Exploration and Analysis of On-Surface and In-Air Handwriting Attributes to Improve Dysgraphia Disorder Diagnosis in Children based on Machine Learning Methods

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Introduction

- Dysgraphia is a learning disability mainly regarded as disarray in written expression. And about 10-30 % of children in the world face difficulties in handwriting.
- Team-based assessments (which include multiple specialists from different domains, such as education, psychology, medicine) are conventionally practiced dysgraphia diagnosis methods in children .
- Dysgraphia diagnosis is challenging since the assessment procedure has to consider multiple cues. And the cues of dysgraphia differ with the child's age.
- Manual assessments are time-consuming, require a lot of human resources and subjected to human bias.
- The automated systems are focused on statistically analysing the characteristics of handwriting acquired by digitizing tablets.

Objectives

- Examine the effectiveness of different supervised machine learning algorithms for classifying the online handwriting features.
- Analyse the effectiveness of On-Surface features alone, followed by the analysis of feature combination of On-Surface (when the pen is touching the surface of the tablet) and In-Air (when the pen is away from the surface of the tablet) features for dysgraphia diagnosis problem.
- Analyse the potential or significance of different attributes of handwriting activity or different categories of online handwritten features (Kinematic, dynamic, spatial, and temporal attributes for On-Surface activity, Kinematic and Temporal for In-Air activity) for discriminating the normally developing handwriting and dysgraphia.
- Develop methods that utilize fewer features than state-of-the-art method (to reduce the computational overhead) without compromising the classification performance.

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Methodology

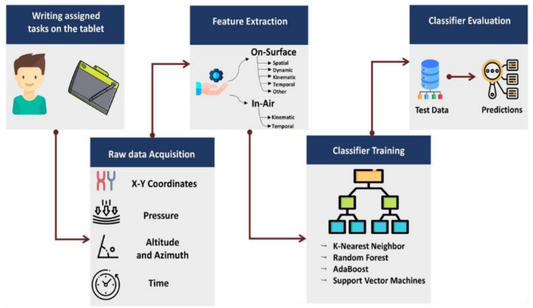

Figure 1 Overview of the proposed methodology

- The proposed approach used an available online handwritten dataset [1] for evaluation.
- It consist of online handwritten data collected from 120 children (57 positive samples).
- 175 features are extracted , it includes 119 On-Surface features and 56 On-Air features.
- This work has considered extracting features from the whole handwriting data combined instead of feature extraction from task-specific (word, letter, sentence, etc.) handwritten data separately to reduce the number of features.

Results

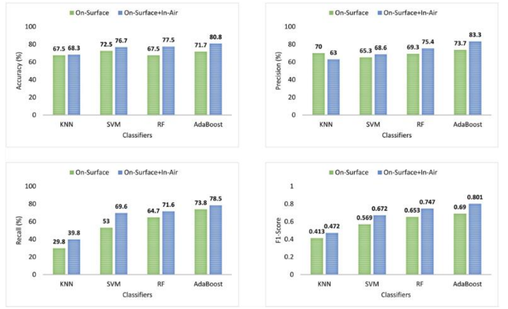

Figure 2 Performance of the On-Surface features and In-Air features, left top: Accuracy , right top : Precision, left bottom : recall , right bottom: F1-Score

Methods	No of features	Accuracy
Adaboost [1]	1176	79.5 %
SVM [1]	1176	78.8 %
RF [1]	1176	77.6 %
CNN [2]	-	76.7 %
SVM	**175**	**77.5 %**
RF	**175**	**77.5 %**
Adaboost	**175**	**80.8 %**

Table 1 Comparison with state-of-the-art methods

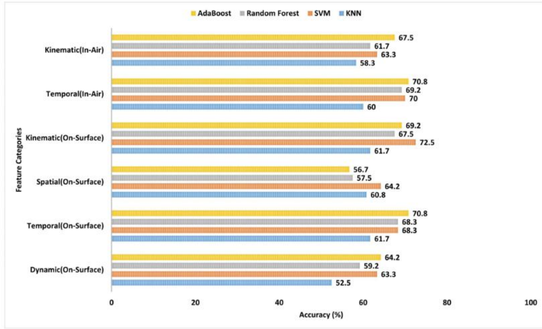

Figure 3 Performance of each feature category with different machine learning classifiers

Conclusion

- The proposed method achieved a state-of-the-art classification performance and a 1.3 % increment in accuracy compared to the literature with fewer number of features.
- Temporal, Kinematic features of handwriting are significant for dysgraphia diagnosis.

References

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2. J. Skunda, B. Nerusil, J. Polec, Method for dysgraphia disorder detec tion using convolutional neural network, in: Proceedings - WSCG 2022:30th International Conference in Central Europe on Computer Graphics, Visualization and Computer Vision, Vaclav Skala-UNION Agency, 2022.

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