# ENGLISH LANGUAGE REVIEW USING PATTERN RECOGNITION AND MACHINE LEARNING

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**Abstract:** *The technology of Document Analysis and Recognition, as a branch of pattern recognition, faces various practical demands in the real world, such as the digitization of books, newspapers, archives, invoicing, and corporate documents. Pattern recognition and machine learning are among the most cutting-edge areas in software science. Statistical learning theory-based neural network approaches and methodologies have recently come under more and more scrutiny. By utilizing the proper character recognition and segmentation modules for optical character recognition (OCR), it is essential to identify the document's language and printing style. In the field of pattern recognition, recognizing handwritten papers is a difficult problem. Algorithms and statistical models that computers use to complete a certain task without being explicitly focused on machine learning (ML). It is possible to utilize these algorithms for a variety of purposes, including data mining and image processing. It is easy to automate tasks by utilizing machine learning when an algorithm has learned how to deal with data. The purpose of this review article is to summarize and compare many well-known methodologies that are utilized at various phases of a pattern recognition system's development. After examining several strategies for pattern identification, it was determined that the most accurate method is optical character recognition (OCR). Optical character recognition (OCR) scanners, on the other hand, have a 99% accuracy rate. Diabetes Retinopathy (DR) also has the lowest accuracy, at just 73.51%.*

**Keywords:** *Pattern Recognition, Machine Learning, Document Analysis Recognition, Optical Character Recognition, Diabetes Retinopathy*

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## INTRODUCTION

The main purpose of the software Document Analysis Recognition (DAR) is to automatically extract data that was originally intended for human interpretation from paper documents. DAR systems often produce output in the form of a symbolic representation that may be processed by a computer afterward [1]. Automated mail sorting and the processing of office documents including bills, bank statements, and business letters are two of the most common uses of DAR. It is now possible for most users to tackle simple recognition problems to the widespread availability of high-resolution scanning devices and powerful computers [2-3].

Pattern recognition and classification is the most difficult element of the system [4]. Characters are taken from each word image during the classification process. Reconstructing a word from individual characters was the next step. It must compare the image collection features extracted from the images of the characters in consideration of multiple image models that have been offered to detect the handwritten characters and produce digital recognition in Figure 1 [5-6].

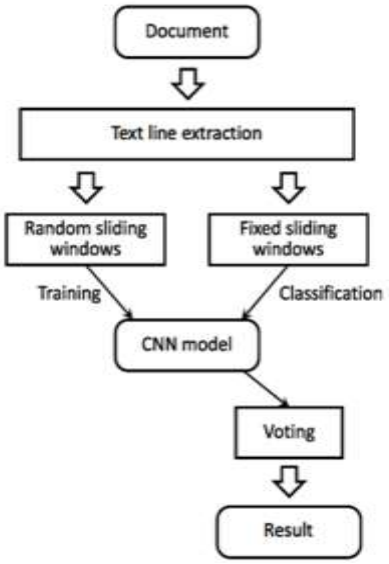


**Figure 1: The framework of the suggested method [7]**

Touch screens, electronic pens, scanners, pictures, and paper documents are all these inputs for handwriting recognition systems. The output is a digital document that can be accessed and edited in the future. Statistical, structural, neural network, and syntactic methods have all been employed, both online and offline [8][9].

**Machine Learning**

Machine learning (ML) is utilized in several ways to increase the efficiency of data processing. In some cases, they are unable to make sense of the information. They have learned from the data and employ machine learning in that situation. The demand for ML is on the rise because of the number of datasets available. Data mining using machine learning is becoming more and more popular across a wider range of businesses. It is the goal of machine learning to gain insights from the data [10]. For example, supervised, unsupervised, semi-supervised, and reinforcing algorithms all fall under the umbrella of machine-learning algorithms in Figure 2.

