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MULTIMODAL INSIGHTS: FORECASTING BEHAVIOR CHANGE IN SPECIAL EDUCATION NEEDS STUDENTS

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ABSTRACT

The availability of educational data in creative ways and formats has given students with special education needs (SEN), whose behaviour and learning are especially sensitive to their physical circumstances and surrounding environments, new possibilities. Multimodal learning analytics (MMLA) gathers and analyses student and learning environment data in a number of ways to clarify the underlying educational ideas. In this work, we used MMLA to forecast the behaviour of special education needs (SEN) children undergoing applied behaviour analysis (ABA) therapy. One kind of special education intervention that aims to address behavioural problems and encourage constructive behaviour changes is ABA treatment. Here, we show that by integrating multimodal educational data, our deep neural network and machine learning models can best predict the behaviour change of SEN children with 98% accuracy and 97% precision. We also demonstrate how adding environmental, psychological, and motion sensor data may statistically improve the performance of prediction models using just traditional educational data. Our efforts have enhanced intensive ABA treatment for over 500 SEN children in Singapore and Hong Kong since 2020 using the Integrated Intelligent Intervention Learning (3I Learning) System.

1. INTRODUCTION

Adolescents who need special education services (SEN) may exhibit hyperactivity, emotional instability, and inattention. Additionally, many individuals are susceptible to intellectual and social problems [1]. Research indicates that inappropriate actions among students with special education needs (SEN), particularly those with autism spectrum disorders (ASD), are associated with abnormal brain development [2]. Additionally, attention deficit hyperactivity disorder (ADHD) and some learning disabilities are inherited [3]. Examples of contextually inappropriate actions that might obstruct SEN children's social and personal development include aggression and self-harm. Therefore, one of the most important special education learning objectives is to promote excellent conduct.

Changing the conduct of students in special education (SEN) is the aim of applied behaviour analysis (ABA) therapy [4]. The two behavioural science ideas that underpin ABA approaches are

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reinforcement and stimulus control. Promoting the change of desirable behaviour may help achieve socially important outcomes [5]. Recently, ABA technologies, including ABA application support systems, were thoroughly examined by Alves et al. [6] (p. 118667). The reviewed works ranged from web-based services and data visualisation for teaching children with low-functioning autism [7] to real-time monitoring [8] and data management [9] for tailored intervention. However, there aren't many research that concentrate on predicting ABA results. It is crucial to keep in mind that behaviour analysis techniques used in ABA therapy are quite systematic and supported by research. Thus, data-driven techniques such as learning analytics (LA) might be used to enhance ABA-related technologies. Since ABA treatment is often used in educational practice to understand and maximise learning and the learning environment, LA has the potential to enhance present ABA therapy in the interim [10].

This project aims to enhance existing ABA therapy by anticipating behavioural changes in SEN children utilising educational data from many modalities. In particular, the following research questions guide our work.

• RQ1: What are the statistical features of the mobility, physiological, and ambient environmental data gathered from ABA treatment sessions for SEN students?

• RQ2: Compared to standard educational data, can sensors and wearable data improve the prediction of behaviour change in SEN students?

• RQ3 Is it possible to use machine learning (ML) algorithms in MMLA to anticipate behaviour changes in SEN pupils, and how well do they perform in comparison to other MMLA studies that have already been done?

The present paper's Sections IV and V will provide comprehensive answers to the aforementioned queries. The following are some of the contributions of our work:

• We create and implement a multimodal ABA treatment data collecting system, gather and examine data from 1,130 ABA therapy sessions, and provide thorough statistical analyses of our findings.

• Using statistical evidence, we demonstrate that wearable data and sensors may greatly improve the prediction of behaviour change in SEN kids compared to standard educational data.

• We show that deep neural networks (DNN) and machine learning (ML) algorithms can reliably forecast how SEN pupils' behaviour will change. We also compare our findings with previous research and provide thorough performance analyses of our prediction models.

