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Handwritten to Text Converter using CNN

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ABSTRACT

Technology has become an essential part of digitizing documents for banks, educational and others. In this paper we have crafted a handwritten converter by using CNN which is able to input the handwritten character and convert it into computerized text. This is because CNNs are really good at image processing and what we are doing in the input debugger is identifying and splitting those individual characters from a huge variety of handwritten input. A dataset of handwritten characters is used to train the model, which uses its hierarchical feature extraction capabilities to pick up patterns and subtleties on how handwriting appears. The obtained result from the experiments identifies that CNNs are very good in predicting high accuracy and low error rate for handwriting to text conversion hence using them in real world application makes a boom on it by performing well across industries.

Keywords: *Handwriting Recognition, Convolutional Neural Networks (CNN), Handwriting-to-Text, Image Processing, Document Digitization, Machine Learning.*

1. INTRODUCTION

The conversion of handwriting to text is a process that leads hand written notes into the form of digital text which helps in any situation for easy access and management. This approach is significant to retain critical documents, provide access easily and manage data efficiently. In the age of digital transformation, where our work is increasingly automated, being able to convert handwritten notes and historic records or forms into digital text with ease can make a world of difference. There has become an absolute necessity in the technological era to convert handwriting into text. [1].

Users can easily preserve their handwritten content, making it searchable and shareable across various platforms. With features like automatic text recognition, integration with cloud services, and support for multiple languages, these tools cater to a wide range of users, from students to professionals. By transforming handwritten notes into clean, readable formats, handwriting-to-text converters not only streamline workflows but also retain the personal touch of handwritten content, making them invaluable in both educational and professional settings [2].

The traditional method for this is optical character recognition (OCR). Technology permits the transformation of a variety of documents like scanned paper even images and pdfs into editable or/and searchable texts. In case of OCR for handwriting to text conversion, the broad stages are the Preprocessing stage (for enhancing the image quality which may include aspects such as correcting distortions, contrast correction, or adjusting brightness etc.), Detection and Segmentation Stage (may involve Kernels to detect edges/characters/features in that context) and finally Character Recognition stage. It then examines the specific shapes and patterns of handwritten characters. [3]. Problems with OCR include print distortion, quality of typed input and a poor resolution image as well as the fact that it struggles to read stylized text in some type settings, defaults in text recognition on scaled scanning or lower quality images due to the background contamination.

Traditional systems of OCR are based on rules through algorithms which can become inadequate depending on the complex variations from character to character, as well as noise in images that can result in text extraction errors. To overcome this weakness, we have CNN utilize the deep learning method to learn hierarchical features from data in a very direct way. CNNs are great at recognizing patterns and structure in images which makes them more invariant to variations in text appearance. They are also highly adaptable to different contexts through training on large (and noisy) datasets, which makes them more efficient too, because you do not need write a bunch of ad-hoc rules for every domain. Therefore, CNN-based OCR systems are more suitable for recognizing difficult text and meanwhile capable of achieving better performance in several applications.[4]

