State-of-the-Art Paper on Amharic Character Recognition

Hailemicael Lulseged Yimer

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Abstract

This research will investigate improving the accuracy and robustness of Amharic handwriting recognition systems. Convolutional Neural Networks (CNNs) will be combined with feature extraction methods like Principal Component Analysis (PCA), t-distributed Stochastic Neighbor Embedding (t-SNE), and Linear Discriminant Analysis (LDA) alongside Dropout regularization for this purpose. Amharic script, primarily used in Ethiopia, presents a significant challenge for handwriting recognition due to its complex character shapes and variations in writing styles across individuals. To address these hurdles, the research proposes a comprehensive methodology that leverages deep learning architectures for feature extraction and classification, along with Dropout regularization. This combination will help reduce overfitting and enhance the model's ability to generalize to unseen data.The CNN-based feature extraction framework will be augmented with PCA, t-SNE, and LDA to effectively recognize characters. These methods will work by reducing the dimensionality of the feature space while retaining critical information that discriminates between characters. Dropout regularization will be employed during training to further improve model generalization on diverse handwriting styles collected from various individuals. This technique will prevent neurons from becoming overly reliant on each other, thereby enhancing the model's ability to perform well on new data.Experimental results on various datasets are expected to demonstrate the effectiveness and stability of the proposed methodology. The research is expected to achieve superior performance in Amharic handwriting recognition tasks compared to previous approaches. Dropout regularization is expected to play a crucial role in this success by promoting model generalization across different datasets. This research will ultimately advance the state-of-the-art in Amharic handwriting recognition.

1 Introduction

In recent years, there has been significant interest in the area of handwritten document recognition. Handwritten recognition poses unique challenges compared to printed documents due to variations in writing styles among different

authors, resulting in differences in character size and shape. The complexities are further compounded by the presence of cursive characters, overlaps, and similarities in unique character shapes. Handwritten Character Recognition System, an intelligent system capable of classifying handwritten characters as humans perceive them, plays a crucial role in addressing these challenges.

Various methods have been employed for offline handwritten document recognition [10]. Traditional approaches involve manual feature engineering and the use of different classification algorithms to classify characters based on extracted features. In contrast, deep learning algorithms, such as Convolutional Neural Networks (CNNs), have demonstrated superior performance by automatically extracting features from raw images of handwritten documents and classifying characters based on learned features [7]. CNNs are particularly well-suited for handwritten recognition tasks due to their ability to learn directly from input data and their capacity to extract features using convolutional operations and techniques such as max-pooling [9].

Recently, CNNs have emerged as the state-of-the-art algorithm for the recognition of handwritten characters [7]. These networks excel at learning visual patterns directly from pixel images with minimal preprocessing, making them highly effective for handwritten recognition tasks. For instance, a CNN-based model achieved recognition rates of 93.7% and 90.2% for lowercase and uppercase characters, respectively, when tested on the UNIPEN English character dataset [9].

Amharic language, an official language of Ethiopia, presents its own set of challenges for character recognition. With its unique script and complex character shapes, Amharic poses significant obstacles for accurate recognition. Although efforts have been made to develop recognition systems for Amharic script [9], the research in this area remains relatively limited compared to other languages.

The proposed research aims to address these challenges by enhancing the accuracy and robustness of Amharic handwriting recognition systems. By integrating advanced feature extraction techniques with CNNs and leveraging dropout regularization, this study seeks to achieve superior performance in Amharic character recognition tasks.

2 Literature Review

2.1 Introduction

Handwritten document recognition, particularly for languages like Amharic, presents significant challenges due to the complexities of the script. Despite the increasing demand for OCR systems tailored for handwritten Amharic character recognition, existing research often falls short in addressing these challenges comprehensively.

3 Recent Advances in Amharic Character Recognition

Advancements in Amharic character recognition have progressed significantly in recent years. Initially, attempts at recognizing handwritten text traced back to 1995 with the introduction of character-level online Handwritten Text Recognition (HTR) employing Hidden Markov Models (HMMs) [3]. However, the limitations of HMMs became apparent due to their inability to consider the context of neighboring characters, hindering accuracy and scalability [5].

Traditionally, handwriting recognition systems relied on machine learning algorithms like support vector machines (SVMs), k-nearest neighbors (K-NN), and HMMs. Nevertheless, the field has since transitioned towards deep learning methodologies, incorporating Convolutional Neural Networks (CNNs), recurrent neural networks (RNNs), and hybrid models that merge deep neural networks with classical machine learning algorithms [6].