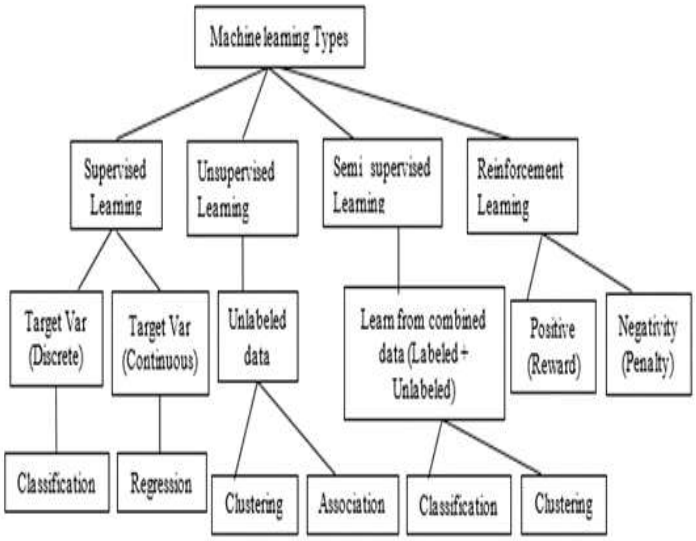


**Figure 2: Various types of ML techniques [12]**

A. Supervised Learning

Supervised learning in machine learning is a method for mapping the inputs to the outputs function using examples of input-output pairs. A machine learning algorithm that requires supervision is referred to as Supervised in the context. There are two parts to the input data as training dataset and the test dataset. There is an output variable in the training set that must be predicted or categorized. To make predictions or classify objects, all algorithms collect patterns from a training set and apply them to a test set to learn. Supervised machine learning algorithms are illustrated in Figure 3. Most common supervised machine learning methods are included here [13].

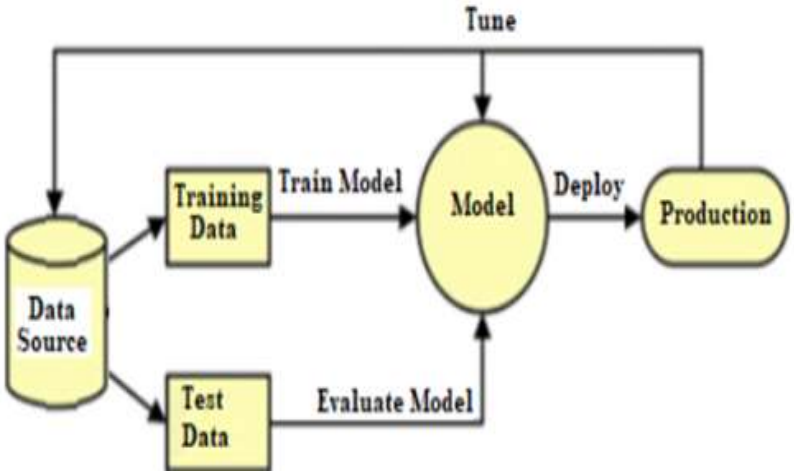


**Figure 3: Supervised learning workflow [14]**

B. Unsupervised

Unsupervised learning is a data-driven technique for analyzing unidentifiable data in the lack of a human observer. It is extensively extracting generative characteristics discovering relevant trends and structures, groupings in data, and exploratory objectives, among other things. Unsupervised machine learning difficulties include associative rule-based association rule creation and anomaly detection are examples of clustering [15].

C. Semi-supervised

Semi-supervised is an approach that combines the benefits of both supervised and unsupervised instruction that aims to improve classification results by utilizing unlabeled samples in the absence of labeled examples. Several semi-supervised algorithms are currently receiving a lot of attention as an alternative to classic machine learning approaches, which have shown impressive results over labeled data but cannot be applied to huge amounts of unlabeled data. Semi-supervised learning approaches use only a tiny percentage of the labeled data for the task at hand. The labeled ratio R is a property that is defined in equation 1. [16].

$$R = \frac{\text{Number of labeled instances}}{\text{Number of all instances}} \quad (1)$$

D. Reinforcement

An environment-driven method of learning, reinforcement learning enables software agents and machines to autonomously determine the best action for a given situation or environment. Based on rewards or penalties, the goal of environmental activism-based learning is to use environmental activists' insights to take action to boost rewards or reduce risks. Although it's a powerful Artificial intelligence (AI) model training tool, it is not ideal for handling simple or straightforward challenges, such as those related to robotics and autonomous driving, as well as manufacturing and supply chain logistics depicted in Figure 4. [17].

