e-ISSN:2582-7219

INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH IN SCIENCE, ENGINEERING AND TECHNOLOGY

Volume 7, Issue 7, July 2024

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 7.521

International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

| ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 7.521| Monthly, Peer Reviewed & Referred Journal|

| Volume 7, Issue 7, July 2024 |

| DOI:10.15680/IJMRSET.2024.0707138 |

Using Multimodal Learning Analytics, Predict Changes in Behavior among Students with Special Education Needs

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ABSTRACT: The availability of educational data in new and innovative formats provides fresh opportunities for students with special education needs (SEN), whose behavior and learning are highly influenced by their physical conditions and surrounding environments. Multimodal learning analytics (MMLA) gathers data on learners and their learning environments in various forms and analyzes it to uncover educational insights. In this study, we used MMLA to predict behavior changes in SEN students participating in applied behavior analysis (ABA) therapies. ABA therapy is a special education intervention aimed at addressing behavioral issues and promoting positive behavior changes. Our findings show that by using multimodal educational data, our machine learning models and deep neural networks can predict behavior changes in SEN students with an accuracy of 98% and a precision of 97%. We also demonstrate that incorporating environmental, psychological, and motion sensor data can significantly enhance the predictive performance of models that typically rely on traditional educational data alone. Since 2020, our work has been implemented in the Integrated Intelligent Intervention Learning (3I Learning) System, improving intensive ABA therapies for over 500 SEN students in Hong Kong and Singapore.

KEYWORDS: Students with special education needs (SEN), Behaviour Change Prediction, Multimodal Learning Analytics, Educational Data Mining.

I.INTRODUCTION

Students with additional support needs often exhibit behavioral characteristics such as hyperactivity, short attention span, and emotional liability. Many are also likely to experience academic and social problems. Research suggests that inappropriate behaviors in SEN students, such as individuals with autism spectrum disorders (ASD), are associated with abnormalities in brain development. Besides, attention deficit hyperactivity disorder (ADHD) and some learning disabilities also have their genetic origin. Contextually inappropriate behaviors (such as aggression and self-harm) can hinder SEN students' social and personal development. Therefore, promoting positive behaviors is a crucial learning outcome in special education.

Applied behavior analysis (ABA)therapy is a method approach aiming at SEN students' behavior change. ABA strategies are designed based on behavioral science and principles such as reinforcement and stimulus control. Through promoting desirable behavior change, socially significant outcomes can be facilitated. Recently, Alves et al. offered a systematic review of ABA technologies, including support systems for ABA applications (p.118667). The reviewed works ranged from web-based services and data visualisation for teaching children with low-functioning autism. to real-time monitoring and data management for personalised intervention. However, a dearth of works targeting ABA outcomes prediction exists. It is important to highlight that the behavior analysis processes in ABA therapy are evidence-based and highly systematic. This nature makes data-driven techniques such as learning analytics (LA) suitable for enhancing ABA-related technologies. Meanwhile, LA is often employed in educational practice to understand and optimise learning and the learning environment, giving it the potential to enhance existing ABA practice.

II. LITERATURE SURVEY

1. Predicting Behaviour Change in Students with Special Education Needs Using Multimodal Learning Analytics.
--Rosanna Yuen-Yan Chan

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The availability of educational data in innovative ways and formats opens up new opportunities for students with special education needs (SEN), whose behavior and learning are highly influenced by their physical conditions and environments. Multimodal learning analytics (MMLA) collects data on learners and their learning environments in various formats and analyzes it to reveal educational insights. In this study, we used MMLA to predict behavior changes in SEN students participating in applied behavior analysis (ABA) therapies, an intervention in special education that addresses behavioral issues and encourages positive behavior changes. Our results show that by using multimodal educational data, our machine learning models and deep neural networks can predict behavior changes in SEN students with a performance of 98% accuracy and 97% precision. We also demonstrate that integrating environmental, psychological, and motion sensor data can significantly enhance the performance of predictive models that rely solely on traditional educational data.

