Deep Learning-Based Detection and Assessment of Dyslexia Using Machine Learning Models

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Context of the project

Dyslexia is a neurodevelopmental disorder that causes serious difficulties with reading, writing, and language processing. If not detected early, it can have negative consequences for children's education and psychological development.

Traditional diagnostic methods (reading tests, clinical observations, and cognitive tests) are time-consuming, subjective, and not available in all schools, especially in resource-poor areas.

Computer vision and deep learning techniques, especially **Convolutional Neural Networks** (CNN), offer faster and more objective diagnostics by analyzing the visual signs of dyslexia letter distortion, irregularity in lines and spaces.

This study aims to build a model that can automatically detect dyslexia based on handwriting data, and while confirming the results of previous research in this field, it also provides a more practical and real-world application-oriented model.

State of the art: Systematically Reviewing the Literature

Deep learning models, especially Convolutional Neural Networks (CNN), have shown promising results in diagnosing dyslexia in recent years.

Aldehim et al - They achieved high accuracy in detecting dyslexia from handwriting samples by applying a CNN architecture. This work is our main reference source and the model structure was applied in our project.

Usman et al - The main challenges encountered in clinical use are examined: Biomarker interpretation; Data privacy; Hyperparameter tuning. The study reveals barriers to the transition to practical applications in this area.

Ghadah Aldehim, Mamoon Rashid and Ala Saleh Alluhaidan et al. "*Deep Learning for Dyslexia Detection: A Comprehensive CNN Approach with Handwriting Analysis and Benchmark Comparisons*". JDR. 2024. Vol. 3(2). DOI: 10.57197/JDR-2024-0010

OPEYEMI LATEEF USMAN, RAVIE CHANDREN MUNIYANDI, KHAIRUDDIN OMAR, AND MAZLYFARINA MOHAMAD. "*Advance Machine Learning Methods for Dyslexia Biomarker Detection: A Review of Implementation Details and Challenges*"

State of the art: Systematically Reviewing the Literature

Alqahtani et al - The application of machine learning and deep learning methods for diagnosing dyslexia was investigated. 19 scientific articles were analyzed using the PRISMA methodology. Focus on preprocessing, feature extraction, and model evaluation.

Alkhurayyif et al - This study investigated the detection of dyslexia using deep learning on brain images (MRI, fMRI) and brain waves (EEG).

Norah Dhafer Alqahtani, Bander Alzahrani and Muhammad Sher Ramzan. *"Deep Learning Applications for Dyslexia Prediction"*

Alkhurayyif, Yazeed & Rahaman Wahab Sait, Abdul. (2024). *A Review of Artificial Intelligence-Based Dyslexia Detection Techniques.* Diagnostics. 14. 2362. 10.3390/diagnostics14212362.

State of the art: Analysis

Data preparation: Alphabet pictures handwritten by dyslexic and non-dyslexic individuals were used.

Model Architecture: Base model: VGG16 (pre-trained with ImageNet)

Top layers: Global Average Pooling + Dense layers (tuned for binary classification)

Approaches Used: Transfer Learning (Reusing the Learned Model)

Data Augmentation (rotation, zoom, translation, panning)

Model Fine-Tuning.

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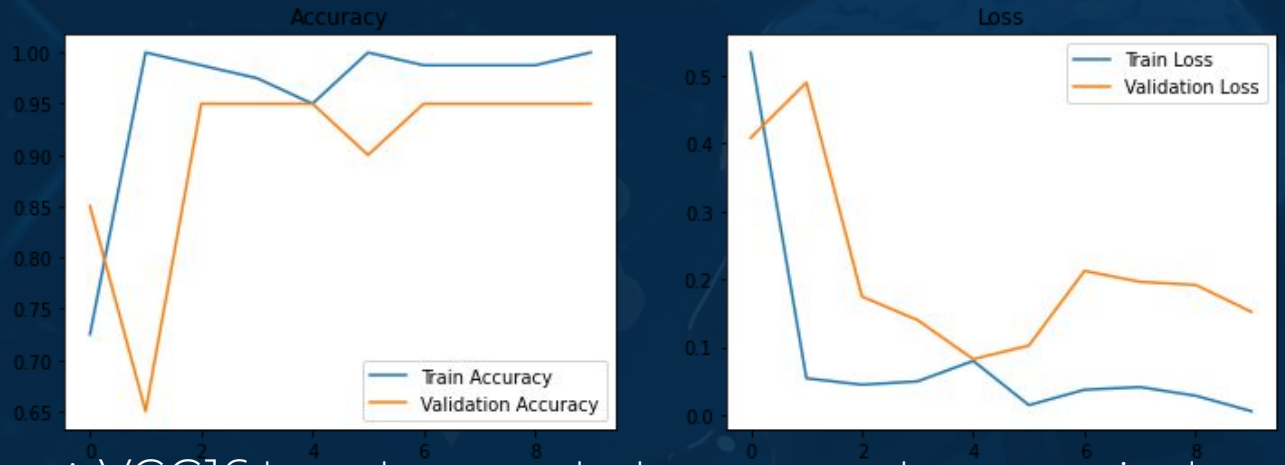
State of the art: Analysis



Conclusion: A VGG16 based approach shows normal accuracy in detecting dyslexia from handwriting. This method could be useful for early diagnosis, especially in multilingual and resource-limited regions. But it should improved for feature early diagnosis of dyslexia.