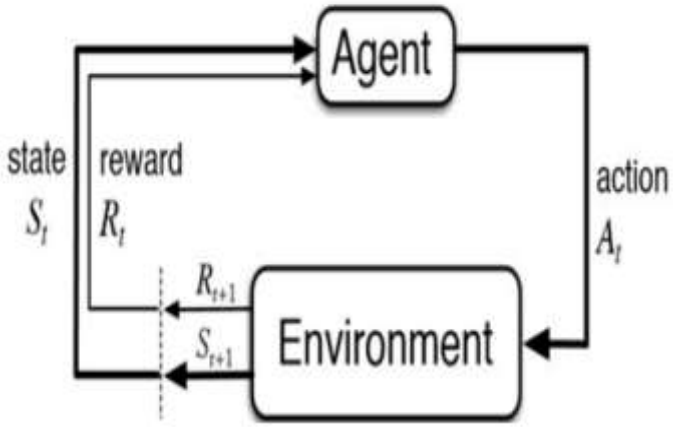


**Figure 4: Reinforcement Learning [18]**

**Pattern Recognition**

The initial use of the word pattern is to describe something that serves as a model for others to follow, and it comes from the same root as a patriot [19]. It is needed to develop methods for automatically categorizing patterns that range from a handwritten text to a face or a speech signal. This is a pressing need in many fields of engineering and science as well as computer vision and artificial intelligence in the fields of biology; psychology; medicine; and marketing [20].

**Pattern Recognition Methods**

Pattern recognition has a wide variety of methodologies that can be used in a variety of fields. These methods are practicable because of intelligent emulation [19].

A. Statistical pattern recognition

Statistical decision and estimating concepts have been widely applied in public relations. Distribution or distribution is a classical way of public relations that was discovered after a lengthy development process based on the probability and statistical distribution of the feature vectors. It is characterized by a family of probability density functions that are conditional on the class in which the model is applied. In Statistical pattern recognition (SPR), they could refer to a set of features vector after placing them in optional order. In addition, statistical pattern recognition simply considers the relationships between the characteristics themselves [19].

B. Data clustering

In data clustering or cluster analysis, the primary objective is to identify the natural groups of a set of structures, locations, or entities. A statistical method for determining individuals of a population is alike or different belong to separate groups based on quantitative comparisons of multiple traits," according to Webster (Merriam-Webster Online Dictionary, 2008).

Clustering can be defined operationally as follows: Determination based on a measure of similarity, K groupings from a representation of n items. Similarities within the same group are strong, whereas similarities across groups are low. The inclusion of noise density skews the results it more difficult to locate clusters. The following are characteristics of an ideal cluster collection of compact and isolated points. Clusters are subjective entities that require domain expertise to comprehend and interpret. However, whereas humans are adept at clustering in two and possibly three dimensions, they required automated techniques to handle high-dimensional data. Many clustering techniques have been suggested in response to the difficulty, as well as the uncertain number of clusters in each dataset. In response to the problem and the unknown number of clusters in the provided data, a large variety of clustering methods have been created [21].

The first neural network model McCulloch-Pits (MP) was planned in 1943, neural networks, particularly Hopfield neural networks (HNN), and the famous BP arithmetic that followed have developed at a

breakneck pace [21].

Based on spatial measurements, this is a data clustering method that is model-independent. Machines can learn to recognize patterns using biological notions implemented in a neural network method of learning. The endeavor has resulted in the creation of artificial neural networks that are based on an understanding of the human brain's functioning. Many different units make up neural networks.

Multilayer perceptron's and Radial-Basis Function (RBF) networks are two members of the feed-forward neural network family that are frequently employed for pattern classification applications. Each layer in the network has one-way connections to the other layers. The Self-Organizing Map (SOM) or Kohonen-Network is a popular option for clustering and feature mapping. The network's design and connection weights are modified throughout the learning process so that it can execute a given classification/clustering task more effectively. Pattern recognition problems are increasingly being solved using neural network models because of their perceived lack of domain expertise (compared to model- and rule-based techniques) and the accessibility of effective learning techniques for professionals to use [20].