2. LITERATURE REVIEW

S. No	Title	Year	Objective	Methodologies	Advantages	Future Scope
1.	A Offline Handwritten Chinese Text Recognition Based on Fully CNN	2021	This is based on fully CNN that aims to improve recognition accuracy and efficiency.	The system employs attention gates and FCN for segmentation free recognition of hand-written text.	It achieves high accuracy, and competitive performance enhances feature extraction	Network optimization, enhanced accuracy techniques, broader dataset testing
2.	End-to-End Historical Handwritten Ethiopic Text Recognition Using Deep Learning	2023	It aims to advance Ethiopic text recognition using deep learning enhancing feature extraction, and addressing data scarcity challenges.	It uses CNN layers for feature extraction, BLSTM layers for sequence learning, and attention mechanisms to enhance recognition.	Improved Recognition Accuracy, Automatic Feature Extraction, Robustness Against Variations, Comprehensive Framework	Dataset Expansion, Exploring Alternative Architectures, Cross-Language Testing
3.	Handwritten Amharic Word Recognition With Additive Attention Mechanism	2024	Develop a CNN-RNN model with additive attention for Amharic word recognition, enhance accuracy using CTC for sequence modeling.	CNNs for feature extraction, RNNs for sequence modeling, and additive attention to highlight features. Data augmentation expanded the dataset, CTC was used for alignment.	Greater Adaptability, Improved Interpretability, Effective Performance	Multilingual Word Recognition, Enhanced Robustness, Real-World Applicability
4.	A Residual-Attention Offline Handwritten Chinese Text Recognition Based on Fully Convolutional Neural Networks.	2021	A residual-attention model using fully CNN to, enhancing accuracy and efficiency without explicit character segmentation.	Android camera captures image, followed by preprocessing, segmentation into lines, words, characters, and feature extraction for character classification.	Recurrent-Free Architecture, Smart Residual Attention Gate Block, Performance Analysis with Expansion Factor, Competitive Recognition Performance	Integration of Language Models, Exploration of Variants, Broader Applications, Improving Computational Efficiency
5.	Handwriting to Text Converter Web Application	2023	Develop a user-friendly web application that converts handwritten text to digital using image processing and machine learning techniques.	The application uses OpenCV, NumPy, Tkinter, and Pillow for image processing and character recognition, with an OCR engine for text extraction.	User-Friendly Interface, Fast and Accurate Conversion, Supports Multiple Handwriting Styles, Editing and Formatting Tools, Accessibility, Image Quality Enhancement	Integration with Mobile Applications, Enhanced Recognition Algorithms, Multilingual Support Expansion, Collaboration Features, Integration with Cloud Services, AI-Powered Features
6.	Automated Handwritten Text Recognition	2023	To develop a system that accurately recognizes and transcribes	Pre-processing, Model Training, System Architecture, Output Generation	Healthcare Application, Historical Document Preservation, Automated Data	Enhanced Recognition, Broader Applications, Integration with Other Technologies

			handwritten text into a digital format for processing, analysis, and storage.		Entry	
7.	Two Decades of Bengali Handwritten Digit Recognition: A Survey	2022	To depict the progress of research in Bengali Handwritten Digit Recognition (BHDR) and provide useful directions for future research.	It investigates on BHDR, analyzing data preprocessing techniques, and summarizing methodologies used in machine learning and deep learning approaches.	It provides an in-depth analysis of existing BHDR works, identifying strengths and weaknesses, which can guide future research efforts.	It suggests broader applications of BHDR beyond conventional fields, including curating publicly available benchmark datasets and proposing robust models for various use cases.
8.	Tulu Language Text Recognition and Translation	2024	To develop a neural machine translation system for English to Indian language translation, specifically focusing on Tulu.	Utilized neural machine translation technology, achieving an accuracy of 89% for simple words and sentences. The model is currently being evaluated with individual sentences, with future assessments planned for phrases.	High accuracy for simple translations and the potential for real-time application development with Tulu Unicode.	Plans to enhance the model for complex sentences, improve dataset collection, and develop a more complex model for real-time applications.
9.	Handwritten OCR: A Comprehensive SLR	2020	To provide a systematic literature review (SLR) of handwritten Optical Character Recognition (OCR) technologies, highlighting trends, gaps, and future research directions.	The review methodology includes the establishment of review protocols, criteria for inclusion and exclusion, search strategies, selection processes, and quality assessment criteria for the studies included in the review.	This systematic review serves as a reference for finding the latest trends in handwritten OCR and highlights research directions for further studies in this domain.	Identifies gaps in current research that require further investigation, suggesting that future studies could focus on improving methodologies and exploring under-researched languages and databases.
10.	Multilingual Text & Handwritten Digit Recognition and Conversion of Regional Languages into Universal Language Using Neural Networks	2021	Utilize neuronal signals in literature. Reduce manpower needed for manually converting old literature into a digitized form. Serve as a reference for character identification. Enrich the digitized language library.	The paper focuses on text recognition of traditional languages, specifically Gujarati and Marathi, using neural networks for multilingual text and handwritten digit recognition.	Improved performance in recognizing characters that traditional OCR techniques may struggle with. Capability to utilize synthetically generated training data, reducing dependency on extensive manual data collection.	The methodology can be extended to include more languages and improve the accuracy and efficiency of OCR systems, particularly in recognizing diverse scripts and handwritten texts.
11.	Handwritten Character Recognition to obtain	2020	The objective of is to develop an Android application for	It uses OCR, which include pre-processing, segmentation, feature	The system achieves a recognition accuracy of 94.12% for handwritten text	The paper suggests that while the current system offers significant accuracy,

