Qeios

Peer Review

Review of: "Academic Performance Prediction Based on Convolutional Neural Networks and IRT Parameters as RGB Images"

El Sayed M. El-Kenawy[1]

1. Institute of Electrical and Electronics Engineers (IEEE), Piscataway, United States

Review of the Manuscript: "Academic Performance Prediction Based on Convolutional Neural Networks and IRT Parameters as RGB Images"

1. Basic Reporting

The manuscript is well-structured, written in clear professional language, and effectively communicates the research problem and its significance. It addresses a novel approach to predicting academic performance using Convolutional Neural Networks (CNNs) with data transformed into RGB images from Item Response Theory (IRT) parameters. This unique methodology integrates computer vision with educational assessments, showcasing a creative application of deep learning in academic performance prediction.

The literature review provides sufficient background on existing approaches to student performance prediction but could benefit from more recent studies to highlight the state-of-the-art in machine learning for education. Suggested citations include:

- https://doi.org/10.1016/j.eswa.2023.122147
- https://doi.org/10.54216/JAIM.080103

Figures and tables are well-designed and effectively support the manuscript. For example, **Table 1** provides detailed correlations for RGB images derived from IRT parameters, showing a Spearman correlation of 0.86 for 20,000 images. These results are well-illustrated in **Figure 4**, which visualizes RGB image samples and their corresponding student scores.

2. *Experimental Design*

The experimental design is robust and well-documented, involving:

1. Data collection from a dataset of over 4 million Brazilian students.
2. Preprocessing and normalization of IRT parameters.
3. Transformation of these parameters into RGB images.
4. Training a CNN model using these images to predict performance.

Strengths:

- A clear pipeline is described in **Figure 2**, which outlines the stages of data collection, image generation, and model training.
- The use of the **TensorFlow/Keras Sequential library** to construct a CNN model demonstrates a practical implementation, leveraging convolutional and pooling layers for hierarchical feature extraction.

Suggested Improvements:

Dataset Details:

- Provide additional insights into the diversity of the dataset, such as the representation of socio-demographic groups or variations in student performance across regions.
- Discuss potential biases in the data and their impact on model performance.

Hyperparameter Tuning:

- While the model is trained with fixed parameters (e.g., batch size = 64, epochs = 80), discussing hyperparameter tuning methods, such as grid or random search, could enhance reproducibility and justify parameter choices.

Preprocessing:

- Elaborate on the normalization process and its implications for transforming IRT parameters into RGB matrices.

3. Validity of the Findings

The manuscript demonstrates strong results, with the proposed model achieving a Spearman correlation of 0.86 for RGB images generated from 16 correctly answered questions. This performance highlights the generalizability and reliability of the method.

Strengths:

- The comparison of correlations across different question counts (as shown in **Table 1**) effectively demonstrates the optimal trade-off between image complexity and predictive accuracy.
- Visualization of RGB images in **Figure 4** offers intuitive evidence of the model's ability to capture patterns in student performance data.

Suggested Improvements:

Error Analysis:

- Include a discussion of the model's limitations, such as potential overfitting or reduced performance on outlier data.
- Provide examples of misclassified cases to identify areas for improvement.

Generalizability:

- Test the proposed method on external datasets or exams beyond ENEM to validate its applicability in other educational contexts.

4. Additional Comments

This research contributes significantly to the fields of educational assessment and deep learning by proposing a novel application of CNNs and IRT. The integration of image-based representations is innovative and provides a unique perspective on academic performance prediction.

General Comments:

- Expand the discussion on potential applications, such as adaptive learning platforms or personalized educational tools.

- Address ethical considerations, including data privacy and the implications of using predictive models in education.
- Future work could explore alternative neural network architectures, such as Vision Transformers (ViTs), to further improve performance.

Conclusion

The manuscript presents a novel, well-executed approach to academic performance prediction, demonstrating strong experimental results and innovative methodology. Incorporating the suggested revisions, particularly in dataset diversity, hyperparameter tuning, and generalizability, would further enhance the manuscript's clarity and impact.

Declarations

Potential competing interests: No potential competing interests to declare.