacter segmentation for Kannada scripts Oct 2012 [3]	Naveena Chikkaguddaiah, Manjunath Aradhya	Connected component Analysis (CCA) Algorithm	Segmentation of Kannada characters written by hand without restriction. Separating touching characters into separate segments	Overlapping words in component segmentation.
Handwritten Kannada Character Recognition using Wavelet Transformand Structural Features Dec 2015 [4]	Saleem Pasha, M.C.Padma	Wavelet Transform andStructural Features, Artificial neural network classifier (ANN)	Features including corner detection, correlation, quadrant density, aspect ratio, and width feature are extracted as structural features.	An understanding of intricate handwritten Kannada characters and numbers

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Kannada Handwritten Word Conversion to Electronic Textual Format Using HMM Model Oct 2016 [5]	Sushma A, Veena.G.S	Hidden Markov Model (HMM)	Recognizing handwritten off-line words in the kannada language	Less accurate training and testing with fewer samples

Script Identification from Handwritten Documents using SIFT Method Sept 2017 [6]	G G Rajput, Suryakant Baburao Ummapure	Scale invariant Feature Transformation (SIFT)	Rotation and Scale Invariant Feature Transformation (SIFT) is a practical method for script identification for Kannada, Hindi, and English scripts.	Line/block level script identification in photographs of handwritten documents
Online Kannada Character Recognition using SVM Classifier Dec 2017 [7]	Rajni KumariSah, Dr. K Indira	Support Vector Machine (SVM) classifier	Just the top three characteristics from the seven retrieved characteristics were taken into account while classifying the characters in this essay.	higher accuracy of recognition even for weaker traits.
Kannada HandwrittenDocument Recognition using Convolutional Neural Network Dec 2018 [8]	Asha K, Krishnappa H K	ConvolutionNeural Network(CNN)	Recognition of Kannada handwritten documents with non-overlapping lines of characters	Identification of overlapping letters and Kannada words and phrases
Deep Learning Network Architecture based Kannada HandwrittenCharacter Recognition Sep 2020 [9]	N. Shobha Rani, Subramani A C, Akshay Kumar P, Pushpa B R	Deep Learning Network Architecture	Transfer learning from the Devanagiri handwritten character recognition method is used to recognize handwritten Kannada characters.	Accuracy and Recognitionrate
HandwrittenCharacter Recognition of Kannada Language Using Convolutional Neural Networksand Transfer Learning March 2021 [10]	ParikshithHegde, S M NagaRajath, D Shwetha, C M Sindhu,P Ravi	Convolutional Neural Network (CNN) and transfer learning	Character recognition from photos of Kannada handwritten characters	Small Dataset

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V. CHALLENGES IN HANDWRITTENTEXT RECOGNITION

A difficult task in the field of artificial intelligence is Kannada Handwriting Character Recognition (KHCR). The difficulty arises from the use of a special set of characters that are exclusive to the Kannada language and are not found in other languages. Also, a wide range of font sizes and styles are employed when writing in Kannada. As a result, computer algorithms have a tough time correctly differentiating between various Kannada characters.

The abundance of fonts accessible for writing in Kannada presents another difficulty for KHCR. As each typeface has a distinct set of characters, it is challenging for computer algorithms to recognize them correctly.

Also, Kannada characters can be written vertically or horizontally. Because of this, character recognition algorithms for computers have a hard time correctly identifying characters that are written in multiple orientations. Algorithms for Kannada Handwritten Character Identification must be created that take into account the wide range of Kannada writing styles and font sizes in order to overcome these difficulties. Aside from that, it could be necessary to create algorithms that can read Kannada characters printed both horizontally and vertically.

VI. CONCLUSION

Character identification from handwritten text is a challenging task that successfully combines a number of different approaches. When used to identify features in an image of a handwritten character, image processing techniques like edge detection, feature extraction, and pattern recognition have some limitations, including poor accuracy, time consumption, poor recognition of cursive writing, and restricted font recognition. To get around these issues and more effectively recognize Kannada handwritten characters, machine learning architectures like CNN and deep learning, as well as a vast volume of datasets, will be helpful.

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