	Editable Text		character recognition that reads text from images, facilitating into editable text.	extraction, and post-processing by the OCR engine to convert the text.	and 100% for printed text. It provides an easy method for users to edit and share recognized data.	further improvements can be made to enhance recognition capabilities, especially for diverse handwriting styles.
12.	Converting Hand-written Content of Scanned Images to Digital Documents	2021	It aims to convert various forms of human handwriting such as cursive, into digital text using Conventional Neural Networks, Optical Character Recognition, and Intelligent Word Recognition	It develops an application that can automatically read and recognize the contents from scanned images, addressing challenges related to recognizing different handwriting styles and image quality.	The application can help digitize handwritten documents, it can be used for processing handwritten cheques, thus improving document management and automation.	The paper suggests that further advancements in OCR technology can enhance the accuracy of handwriting recognition, making it more applicable across various industries that deal with handwritten documents.
13.	Handwritten Text Recognition using Machine Learning Techniques in Application of NLP	2019	It aims to develop a technique for computers to receive and interpret intelligible handwritten input from sources such as paper documents, touch screens, and photographs.	The paper discusses the adoption of HTR software, which categorizes or classifies data or objects efficiently..	The technology allows for easier storage and access of data that was traditionally stored, and it provides enhanced security for the data.	The paper suggests ongoing advancements in handwriting recognition technology and its applications in various fields.
14.	A Review on conversion of handwritten notes to digitalize version using Tensor Flow	2023	To describe a method for handwriting beautifying that enhances the legibility of handwritten documents while retaining the original handwriting.	It includes a handwriting apperception system that formats, segments characters, and identifies words, involving steps like pre-processing to convert handwritten characters to digital representation.	The proposed method allows for better interpretation of distorted documents, making them more acceptable and readable.	While not explicitly stated, the future scope could involve further improvements in handwriting recognition accuracy and broader applications in digitizing handwritten documents.
15.	Optical Character Recognition Based Webapp	2022	To create a portable solution that helps the specially-abled blind community by identifying and extracting text from product labels and currency notes using Optical Character Recognition (OCR).	It uses OCR methodology to recognize text. It deploys on a Raspberry Pi computer with a camera for image acquisition. Preprocessing and edge detection using the OpenCV library and conversion of extracted text into audio using the espeak library.	Provides an accessible tool for the blind community to interact with their environment by reading labels and currency, enhancing their independence.	Development of an ensemble model combining different OCR engines with advanced deep learning algorithms like Long Short Term Memory Networks (LSTMs) to improve accuracy and performance.

This paper presents a new residual-attention and fully convolution dual pathway network for handwritten Chinese text recognition. It proposes a residual attention gate block, which allows the model to pay more or less attention to salient handwriting features while suppressing useless background components. The experiments on two benchmark datasets CASIA-HWDB and ICDAR-2013 had showed competitive results in terms of the character error rate, with and without a language model. The paper is arranged as follows: Section 2 reviews related works, Section 3 introduces the proposed approach and Section 4 presents experimental results and further directions of future work. [5]

This manuscript aims to improve recognition of handwritten Amharic words through the use of deep learning employing a complete additive attention mechanism. It starts with a literature review, which demonstrates the scarcity of research on machine learning for Amharic script recognition. The authors introduce a new architecture and describe how their model is trained. Experiments show that this additive attention mechanism achieves competitive results compared to the state-of-the-art models, overcoming performance issues resulting from noise and diversity of writing style between people by helping the model to focus on essential parts of generated handwritten words. The study says the performance metrics got significantly improved, when more images (34,047) were used in training and preprocessing was performed at a high level. The authors highlight the future research that is needed for improving the robust quality of their model by introducing signal noise reduction and augmentation techniques to generalize, making it more practical in real-world scenarios. This work is a significant advance in OCR for the Amharic script and demonstrates that the method has shaken potential to advance handwritten word recognition accuracy.[6]