A. Structural pattern recognition

It is not based on a well-established concept that depends on feature extraction and segmentation to recognize organizational patterns. Recognition of structural patterns emphasizes structure, i.e., how some simple sub-patterns build one pattern explained in detail. Syntax analysis and structure matching are two of the most used ways to identify structural patterns. On the other hand, structure matching employs a mathematical approach based on sub-patterns for syntax analysis. Structured pattern recognition is the best way to look at the relationships between parts of an object. Structural pattern recognition, unlike other approaches, is capable of handling symbol information and can be employed in more complex applications, such as image interpretation. They could use statistical classification or neural networks to solve the more difficult challenge of pattern recognition, for instance, the recognition of three-dimensional objects recognizes structural patterns [19].

**Pattern Recognition System**

A pattern recognition arrangement may be applied in several different ways. thought of as a method that can handle actual and noisy data. The human expert's decision is the most important factor in determining whether the system's choice is correct [19].

A. The structure of the pattern recognition system

Three main stages make up a PR-based pattern recognition system. The first step is to gather data, and the next two are to analyze and classify patterns found in that data. Data construction is the process of transforming raw data into a form that can be processed by computers. Data processing, such as feature extraction and data dimension compression, is the primary goal of pattern analysis. When it comes to identifying patterns, pattern classification is all about using data gained via pattern analysis. An integer label, such as "1" or "0," is the result of a classification PR problem, which assigns an item to a particular class [19]. The following is a list of the basic components of a PR system in Figure 5.

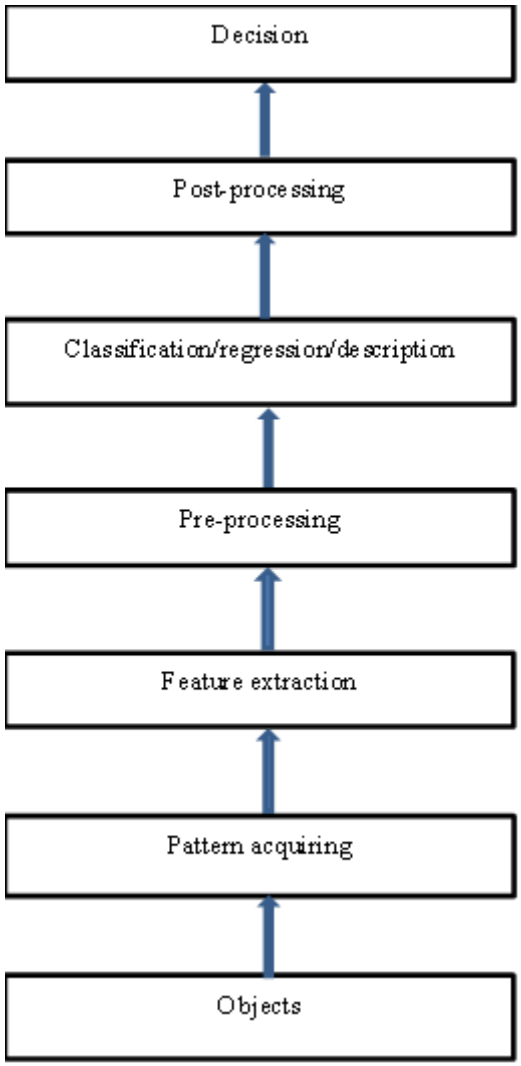


**Figure 5: The composition of the PR system [19]**

## LITERATURE SURVEY

Pattern recognition and machine learning are used in the work to analyze language in scanned documents. The following are the explanations provided by various researchers and authors of related works:

**Rabby et al., (2021) [22]** explain that Bangladeshi is the world's most widely spoken language. To develop an OCR system, it is critical to identify and execute character recognition and segmentation modules in a certain language and print style. Utilizing numerous deep learning models, the author suggested a novel technique for automatic identification of each document's language and printing style, including both printed and handwritten, in terms of a script (Bangla or English). Moreover, they could classify text as printed or handwritten, a classification challenge that obtained greater than 99% test accuracy at the character level. Additionally, under the suggested model, Only Bangla and English can now be detected, and there are only printed and handwritten forms of the written word that can be detected now. But they are working to expand their detection capabilities to include more languages and writing styles such as letterpress characters and font families.