Our study will provide fresh perspectives on ABA procedures, particularly in using wearable technology and Internet of Things (IOT) sensors to forecast students' learning. The use of MMLA to improve behavioural interventions in SEN students and foster their skill development will be further realised by the engineering community as a

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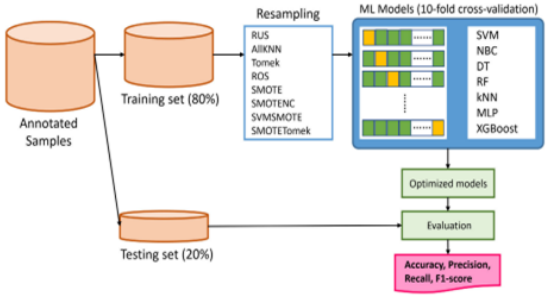
whole via this effort. Additionally, the novel results in this work provide useful references for further special education technology research.

2. SYSTEM ARCHITECTURE



3. EXISTING SYSTEM

Through the systematic use of educational tactics drawn from behaviour principles, Applied Behaviour Analysis (ABA) is an intervention strategy that aims to decrease problem behaviours and enhance socially relevant behaviours [4]. Experimental assessments of behaviour have provided a scientific evaluation of the collection of fundamental principles, which are assertions about how environmental factors operate as input to a function of behaviour (p.155). Behaviour in ABA is defined as the learner's engagement with his or her environment, which includes the movement of one or more bodily parts. Behaviour is learnt in the context of the environment. The whole collection of physical conditions in which the learner is placed is also considered to be the learning environment.

The accomplishment of behaviour modifications that enhance learners' quality of life in terms of communication and everyday living abilities is the learning objective of ABA classes. Prior to the ABA classes, a methodical and quantifiable behaviour evaluation plan is established. Positive rewards are often used to promote goal attainment, and the desired behaviour is frequently divided into smaller tasks. The assessment criteria include whether the student is performing in a manner that is unrelated to the task (off task), if a cue from the therapist is required to help the student complete the work, and whether the target task is completed (plus) or not (minus). Additionally, if a behaviour modification is long-lasting, it is successful [11]. To guarantee the efficacy of the treatment, a follow-up evaluation of the formed behaviour is also required.

Because they struggle with sensory processing, students with special needs may be more vulnerable to environmental factors. High CO2 content was linked to tiredness and focus issues in SEN kids, particularly those with ADHD, according to a prior research [12]. Preschoolers with intellectual disabilities may get distracted from their studies and have negative effects on their mood and health due to classroom thermal discomfort, such as high ambient temperatures [13]. Due to their psychologically taxing circumstances, students with intellectual impairments (ID) may be more susceptible to acoustic discomforts, according to the same research (p.115). Researchers also looked at the connection between SEN pupils' comfort and classroom illumination. They discovered that although glare and improper

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illumination had varying effects on certain SEN kids, they generally caused them to feel drained and agitated [14]. However, other than turning lights on or off, instructors and therapists sometimes have little influence over illumination qualities (p.105).

Both SEN and non-SEN children' learning and participation may be impacted by emotion. Students with ID in particular often display anxiety as a result of internal tension. Physiological indicators of stress that impair learning include heart rate, blood pressure, and body temperature [15]. Mild circumstances have been shown to lower these inhibitors in SEN kids [16]. It is well known that SEN children' learning performance was hampered by unusually high or low skin conductance levels (as determined by galvanic skin response, or GSR) [17]. Additionally, a research discovered that SEN pupils' short-term memory abilities were enhanced by body movement enabled by motion-based technology.

To enhance learning analytics, MMLA uses a variety of educational data sources and formats, including activity logs, audio, video, and biosensors [19]. The Internet of Things (IoT) technologies greatly improve MMLA as they make it easy to collect multimodal data from the intricate learning environment [20]. IoT sensors that measure the ambient learning environment (e.g., light, humidity, temperature, and noise) and detect learners' movements (e.g., head and body) and physiological (e.g., heart, brain, and skin) behaviour are examples of multimodal educational data. After being gathered from tangible things or human bodies, these data were converted into a machine-readable format and sent into MMLA [21]. Validated learning theories may be used to offer potential interpretations of the observed learning process.

Disadvantages

• Why Because our prediction objective is a binary output, instructors and therapists have less information about kids' ABA learning.
• The present method of gathering data involves a one-on-one interaction between students and therapists. On the other hand, one-to-few or one-to-many classroom instruction is often used in the everyday special education setting.
• The present study's measuring equipment is expensive. Empatica E4 bracelets, for instance, were used, despite the fact that they might cost over $1,000 USD.