The paper talks about how the document image retrieval methods can be combined to improve access to multimedia and text content in a general sense, with emphasis on recognition of historical languages like Gujarati and Marathi. The goal is to improve the digitization of old literature, doing so by taking advantage of neuronal signals. The methodology introduced in this paper is used as an example for character recognition and promotes building new digital corpora of language making, that can help handicapped persons with speech disorders or even other speakers. Together, the paper highlights significance of technology for conservation and accessibility of cultural literature.[7]

The paper provides a comprehensive overview of Optical Character Recognition (OCR) technology, particularly focusing on its application in recognizing handwritten characters. It discusses the increasing trend of digitizing handwritten documents for easier information storage and retrieval. The process of OCR involves several critical steps, including pre-processing, segmentation, feature extraction, and post-processing, which together enable the transformation of handwritten text into an editable electronic format. The authors highlight the challenges associated with recognizing characters from various handwriting styles and propose a system that utilizes Android devices to capture images of handwritten documents. This system not only recognizes the text but also allows users to edit and save the output in text or PDF format. The paper acknowledges the contributions of various researchers in the field and emphasizes the significance of developing effective OCR systems for practical applications in everyday scenarios.[8]

The authors address the challenges associated with recognizing and converting handwritten documents into digital text, which is crucial for various applications in data entry, archiving, and accessibility. The study uses high-level machine learning, focusing a lot on deep learning algorithms to improve the performance of handwritten text recognition. Their approach to recognition consists of training a convolutional neural network (CNN) on an extensive dataset of handwritten samples, so that it can learn many different styles and improve upon its recognition. The experiments show that the proposed system, compared to other systems, has a high level of accuracy in transcription. The paper authors state that The automated system not only ease transcription but it can be a handy tool for practical applications like transcribing historical documents and helping people with disabilities. This research provides an effective method to address this challenge of handwritten text transcription in optical character recognition. [9]

A paper was published by E. Pavithra, R. Yadav et al., (2022) demonstrates a low-cost, mobile-device for blind people to navigate their surroundings with more safety and independence. The device detects obstacles using ultrasonic sensors and gives audio feedback to the user about how far detected objects are from him/her, facilitating mobility and independence of blind. This low-cost and compact design can help improve the life of a larger section of the visually impaired community to a considerable extent. [10]

The paper "Handwritten Text Recognition and Translation with Audio" by Patibandla et al. (2022) describes a system that automatically processes handwritten text to translate into the target language, and then outputs the translated text audio of this paper. The system achieves successful transformation of written information to accessible content using optics character recognition (OCR) for digitization, machine translation (MTAA) for language conversion and text-to-speech (TTS) technology for audio output empowering the users with independent access to printed information everywhere. This creative technique increases the ease of use and could greatly increase the standard of living for blind people. [11]

The Paper “Convolution Neural Networks for Text Recognition” by Sushmitha et al. (2021) discussed convolutional neural networks (CNNs) in the text recognition and more. CNNs, known for their ability to learn intricate patterns and features, are aptly used by the authors to facilitate text processing and recognition in images. CNNs can outperform traditional approaches in the areas of printed and handwritten text recognition, as revealed by this research. Our results show that CNNs can be used to improve state-of-the-art text recognition frameworks, making them more resilient to the diversity of real-world text use-cases.[12]

The paper "Handwritten to Text Document Converter" by Deepthi et al. (2022) presents a system designed to convert handwritten documents into digital text format. The paper "Handwritten to Text Document Converter" by Deepthi et al. (2022) presents a system designed to convert handwritten documents into digital text format. The authors discuss the challenges associated with handwritten text recognition, such as variations in writing styles and the quality of input images. They propose a solution that utilizes advanced image processing techniques and machine learning algorithms to enhance the accuracy of text conversion. The study demonstrates that their approach effectively improves the recognition rate and facilitates seamless digitization of handwritten materials, making it a valuable tool for archiving and accessing written information.[13]

The paper "Deep Learning-Aided OCR Techniques for Chinese Uppercase Characters in the Application of Internet of Things" by Yin et al. (2019) explores the use of deep learning techniques to enhance optical character recognition (OCR) for Chinese uppercase characters, specifically in the context of the Internet of Things (IoT). In this article, the authors discuss their model which employs convolution neural network (CNN) as an integrated approach for enhancing character recognition with accuracy and efficiency.