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State of the art: Interpretation of Results

The experiments demonstrated that the VGG16-based deep learning model can effectively learn the differences between the handwriting of dyslexic and non-dyslexic individuals. Transfer learning and data augmentation techniques significantly increased the generalization ability of the model.

The results showed that the model can successfully classify not only learned patterns, but also new and diverse writing patterns.

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State of the art: Interpretation of Results

```
y_pred = (model.predict(np.repeat(X_test, 3, axis=-1)) > 0.5).astype(int).flatten()

accuracy = accuracy_score(y_test, y_pred)
precision = precision_score(y_test, y_pred)

print("Model Evaluation:")
print(f"Accuracy: {accuracy:.2f}")
print(f"Precision: {precision:.2f}")
```

```
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 580ms/step
Model Evaluation:
Accuracy: 0.95
Precision: 0.91
```

The **accuracy** and **precision** indicators used to evaluate the model proved that it achieved enough success in detecting dyslexia.

These results highlight the potential for practical application of artificial intelligence in dyslexia diagnosis and are consistent with existing research.

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Literature Review

Previous studies have shown the effectiveness of artificial intelligence in detecting dyslexia. Aldehim et al. (2024) obtained high-accuracy results based on the handwriting of dyslexic and non-dyslexic individuals using a CNN model. This approach facilitates automatic extraction of visual features and early diagnosis.

Usman et al. highlighted the successful application of CNN architectures in the analysis of other neurological disorders (Alzheimer, Parkinson) in addition to dyslexia. Our work improves on existing models and offers a more practical and scalable solution with VGG16.

Required skills and Required tools

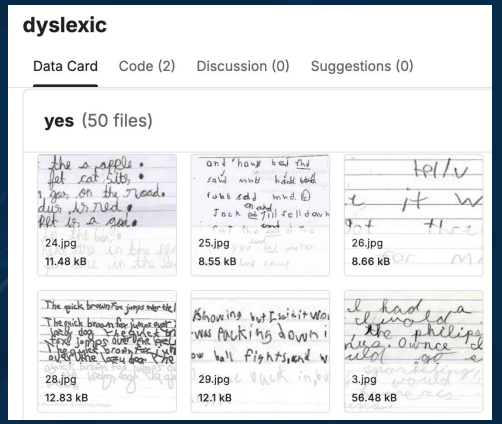
1. **Programming & Data Science**
   - Machine Learning & Deep Learning
   - VGG16, Data augmentation, image processing
   - Proficiency in Python for data analysis and model development

2. **Medical Knowledge**
   - Basic understanding of dyslexia as a medical/neurological condition

Required skills and Required tools

1. **Programming Languages and Libraries**
   - Python
   - TensorFlow, Keras, PyTorch
   - OpenCV, NumPy, Pandas, Scikit-learn

2. **Dataset & Data Sources**
   - Handwriting Dataset: https://www.kaggle.com/datasets/oussamaslmani/dyslexic



Originality of the project

- It applies a deep learning model (VGG16) aimed at diagnosing dyslexia from handwriting images.

- Traditional methods are usually based on reading tests or psychological assessments, whereas we present an automatic approach based on visual cues.

Originality of the project

- Handwriting features such as letter deformation, irregular spacing, and stroke flow can be indicators of dyslexia, and this area has not yet been extensively researched. Our project aims to fill this gap.

- The uniqueness of the project is that it uses a deep learning approach for handwriting-based dyslexia diagnosis. The innovative aspect of the project is the uploading of a handwriting sample and its automatic evaluation by the system.

```python
def predict_handwriting_image(image_path, model, size=(128, 128)):
    image = preprocess_image(image_path, size=size)
    image = image / 255.0
    image = np.stack((image,) * 3, axis=-1)
    image = np.expand_dims(image, axis=0)
    prediction = model.predict(image)
    return f"Non-Dyslexia - {prediction}" if prediction > 0.5 else f"Dyslexia - {prediction}"
```

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Research methodology: Experimental Research

This project is based on an experimental research methodology. The main goal is to test how well a deep learning model correctly diagnoses dyslexia based on handwriting samples. The data was first preprocessed, then a model was built using a CNN architecture, and the results were analyzed based on various metrics.

Research methodology: Experimental Research

Surveys – Not Eligible

Surveys are more for collecting information from people (questionnaires, responses). This research is not survey-based.

Mixed-Methods Research – If added, it would be appropriate

If we want to evaluate the effectiveness of dyslexia diagnosis in the future with both surveys and model results, then "mixed-methods" may be appropriate.