4. PROPOSED SYSTEM

1) Gathering multimodal learning data: This involves both administering ABA treatments and recording the unprocessed learning data that emerges from various modalities.
2) Pre-processing and annotation of data: This includes taking relevant information out of the raw records, creating data traces in the necessary modality, fusing the traces, and then adding learning labels to the fused data to create labelled samples.
3) Data processing, model construction, and assessment: This includes conventional machine learning processes, such as training, testing, performance evaluation,

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model building, and any required resampling.

Advantages

• We create and implement a multimodal ABA treatment data collecting system, gather and examine data from 1,130 ABA therapy sessions, and provide thorough statistical analyses of our findings.

• Using statistical evidence, we demonstrate that wearable data and sensors may greatly improve the prediction of behaviour change in SEN kids compared to standard educational data.

• We show that deep neural networks (DNN) and machine learning (ML) algorithms can reliably forecast how SEN pupils' behaviour will change. Additionally, we compare our findings with previous research and provide thorough performance assessments of our prediction models..

5. IMPLEMENTATION

Modules description

Service Provider

The Service Provider must use a working user name and password to log in to this module. He can view trained and tested accuracy in a bar chart, view trained and tested accuracy results, view student behaviour change status prediction, view student behaviour change status ratio, download trained data sets, view student behaviour change status ratio results, and view all remote users after successfully logging in.

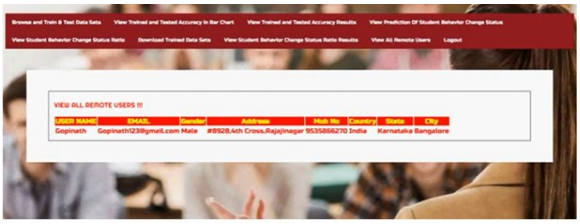
View and Authorize Users

The administrator may see a list of all registered users in this module. Here, the administrator may see the user's information, like name, email, and address, and they can also grant the user permissions.

Remote User

A total of n users are present in this module. Before beginning any actions, the user needs register. Following registration, the user's information will be entered into the database. Following a successful registration, he must use his password and authorised user name to log in. Following a successful login, the user may do tasks such registering and logging in, predicting student behaviour, changing the status type, and seeing their profile.

6. SCREEN SHOTS



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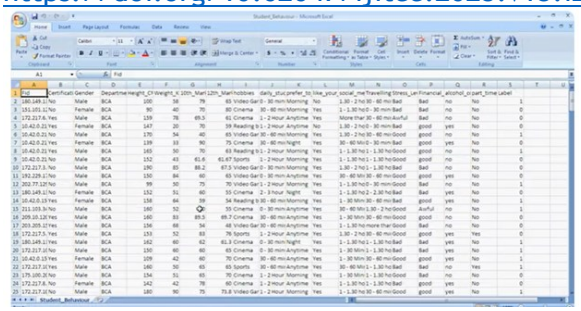