Experimental results show that the deep learning-based OCR method outperforms classical methods, not only in terms of recognition rates but also in its robustness to variances. This development has important consequences for the many IoT use cases that rely on text recognition as an essential part of their processing and communication.[14]

The paper "Handwriting Recognition and Beautification Methodology" by Aayush Shah et al. (June 2023) presents a comprehensive approach to handwriting recognition and beautification. The project can be split into two big parts, the handwriting recognition and the handwriting beautification as mentioned by its creators. They present a fresh idea for handwriting recognition by feature extraction and relative location matching with the aid of directed graphs. The objectives is to provide a handwriting recognition solution that been developed and sold, however has sufficient robustness to handle some unique writing styles. The handwriting enhancement part groups the distorted documents and modifies them whilst maintaining the handwriting of the writer as is and easy to be read. It includes steps such as creating a feature-graph database, noise reduction, thinning, slant estimate and correction, line/character separation, feature extraction and matching. The authors claim that the output of this system is human-interpretable and likely to be used as an aid for handwritten document legibility. [15]

The paper "Improving Offline Handwritten Text Recognition with Hybrid HMM/ANN Models" by España-Boquera et al. (2011) investigates the enhancement of offline handwritten text recognition through the integration of hybrid models combining Hidden Markov Models (HMM) and Artificial Neural Networks (ANN). The authors describe the drawbacks of rule-based recognition systems and a different technique which enhances accuracy and robustness for overcoming limitations as in identification tests by using ideas of both HMMs and ANNs [2]. Extensive experiments validate that our hybrid model is superior to other traditional methods and can obtain remarkably higher recognition rates on different data sets. These results give the impression that combining these two methods serve to overcome existing difficulties of handwritten text recognition and thus can contribute significantly to the field. [16]

3. MOTIVATION

A fast and accurate handwriting-to-text converter is a necessary technology in education, healthcare and finance, all driven by digital systems. Handwritten notes, forms, and records continue to play a major role in our day-to-day workflows despite movement towards digital documentation. Where this information is stored electronically, for example in a PDF format or similar, it can be transcribed by hand into digital text but at the scale required this is both time-consuming and subject to errors. These systems are generally built to be used with printed text and find it difficult to accommodate the variation in how handwritten text is written, since each person writes a little differently. Objective of this project is to combat these limitations using Convolutional Neural Networks (CNNs) to create a better, robust and precise Handwriting recognition system.

Using CNN in handwriting recognition has a very strong resolution as it is evolved for image processing and pattern discovering. All convolutional layers give the network the ability to learn and capture handwritten data features, and to handle penmanship variability such as different writing styles, shapes, or irregularities. This could be a huge step forward for it in automating bulk document digitization tasks where heaps of handwritten content have to be processed quickly and accurately. This could facilitate functional deployments in a variety of application spaces, greatly improve access to handwritten data and, preserve vital handwritten records in digital form.