**Wei et al., (2021) [23]** stated that relaxometry based on nuclear magnetic resonance (NMR) is widely utilized in a variety of disciplines of research due to its advantages over metabolomics techniques, including ease of preparation, ease of use, and low price. However, there are no publications on metabolic mixes that

can be evaluated by T2 relaxation curves, which are commonly used in metabolomics research such as determining their geographical origin and extracting features via Data mining and pattern recognition. The author would go through the data mining technique for relaxing metric data in that work (i.e., relaxometry learning). Analysis and a machine-learning method are the foundations of the approach, which is well-suited for studying relaxation curves.

**Rani, N. Shobha., (2020) [24]** suggested that the handwritten Kannada character identification based on Devanagari handwriting recognition technology can be used to impart knowledge. The enormous Devanagari recognition system data corpus will be used as training material to recognize traditional Kannada characters written by hand, albeit with a smaller database. VGG19 NET uses deep learning network architecture to transfer knowledge for recognition.

A hidden output layer, two tightly connected ones, and five blocks of hidden layers make up the VGG19 NET architecture. Each block has layers of convolution and a layer of maximum pooling except the block. A total of 92000 photos with 46 classes make up the Devanagari character set in the suggested classification framework, whereas the 81654 training pictures and 9401 testing photos total 188 classes with 200-500 sample images in each. VGG19 NET uses 1,23,654 data samples in its training. They employed 9401 samples with an accuracy of close to 90% for experiments with 188 classes made up of 40-100 samples apiece. 73.51% accuracy after 10 epochs of evaluation with the VGG19 NET, with a loss of 16.18%.

**Alyoubi et al., (2020) [25]** planned that Diabetic Retinopathy (DR) causes abnormalities in the retina that impede vision when they're not well planned. Due to the irreversibility of DR, therapy can only sustain eyesight, not restore it. It is possible to drastically lower the risk of visual loss with early detection and treatment of DR. Ophthalmologists' use of DR retina fundus images for diagnosis is labor-intensive, expensive, and prone to error compared to computer-aided evaluation. Recently, deep learning has evolved as one of the most important technologies and widely used approaches for optimization in a range of sectors, most notably medical picture analysis, and classification. Convolutional neural networks (CNN) are becoming more extensively employed as a method for deep learning in medicinal copy processing due to their effectiveness. The analyses of recent ways of recognition that are state-of-the-art, and categorization of Deep learning methods are used to DR fundus pictures. Table 1 summarizes the related work.

**Wang et al., (2020) [26**] planned that computers can now understand human languages through Natural Language Processing (NLP). An important function of natural language processing (NLP) is to segment words for deeper grammatical and semantic analysis. Multimodal neural networks (MNN) are suggested. There is a multilayer sub-neural network for each mode, and each one has its distinct structure. It is a tool for converting features from one model to another. An English word recognition system based on a network model approach is developed to address the problem word segmentation approaches cannot guarantee the long-term dependability of text semantics and extended training prediction time. Shortens network training and prediction times by utilizing the Conditional Random Field (CRF) model to annotate several phrases at once. Bi-direction Gated Recurrent Unit (BI-GRU). According to the results of the experiments, as it relates to word segmentation, however, this technique performs comparably to the BI LSTM-CRF model, however, the average estimated processing rapidity is 1.94 times quicker boosting word segmentation processing efficiency.

P**aliwal et al., (2019) [27]** analyzed that scanners and mobile phones are making it increasingly difficult to extract information from unstructured document pictures like receipts, insurance claim forms, and financial bills. Data extraction from photographs containing tabular sub-images presents a distinct set of challenges, compounding the difficulty of the task.

It involves accurately detecting identifying and extracting information from the rows and columns of the specified table in a picture. Detection of tables has come a long way, but extracting the data from them remains a challenge since it requires a more precise recognition of the table structure (rows and columns). There have been several previous attempts that used two different models to tackle the table detection and structure recognition issues. An end-to-end deep learning network for the identification and recognition of tables and structures is presented as Table Net. The approach relies on the interdependence between the two objectives of identifying tables and recognizing their structures to separate the table and column areas. International Conference on Document Analysis and Recognition (ICDAR) 2013 and Marmot Table, two

publicly available datasets, were used for these experiments and yielded. The suggested model and extraction technique produce state-of-the-art results.

