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DysDetectV1: DYSLEXIA-DYSGRAPHIA SEVERITY CLASSIFICATION USING HANDWRITING IMAGE AND MACHINE LEARNING MODEL

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ABSTRACT

The existence of dyslexia-dysgraphia symptoms is assessed by a specialist or evaluator through observation of the candidate using prescribed techniques and a scoring system. Nonetheless, this methodology presents some limitations, including time consumption, the potential for activities to be incomplete, and ultimately, the risk of yielding biased outcomes. The growth of technology has significantly evolved ways for automatic dysgraphia detection, leading to a diversity of handwriting-based methodologies. Nevertheless, limited research highlights the detection of handwritten images using a handwritten image collection, particularly in the development of machine learning models. Therefore, this study introduces DysDetectV1, which is an innovative approach to classifying the severity of dyslexia-dysgraphia using handwritten samples. It uses Residual network feature extraction and a bagged tree model to classify the severity of dyslexia-dysgraphia levels. The model was then evaluated using a multi-class confusion matrix and represented accuracy, precision, and recall measurements. This research has the potential to enhance handwriting classification for individuals with dyslexia-dysgraphia by utilizing handwritten images and a machine learning model. This comprehensive approach is crucial for developing reliable tools that facilitate the early identification and support of children experiencing learning difficulties, in line with the overarching goal of improving educational outcomes. This research aligns with the primary objective of enhancing handwritten recognition for educational purposes, thereby fostering early childhood development in relation to SDG 4 (Quality Education).

Keywords: *Dysgraphia, Dyslexia, Handwriting Disorder, Machine Learning, Convolutional Neural Network*

INTRODUCTION

Dyslexia-Dysgraphia is a neurological learning disability that affects fine motor abilities and written expression. It frequently results in unreadable handwriting, irregular letter sizing, and poor spatial organization on paper (Chung et al., 2020). Children with dysgraphia often struggle in classrooms where handwriting is the major medium of communication and evaluation. Despite its impact on learning outcomes, dysgraphia is frequently underdiagnosed, especially in early school settings where traditional evaluation methods are time-consuming and may be biased due to human observation, which could overlook the criteria and errors (Biotteau et al., 2019).

Recent advances in artificial intelligence and computer vision have created new opportunities for spotting learning issues using image-based handwriting analysis. Handwriting images feature rich visual patterns that represent a child's motor coordination, pressure control, and letter constructional abilities, which are crucial in recognizing dysgraphia severity (Asselborn et al., 2018). This project describes an AI-based detection framework that uses handwriting images to diagnose dysgraphia in children. A Residual Network (ResNet) extracts sophisticated and discriminative visual properties from handwriting samples, including letter deformation, alignment irregularity, and spacing anomalies (Liao et al., 2025). These features are then classified using a Bagged Tree Ensemble model, which integrates multiple decision trees to increase classification accuracy and generalizability while lowering the risk of overfitting.

The proposed method is intended to be non-invasive, low-cost, and scalable, allowing educators and practitioners to assess children for dysgraphia based purely on handwriting. This immediately contributes to the Sustainable Development Goal 4 (SDG 4), which promotes inclusive and equitable quality education and supports early interventions for students with special needs.

METHODS

This study describes an approach for image-based classification of dysgraphia severity that uses Bagged Tree ensemble learning and features recovered from a Convolutional Neural Network (CNN) Residual Network. The approach stresses robust evaluation by K-Fold cross-validation, with k set to 3, ensuring reliable performance estimation despite the small sample size The evaluation includes 136 handwriting images covering three severity levels, which are high-risk, moderate-risk, and low-risk. The handwriting images were collected from the Association of Dyslexia Malaysia (PDM), which involved 136 students aged six to twelve years old.

Figure 1 depicts the proposed automated system's architecture, which combines CNN-based feature extraction with ensemble classification. A Residual Network is modified to meet the input image dimensions and satisfy multiclass output needs, while capturing hierarchical visual cues important to handwriting impairments. The deep feature maps generated by the ResNet model are high-level abstractions of handwriting features like stroke irregularity, letter distortion, and spatial alignment. These extracted characteristics are then fed into a Bagged Tree classifier, which combines the

predictions of numerous decision trees trained on random subsets of the data to improve generalization and reduce model variance. The ensemble approach protects against overfitting while maximizing the discriminative ability of ResNet-extracted features for accurate classification.

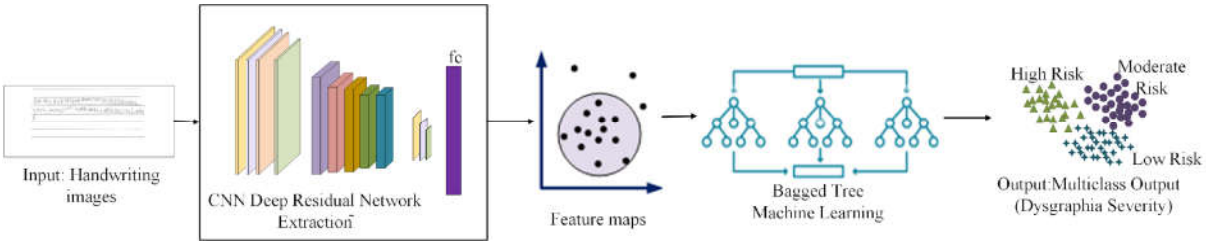

Figure 1.: The architecture of the automated classification level of dyslexia-dysgraphia severity

This study creates a dependable practical image classification system for dysgraphia detection by integrating deep learning and ensemble machine learning approaches. The addition of K-Fold cross-validation strengthens the model's performance stability and provides a realistic option for early detection of handwriting-related learning problems in educational settings.

RESULTS AND DISCUSSION

The proposed dysgraphia detection model achieved an outstanding overall accuracy of 92.65%, illustrating the effectiveness of combining deep feature extraction with a CNN Residual Network (ResNet-18) and a Bagged Tree Ensemble Classifier. As shown in Table 1, the system functioned consistently at all severity levels, with precision values of 96.88%, 91.29%, and 90.06%, and recall values of 92.52%, 91.38%, and 95.21% for the high, moderate, and low severity classes, respectively. The high severity class showed the best precision, demonstrating the model's superior ability to identify pronounced dysgraphic characteristics, whereas the low severity class produced the highest recall, highlighting its sensitivity in recognizing mild cases, which is an important aspect for early screening. The balanced performance in the moderate class adds to the model's robustness. These findings demonstrate that, even with a small dataset, the combination of residual learning and ensemble approaches provides a robust and reliable methodology for multiclass dysgraphia severity classification. The addition of K-Fold cross-validation improves the model's generalizability and stability, making it a viable tool for detecting handwriting-related learning issues in educational settings.

Table 1.: Classification performance for each class

Severity Classes	Precision (%)	Recall (%)
high	96.88	92.52
moderate	91.29	91.38
low	90.06	95.21

CONCLUSION

In conclusion, this innovative system successfully demonstrates the effectiveness of automated feature extraction from handwriting images in classifying the severity levels of dyslexia-dysgraphia. The findings highlight its potential to significantly enhance the screening methods, enabling early detection, timely intervention, and targeted support for affected individuals. Overall, the automated extraction approach has proven effective in assessing dysgraphia severity and may also indirectly contribute to the identification of dyslexia-dysgraphia.

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