4. PROPOSED SYSTEM DESIGN

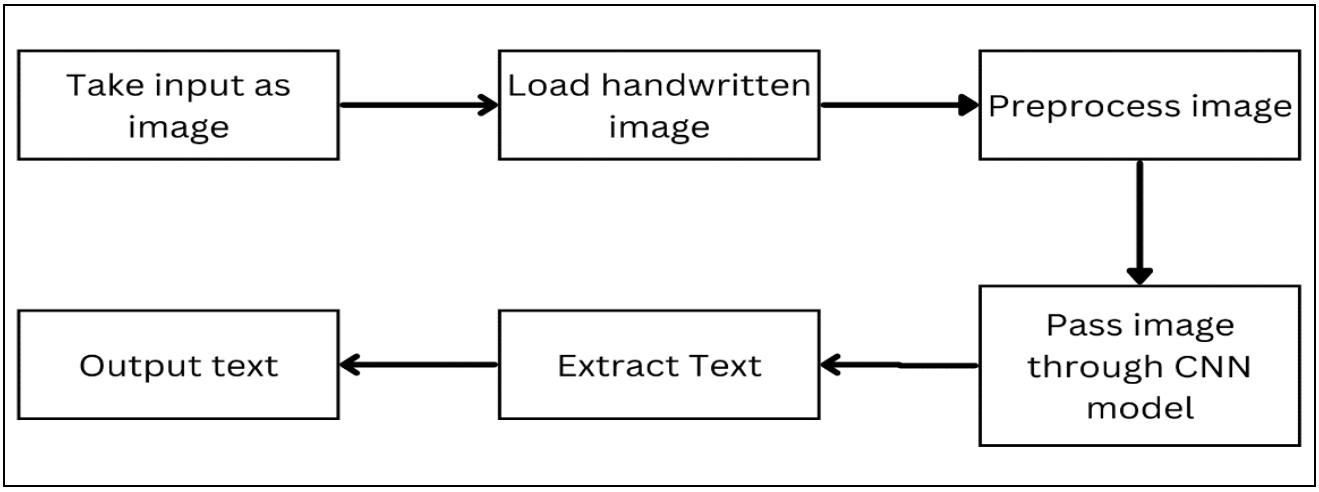

Figure 1: Proposed Block Diagram for Handwritten to Text convertor

The block diagram represents the flow of a handwriting-to-text conversion system using a Convolutional Neural Network (CNN). It starts by taking an input image, which is a scanned or captured image of handwritten text. Then image is to even this a little more in the preprocess steps by utilizing the image re-sizing, normalization or noise reduction, to impact quality and clarity modifications of this image that is loaded for further processing.

After pre-processing the image, it is passed to a CNN model which will find patterns, shapes and features in that handwriting. Relevant features from the image are extracted and converted into text by CNN. The final results are the extracted text. This System Purpose Automates Written Notes Which converts Into Machine readable text and it uses the power of deep learning has used CNN for feature definitive and recognition Text.