**Sánchez et al., (2019) [28]** intended handwritten text recognition to be utilized to access the worldwide collection of historical materials housed in archives and libraries. Automated Handwritten Text Recognition (HTR) can be a difficult problem to solve because Feature extraction, image processing, and document image analysis are among the sophisticated Pattern Recognition techniques. They must be used in conjunction with one another. This work provides the HTR benchmarks that increase in complexity from various perspectives, based on historical documents provided in English and German during the 2013 through 2017 ICFHR and ICAR conferences' open contest. There is a suggested system for each benchmark that improves upon the previous work that has been done under similar circumstances. The goal of the study is to set new standards and benchmarks for HTR technology progress by presenting fresh challenges and illuminating current state-of-the-art outcomes together with the datasets and all the software tools necessary to build the most basic systems accessible for free.

**Lu et al., (2019) [29]** analyzed optical coherence tomography (OCT) as a minimally invasive imaging technology. It may produce micrometer-resolution three-dimensional pictures of retinal constructions. These pictures can aid in identifying virus-connected changes beneath the retinal surface, the existence of edema or fluid accumulation can impair vision and are indicative of retinal vascular abnormalities.

The goal of the author is to present Multiclass Fluid detection (MFD) and segmentation in OCT pictures of the retina as a new framework. A neural network with all its connections convolutional was trained to distinguish and classify by a graph cut technique, fluid pixels can be produced based on OCT pixel intensity and segmentation of the retinal layers. Random forest classification was used to identify and remove the incorrectly identified fluid areas from the segmented regions of fluid. The suggested framework takes first place in Segmentation difficulty in detecting (mean dice: 0.7667) (mean AUC: 1.00).

**Rashid et al., (2018) [30]** suggested that tables are a convenient way to express data structurally. Recognizing tables is critical for extracting information from document images. Typically, current OCR algorithms deliver textual data extracted from tables without understanding the table's real structure. Recognizing the table structure is critical for deriving the content's contextual significance. Recognizing table structures in diverse texts is difficult because of the wide variety of table layouts. It becomes more difficult when there are no physical rulings on the table. In a model of a pre-trained neural network, the textual content of documents is categorized as table or non-table elements. The system was trained on a portion of the photos for UW3 images and demonstrated greater than 97% table and non-table detection components on a test set.

**Chen et al., (2015) [3]** stated that OCR methods cannot be directly utilized. As far as Recognition systems are concerned, they are designed to work with only one language and a single orientation. Therefore, they could only handle those types of texts. Many non-character-based ways of recognition have been developed to address the issue. These approaches did not perform as well as more advanced OCR systems. As a result, it is preferable to identify the linguistic type and position before performing OCR. Moreover, it is quite difficult to extract consistent information for recognition. Since the forms of the letters in different languages are significantly confusing. Convolutional neural networks (CNN) have recently demonstrated remarkable effectiveness in pattern recognition tasks. As a result, CNN is an excellent choice for such demanding assignments. The author started CNN to acknowledge text attributes. There is indeed a new sliding window voting method suggested to reduce the size of the network. The technique demonstrated a very high recognition rate in the experiments. The results validated the suggested strategy, which may also be used to develop a document interpretation system using OCR technology. There is a wide range of authors who used the technique and presented their discoveries, as can be seen in Table 1.

