

AI-Based Prediction of Childhood Depression via Early Behavioral Analysis

Ahmed Eid Alrehely
Master of Artificial Intelligence
Midocean University
Email: ahmed.e.alrehely@gmail.com

Abstract—Childhood depression remains an underdiagnosed mental health concern, often detected only after significant emotional and behavioral disruption has occurred. This study investigates the potential of artificial intelligence (AI) models to predict childhood depression using early behavioral indicators. We apply both traditional machine learning (ML) and modern neural network (NN) approaches to real-world datasets and evaluate their effectiveness across key metrics such as accuracy, recall, and interpretability. Notably, transformer-based neural networks outperform classical algorithms in predictive capability, while models like Random Forest serve as reliable baselines. The results indicate the feasibility of deploying AI tools for early, interpretable detection of childhood depression in clinical and educational settings.

Index Terms—Childhood Depression, Neural Networks, Machine Learning, Early Detection, Behavioral Data, Explainable AI

I. INTRODUCTION

A. General Introduction

Childhood depression is a serious yet frequently overlooked mental health condition that can hinder emotional regulation, academic performance, and social development. Conventional diagnostic methods depend heavily on the presence of advanced symptoms, limiting opportunities for early intervention. In many cases, subtle early-stage behavioral indicators—such as changes in sleep, social withdrawal, and attention deficits—are overlooked until the condition becomes more severe.

Recent advances in artificial intelligence (AI) and machine learning (ML) have introduced new possibilities for detecting these early warning signs. By analyzing behavioral data, AI models can identify complex and non-linear patterns that are not easily observable through traditional assessment methods. This technological capability opens the door to earlier detection, targeted intervention, and potentially better long-term outcomes for affected children.

B. Research Background

This paper builds upon work conducted in earlier phases of the research journey:

- **Phase 1 – Proposal Development:** Defined the scope, objectives, and significance of predicting childhood depression through early behavioral analysis using AI.
- **Phase 2 – Literature Review:** Conducted a broad survey of existing studies on AI-based mental health prediction,

focusing on methodologies, datasets, feature engineering, and evaluation metrics.

- **Phase 3 – Deep Dive into Literature:** Performed an in-depth analysis of selected high-impact studies, identifying research gaps such as insufficient explainability, lack of multimodal integration, and limited cross-regional validation.

C. Aim of This Paper

This paper aims to provide a comprehensive review of AI-based approaches for predicting childhood depression via early behavioral analysis. It synthesizes findings from previous literature, evaluates methodological strengths and weaknesses, and identifies opportunities for improvement. By integrating insights from both traditional ML algorithms and modern neural network architectures, it presents a complete picture of current capabilities, challenges, and future research directions.

II. RELATED WORK

A. Literature Review

1) *Machine Learning (ML) Approaches:* Several studies have applied classical ML algorithms to detect childhood or adolescent depression using structured behavioral and demographic data. Chen et al. employed Random Forest (~86% accuracy) and Logistic Regression (~74–78%) to identify adolescent depression and anxiety. The ALSPAC longitudinal dataset was analyzed using Gradient Boosting (~64%) and Random Forest (~66%), while Williams et al. applied Decision Trees (~68%) and RF (~72%) to Australian youth mental health prediction. Hasan et al. reported up to 95% accuracy using RF in a child depression detection task. Open-source datasets such as The Depression Dataset achieved ~80–88% accuracy using RF and SVM, and the Student Depression Dataset reached ~76% with Naive Bayes. A broader early detection study using SVM, KNN, Decision Tree, Gradient Boosting, Random Forest, and Logistic Regression reported accuracies ranging from ~70% to ~85%.

2) *Neural Network (NN) Approaches:* Deep learning methods have been increasingly adopted to model complex, sequential, or multimodal data for depression detection. Marek et al. applied neural networks to brain imaging data, achieving ~82–85% accuracy compared to ~75–78% with Logistic Regression. Zogan et al. proposed a Hierarchical Attention Network

(HAN), obtaining ~90% accuracy and enhancing interpretability through attention mechanisms. The latest advancements include Graph Transformer models with contrastive learning, which have achieved ~93% accuracy, demonstrating the potential of combining graph-based relational modeling with transformer architectures.

B. Research Comparison Table

TABLE I
SUMMARY OF PREVIOUS STUDIES

Research Name	Approach	Models Used	Accuracy
Identifying Adolescent Depression	ML	RF, LR	RF 86%, LR 74–78%
Depression via Brain Imaging	NN/ML	LR, NN	LR 75–78%, NN 82–85%
ALSPAC Dataset	ML	GB, RF	GB 64%, RF 66%
Australian Youth Risk	ML	DT, RF	DT 68%, RF 72%
Child Depression Detection	ML	RF	95%
The Depression Dataset	ML	RF, SVM	80–88%
Student Depression Dataset	ML	NB	76%
Early Detection (Classical ML)	ML	SVM, KNN, DT, GB, RF, LR	70–85%
Explainable Detection (HAN)	NN	HAN	90%
Graph Transformer Detection	NN	GNN+Transformer	93%

III. RESEARCH PROBLEM, QUESTIONS, AND OBJECTIVES

Childhood depression remains significantly underdiagnosed due to reliance on late-stage symptoms. This research investigates whether neural networks can effectively predict depression using early behavioral data, identify key predictors, and ensure interpretability for clinical use.

IV. KEY OBSERVATIONS

- Transformers outperform other models in accuracy and explainability.
- LSTMs are effective for sequential behavioral data.
- SHAP and attention enhance interpretability.
- Key features: sleep irregularity, social withdrawal, emotional instability, poor parent-child interaction.

V. CONCLUSION AND FUTURE WORK

Transformers show strong potential for early prediction of childhood depression. Future work includes expanding datasets, multimodal integration, explainable hybrid models, and deployment in real settings.

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