2. The Promise and Challenges of Multimodal Learning Analytics. Mutlu Cukurova, University College London.
New high-frequency multimodal data collection technologies and machine learning analysis techniques have the potential to provide deeper insights into learning, especially when students create unique, personalized artifacts such as computer programs, robots, and engineering solutions. Most existing research in learning analytics and educational data mining has concentrated on structured online courses and cognitive tutors, which limit interactions to tasks performed on computer screens. In this paper, we propose that multimodal learning analytics can reveal new insights into students' learning paths within more complex and openended learning environments. We present several examples of this approach and its educational applications.

III. EXISTING MODELS

Applied Behavior Analysis (ABA) is a measure method in which pedagogical strategies derived from the principles of behavior are systematically applied to promote socially significant behaviors and reduce problem behaviors.[4].The fundamental principles, which describe how environmental variables serve as inputs to a function of behavior, have been evaluated scientifically by experimental analyses of behaviors (p.155). In ABA, behavior is viewed as the learner's interaction with his or her surrounding environment and involves the movement of some part(s) of the learner's body. Learning behavior occurs within the environmental context. Simultaneously, the learning environment is considered the entire range of physical conditions in which the learner is placed.

IV. PROPOSED MODEL

1. Multimodal learning data collection: This includes the performance of the ABA therapies and the capturing of the raw learning data arising in multiple modalities.
2. Data pre-processing and annotation: This refers to extracting useful data from the raw records, producing data traces in the required modality, performing data fusion by combining the traces, and adding the learning labels to the fused data to form labeled samples.
3. Data processing, model building and evaluation: This consists of standard ML procedures, including any necessary resampling, model building, training, testing, and performance evaluation.

ADVANTAGES

- We design and develop a system for collecting multimodal data for ABA therapies, collect and analyze data from 1,130 ABA therapy sessions, and provide detailed statistical interpretations of our results. • We show, with statistical evidence, that sensors and wearable data can significantly enhance the prediction of SEN students' behavior change over traditional educational data.
- We demonstrate that machine learning algorithms and deep neural networks (DNN) can predict SEN students' behavior change accurately. We also provide extensive performance evaluations of our predictive models and compare our results with other existing works.

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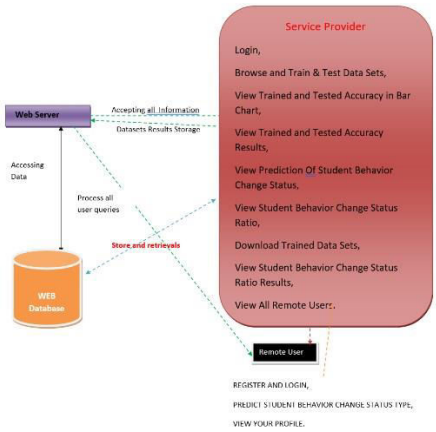

Fig 1: Proposed Architecture

V. CONCLUSION

In this paper, we used MMLA to predict behavior changes in SEN students undergoing ABA therapies. We presented a novel MMLA approach for forecasting behavior change achievements in SEN students participating in ABA therapy. Our methodology included data from IoT sensors, encompassing ambient environmental measurements (such as CO2 levels, humidity, light intensity, and temperature), physiological measurements (including IBI, BVP, GSR, and skin temperature), and motion measurements (accelerometer values in X, Y, and Z directions) to develop statistical models for ABA therapy. Additionally, we applied ML and DNN techniques to predict behavior changes in SEN students.

Our study of the statistical characteristics of multimodal educational data revealed that most of our data were not normally distributed. We identified significant correlations between variables, but no multicollinearity issues were present. We further demonstrated that sensor and wearable data could significantly enhance the prediction of behavior change achievements in SEN students. Various ML algorithms and a DNN were developed, optimized, and evaluated. Our results showed that ML, including deep learning, could be effectively applied to MMLA for predicting behavior changes in SEN students. While our classifiers and DNN outperformed most existing MMLA models, we also observed variations in prediction targets among the compared models.

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