**Table 1: Summary of Related Work**

| S. no | Author's | Techniques Used | Outcome |
|---|---|---|---|
| **1.** | **Rabby et al., (2021) [22]** | Conventional neural network (CNN) | CNN was able to identify the document's characteristics.<br>The new voting method with a sliding window reduces the size of the network while maximizing the use of the text line's content.<br>The method achieved a very high success percentage in the tests. |
| **2.** | **Wei et al., (2021 [23]** | Optical character recognition (OCR) | Due to its ability to distinguish between handwritten and printed texts and the high degree of accuracy achieved in testing.<br>Optical character recognition (OCR) is a critical component in character recognition and segmentation systems. |
| **3.** | **Rani, N. Shobha., (2020) [24]** | Optical character recognition (OCR) | OCR is employed to establish tables and extract data from document images by table recognition.<br>Test sets yielded a 97% accuracy rate in the ability to distinguish between components on and off a table.<br>Understanding the context of the content requires an understanding of the table structure. |
| **4.** | **Alyoubi et al., (2020) [25]** | Table-Net and deep learning | Techniques are employed in the identification and recognition of tables and their structures.<br>It comprises accurately detecting the tabular region inside a picture and then recognizing and extracting data from the selected table's rows and columns. |
| **5.** | **Wang et al., (2020) [26]** | NLP (Natural Language Processing) | An important function of natural language processing (NLP) is to segment words for deeper grammatical and semantic analysis.<br>Tool for converting features from one model to another. There are issues with word segmentation processing. |
| **6.** | **Paliwal et al., (2019) [27]** | Handwritten Text Recognition (HTR) | It is utilized to identify textual material. They are aimed at becoming new challenges for HTR technologies to spur future innovation.<br>Baseline systems are implemented by publicly available datasets and software tools. |
| **7.** | **Sánchez et al., (2019) [28]** | Deep Learning Network (DLN) | A novel model for handwritten Kannada character recognition is described that uses handwritten Kannada characters.<br>The Devanagari handwritten recognition system's training data was used. |
| **8.** | **Lu et al., (2019) [29]** | Machine learning | Automated learning technique and analytic framework specifically designed to analyze relaxation curves. |
| **9.** | **Rashid et al., (2018) [30]** | Optical coherence tomography (OCT) | A graph-cut algorithm can extract the intensity of OCT pictures and retinal layer segmentation to produce 3D scans of retinal structures with micrometer resolution. |
| **10.** | **Chen et al., (2015) [3]** | Diabetic Retinopathy (DR) | In comparison to computer-aided diagnosis techniques, Doctors' manual inspections of DR retina fundus pictures are time-consuming, labor-intensive, expensive, and prone to misdiagnosis. |

**Comparative Analysis**

This section of the study offers a comparative analysis of the pattern recognition abilities of several deep learning approaches. It is the most widely used technique for recognizing patterns. CNN Table Net, CNN Simple, Deep Learning Networks (DLN), and Machine Learning (ML) are only a few of the approaches employed (ML). An OCR scanner has a 99% success rate. First, OCR has an accuracy rate of 97%. Table 2 displays the accuracy comparison. Figure 6 provides a graph comparing the accuracy of the results:

**Table 2: Comparison based on Accuracy**

| Technique | Accuracy (%) |
|---|---|
| OCR [24] | 99% |
| OCR [32] | 97% |
| DLN [25] | 73.51% |
| DR [27] | 94.5% |

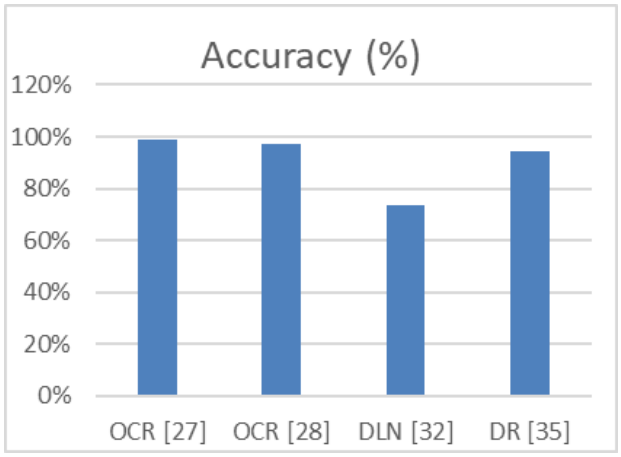


**Figure 6: Comparison graph based on Accuracy**

## CONCLUSION AND FUTURE SCOPE

The author recommends a CNN model for the identification of orientation and document language. The Convolutional Neural Network (CNN) provides substantial improvement when used in conjunction with the handwritten document character recognition approach. To categorize document terms into table or non-table categories, a neural network is trained on these contextual cues and then tested. The suggested framework investigated the difficulties associated with the classification of characters in the Devanagari Dataset Both the quality of the training data and the effectiveness of the machine learning procedures are necessary for a successful model. Additionally, machine learning methodologies were discussed to illustrate their applicability for a variety of real-world issues across a variety of major application fields. In the future, another method of improving the character segmentation model would be to move beyond a greedy search for the most likely solution. To implement a robust technique providing more accuracy and less error rate in the future.

**Conflict of Interest**

The author declares that there is no conflict of interest.

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