In the Handwritten Amharic Word Recognition (HAWR) task, concatenating features at the feature level demonstrated superior performance compared to concatenating at the HMM level, especially across diverse document qualities and varying training and test data sizes [1]. Nonetheless, HMMs alone prove inadequate in addressing the complexities associated with offline handwriting recognition, such as handling variable-sized input images and output character sequences, compounded by the cursive nature of handwriting.

Despite progress, literature on HAWR remains relatively scarce, with existing research primarily focused on isolated handwritten character recognition [4]. Traditional methods, including those based on HMMs, encounter challenges in accurately segmenting characters from handwritten text due to its cursive nature, leading to diminished accuracy [8].

Recent endeavors have targeted the recognition of printed and synthesized Amharic text-line images [**?**], [2]. These studies have adopted end-to-end learning strategies, employing CNNs for feature extraction and RNNs with Connectionist Temporal Classification (CTC) for sequence labeling. However, existing datasets have been limited to only two Amharic font types, restricting the models' applicability [2].

This research proposes a novel approach to overcome the challenges of Amharic character recognition. By leveraging CNNs for feature extraction in conjunction with advanced techniques like PCA, t-SNE, and LDA, this study aims to achieve superior performance in recognizing individual Amharic characters. Additionally, Dropout regularization will be employed to enhance model generalization across diverse writing styles. This comprehensive methodology, along with the potential contribution of a new dataset of handwritten Amharic characters, is expected to significantly advance the state-of-the-art in this field.

4 Proposed Methodology

Our proposed methodology builds upon the findings of existing research by integrating advanced feature extraction techniques and Dropout regularization into the CNN-based recognition system. By addressing the identified research gap, our approach aims to advance the state-of-the-art in Amharic handwritten document recognition.

5 Experimental Setup

We describe the experimental setup used to evaluate our proposed methodology. This includes details on the dataset, training/validation/test splits, hyperparameters, and evaluation protocols.

6 Results

We present the results of our experiments, including accuracy rates, comparison with existing approaches, and analysis of model performance under various conditions.

7 Discussion

The discussion section interprets the results, discusses the implications of our findings, and identifies strengths and weaknesses of our proposed methodology. We also highlight potential a venues for future research.

8 Conclusion

In conclusion, we summarize the key findings of this paper and discuss its contributions to the field of Amharic character recognition. We reiterate the importance of understanding the state-of-the-art and propose directions for further research.

References

[1] Y. Assabie and J. Bigün. Offline handwritten amharic word recognition. *Pattern Recognition Letters*, 32:1089–1099, 2011.

[2] B. Belay, T. Habtegebrial, M. Liwicki, et al. Amharic text image recognition: Database, algorithm, and analysis. In *2019 International Conference on Document Analysis and Recognition (ICDAR)*, pages 1268–1273, 2019.

[3] Yoshua Bengio, Yann LeCun, Craig Nohl, et al. Lerec: A nn/hmm hybrid for on-line handwriting recognition. *Neural Computation*, 7(6):1289–1303, 1995.

[4] Mesay Samuel Gondere, Lars Schmidt-Thieme, and Abiot Sinamo Boltena. Handwritten amharic character recognition using a convolutional neural network. 2019.

[5] Alex Graves and Jürgen Schmidhuber. Offline handwriting recognition with multidimensional recurrent neural networks. In *Advances in Neural Information Processing Systems*, volume 21, pages 545–552, 2009.

[6] Norhidayu Abdul Hamid and Nilam Nur Amir Sjarif. Handwritten recognition using svm, knn and neural network. *CoRR*, abs/1702.00723, 2017.

[7] Y. LeCun, L. Bottou, Y. Bengio, and P. Haffner. Gradient-based learning applied to document recognition. *Proceedings of the IEEE*, 86(11):2278–2324, 1998.

[8] M. Meshesha and C. Jawahar. Optical character recognition of amharic documents. *African Journal of Information and Communication Technology*, 3(2), 2007.

[9] A. Moges, A. Bewketu, D. Dadi, and T. Dibaba. A study on the performance of convolutional neural networks in offline handwritten amharic character recognition. In *2017 International Conference on Advances in Computing, Communications and Informatics (ICACCI)*, pages 1117–1123. IEEE, 2017.

[10] R. Plamondon and S. N. Srihari. Online and off-line handwriting recognition: a comprehensive survey. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 22(1):63–84, 2000.