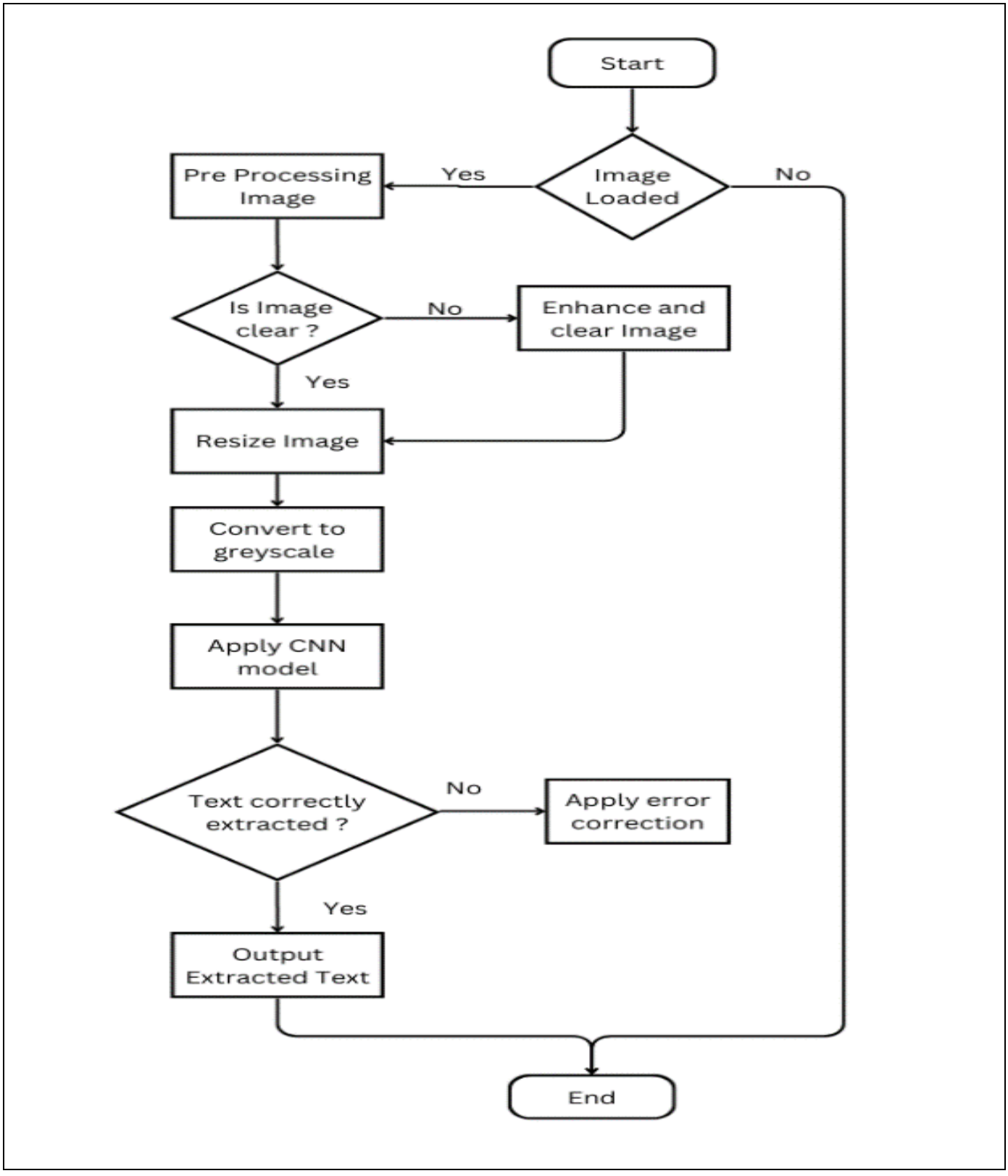

Figure 2: Proposed Flowchart for Handwritten to Text convertor

This is a flowchart to show the process of converting handwriting to text through CNN with handwritten image load as a starting point. After the image is loaded successfully, it goes through a series of preprocessing steps where the image undergoes some operations to improve, clean it from any noise and distortions. Next this image is check with the clear or no if it is not clear then go back to enhance stage for clarity of image and passing the gray scale image through CNN model where a feature extraction done by model try to understand the text. And after processing the image through CNN, we check that if this text was extracted properly. If any errors are discovered, a correction step fixes the output (possibly through methods like spell-checking or even language modeling). When the text is properly extracted it outputs the final result. This flow guarantees a continuous pipeline from raw image to correct text conversion, validating processes at various levels in the process, thereby advancing CNN performance.