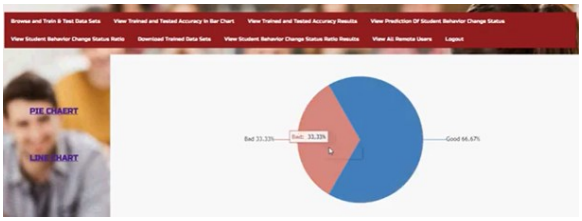

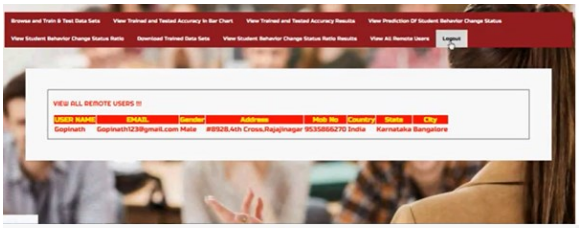

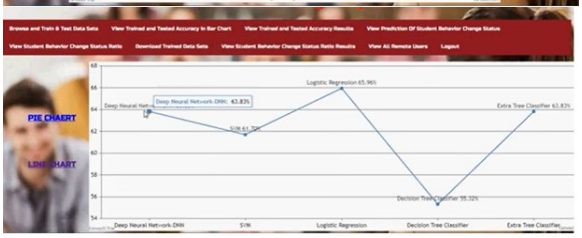

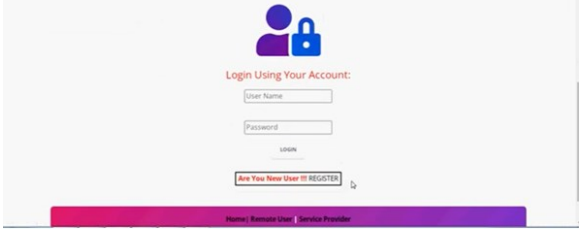

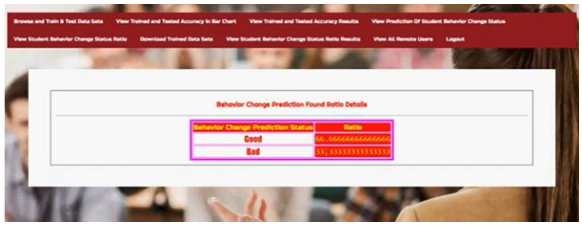

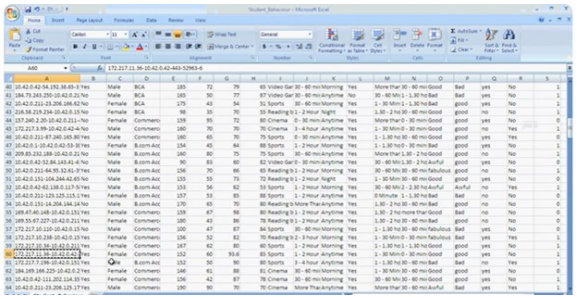

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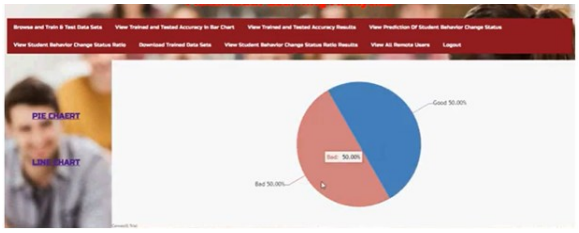

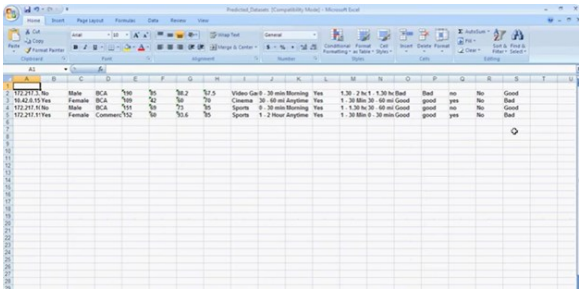

7. CONCLUSION

In this research, we predicted behavioural changes in special education (SEN) children receiving ABA treatment using MMLA. For predicting the effectiveness of behaviour modification in ABA therapy for children in special education, a novel MML approach is presented. We used data from IOT sensors, including physiological measurements (IBI, BVP, GSR, and skin temperature), motion measurements (accelerometer values in X, Y, and Z directions), and ambient environmental measurements (CO2 level, humidity, light intensity, and temperature), to build statistical models for ABA therapy. Furthermore, we anticipate behavioural changes in SEN children using ML and DNN techniques.

We looked at the statistical features of the multimodal educational data and found that most of our data are not regularly distributed. Our variables did not show multicollinearity, despite the fact that there were significant relationships between them. We also showed how wearable sensors and data might significantly enhance the prediction of behaviour modification success for children with special education needs. ML methods, including a DNN, were developed, refined, and evaluated. Our results demonstrated that MMLA and ML, especially deep learning, may be used together to predict behavioural changes in SEN children. On the other hand, our classifiers and DNN perform better than most of the existing MMLA models. However, we also observed that the models under comparison had different prediction goals.

Encouraging positive conduct in special education (SEN) students is essential to their social and mental development. Additionally, one effective therapeutic technique that focusses on behaviour change in this specific population is ABA therapy. Understanding the learning environment and the learner's physiological state during ABA therapy sessions is essential to

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understanding how behaviour skills are acquired and how they affect subsequent behaviour modification. The current study has confirmed the hypothesised connections between the learner's physiology, the learning environment, and the learning outcome in ABA therapy. A number of limitations and important upcoming initiatives are also mentioned. All things considered, our study backs up the growing demands for ML to help kids with developmental and neurological disorders in their academic endeavours. [43].

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