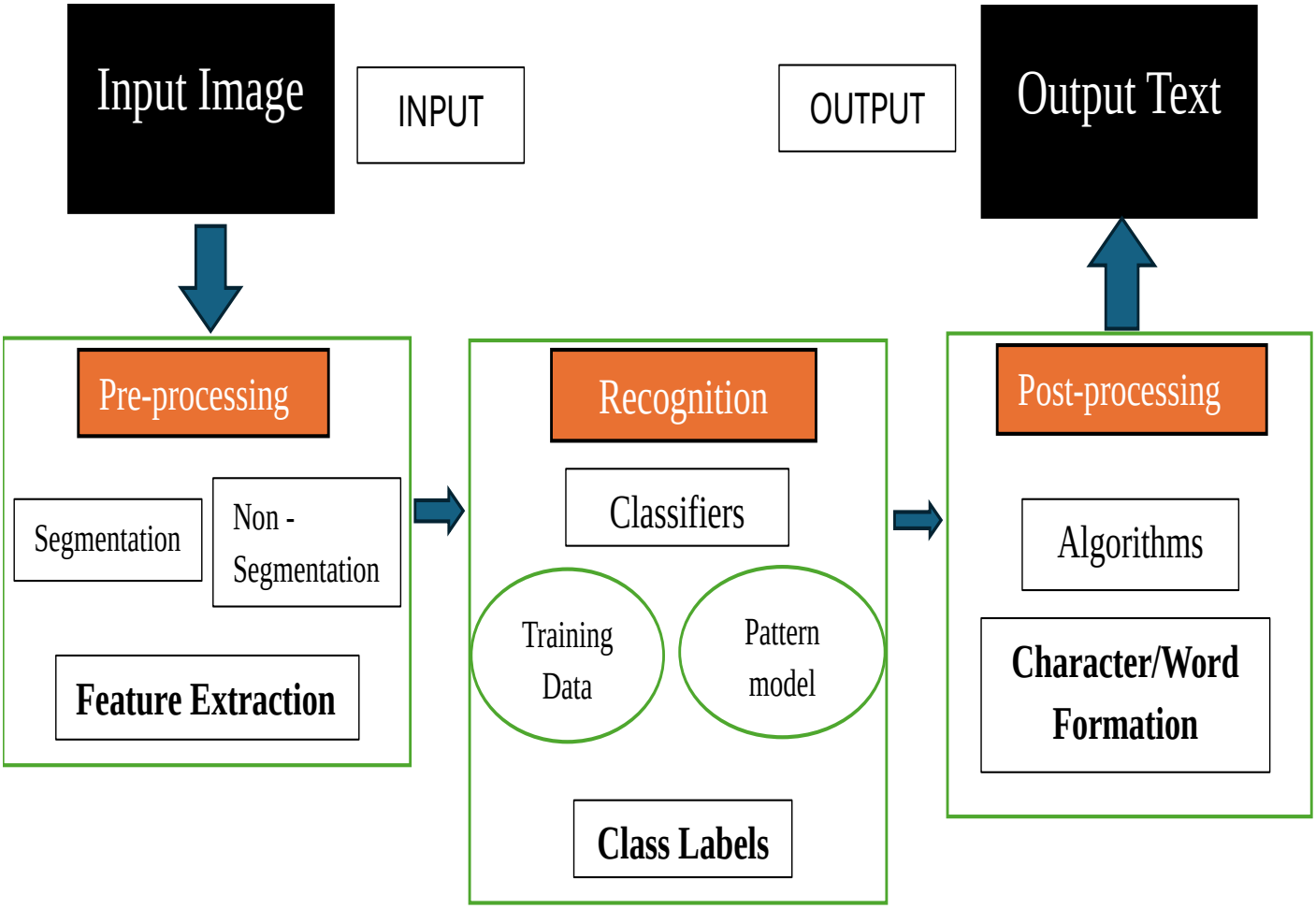

Figure 3: Proposed System Architecture for Handwritten to Text convertor

The following architecture diagram illustrates the handwritten to text recognition process: The result is called Pre-process Input Text, which has many modifications in a form of human-like text, often handwritten text on a device. In pre-processing, the input is split into strokes, sub-strokes or characters / preprocess all at once. Next apply the feature extraction to identify features of the handwritten text.

Then during the recognition phase classifiers are employed to match those features against a set of training data and pattern models. The system then gives class labels (identifying characters or words) to the comparisons made. Lastly, in the post-processing stage, algorithms fine-tune the recognized text to create actual characters, words or Aksharas (used by some scripts). This leads to the generation of the recognized text as output, thus making a machine-readable handwritten input. This architecture provides you with a dual stream of accuracy by using both well-defined feature extraction as well the definitive classification technique.

5. EXPECTED RESULT AND CONCLUSIONS

The ultimate goal of the handwriting to text conversion is to create a fast and accurately system that can convert hand writing input into machine readable textual data. Your CNN model should be able to recognize different types of handwriting, while it robustly extracts useful information from the image text regardless of varied character shapes and noise components within input. It is believed that pre-processing phase such as image enhancement, resizing and gray scaling can lead to a better-quality image recognition. In addition, through post-processing techniques like error correction, the system should also show high precision with very low errors. The model must be able to run fast enough for images to be processed in real-time or near real-time, so that it would be feasible for broader deployment into daily lives. What we want to do is, have the extracted text in a clean formatted manner, i.e., so that I can take this text and get it saved stored or use it for further analysis or use them with word processing. In the end, the system is designed to be resilient to a wide range of handwriting inputs and produce an accurate, legible output text.

Finally, we can conclude the handwriting to text conversion project using CNN as it is an automated way of converting handwritten inputs to machine readable form or digitized and for analytical usage. The system improves the quality of the input through pre-processing and identifies the characters correctly by extracting only the necessary features on it; then, CNN model takes those inputs now. The post-processing step perfects the output, bringing it down to no errors less precision. Hopefully, this project will expect to handle different styles of handwritten text and different conditions; making while eventually creating a stable production-ready solution for OCR. As a result, this converted system have fast text convert service like (real-time or near real-time) and it can also become useful in digital documentation, text data evaluation and the old handwritten data as possible.

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