Leveraging Data-Driven Approach to Empower Assistive Technology

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***Abstract* — Assistive technology plays an important role in aiding people with Special Educational Needs and Disabilities (SEND). Filisia Interface Ltd has successfully developed an award-winning assistive hardware (COSMO), which is being used in schools, therapy, and homes to aid in learning for users with SEND. However, interoperability and integration with existing systems to ensure compatibility and smooth data exchange and personalization and adaptability are among key challenges in developing assistive technology. This research paper explores how a data-driven approach can be leveraged to empower the emerging potential of assistive technology and its impact on EdTech. The paper investigates how assistive technology is being used and the limited options for customizations and personalization for individuals with different physical or cognitive conditions. Also, this paper highlights how key metrics from the COSMO assistive hardware are used alongside its partner application to create an integrated system that processes and visualizes this data for interpretation by therapists and teachers for progress tracking purposes. The first version of the system has been deployed and is in its user evaluation stage which has been very well received.**

Keywords- assistive technology; EdTech; Special Educational Needs and Disabilities (SEND); progress tracking.

I. INTRODUCTION

The term Assistive Technology refers to a wide spectrum of tools, devices, and software that aid in communicative, sensory, physical, or cognitive function for individuals with special requirements [1]. Beyond its various applications and advancements in the technological field, it plays a much more important role in promoting accessibility, equal opportunity and creating a more inclusive environment. Its importance in the modern world stems from its ability to close the gap between ability and access. The usage of assistive technology in domains such as education, employment, or even just as an aspect of daily life can help people with disabilities to be active participants in their respective activities and improve social interactions.

In EdTech, technologies like speech recognition, gaze tracking, and collaborative learning insights further enrich the learning environment, ensuring an inclusive and effective educational experience [11]. Assistive technology for Special Educational Needs and Disabilities (SEND) plays a crucial role in promoting inclusive education, enhancing learning experiences, and empowering individuals with diverse abilities. This technology encompasses a wide range of tools, devices, software, and strategies that help individuals overcome barriers and participate fully in educational activities [2]. That being said, extensive ethical considerations are vital, ensuring data privacy and security while leveraging data to empower students with disabilities and foster equitable learning outcomes [3]. In addition to that, some major concerns in the current assistive technology market were discovered.

1. Personalization and customization: Most available assistive technologies were found to be developed for specific conditions hindering effectiveness in scenarios with a wide spectrum of conditions [4].
2. Lack of research and development: There may be disability-specific needs that are overlooked during the development of assistive technologies due to insufficient research into the condition [5].

This study was conducted alongside Filisia Interfaces Ltd and the assistive technology and application they developed. The company specializes in developing assistive technology products and solutions, particularly for individuals with special educational needs and disabilities. The product (COSMO) is a combination of assistive hardware and custom-built software that acts as a learning environment.

The focus of this paper is on how a data-driven approach can add to the functionality of assistive technology to track the progress of users with SEND, aid in adaptive gaming, and possibly help with pattern recognition of specific markers to differentiate various communicative, sensory, physical, or cognitive conditions. By doing so, this study also aims to bring COSMO into focus and how it addresses the gaps in the current assistive technology market.

The rest of this paper is organized as follows. Section II explores the use cases and similar studies that have been conducted on topics concerning data and assistive technologies. Section III describes the work performed for this research paper using the COSMO devices and the methodology, development, and implementation of data-driven software. Section IV addresses the content that is visualized using graphs and how it can be interpreted to facilitate progress tracking. Section V talks about possible work in progress or additional aspects of the topics to be added and finally close the article.

II. RELATED WORKS

Assistive technology is by no means a new topic of research as their application can be seen in various domains and there have been numerous studies and case studies detailing the research and development that has been carried out towards the improvement of the technology, as well as understanding the conditions of the users [1][6]. A comprehensive literature review has been performed to

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understand how assistive technology is being used, its implications, and the challenges it has faced. This research also sheds light on how the process of research and development of assistive technology has been carried out collaboratively with the private sector [6]. To that extent, this section will detail some of the pertinent papers and articles relevant to the topic at hand.

To start with, collaborative research conducted by Filisia Interfaces Ltd and the University of Birmingham discovered that technology-assisted music-making can have a positive impact in enhancing engagement and social interaction in children with Autism [7]. This study used the COSMO buttons and specific music-based activities provided by the company to test the social-emotional communication and response, attentiveness, and engagement of a group of children with Autism. It deducted that in this scenario, using sounds alongside assistive hardware showed positive outcomes [8].

Similarly, the thesis "Using Wearable Assistive Technology to Improve Time Management of Students with Disabilities in a School-Based Employment Training Setting" [9] and the experiments conducted suggest that using wearable assistive technology in the form of smartwatches (Apple Watch) can help students with disabilities function with a higher degree of attention and improved time management. This thesis goes on to signify the usefulness of assistive technology and the socio-economic impacts it can have by making students with disabilities more employable.

Another research paper, "Augmented Learning Environments as Assistive Technology for Kids with Learning Disabilities" [10] shows the effects of creating a learning environment augmented by assistive tech and the benefit it has for teaching kids with learning disabilities.

III. Assistive Technology in Action

This section elaborates upon how the assistive technology developed by Filisia Interfaces is being used in schools and therapy, the methodology behind progress tracking using COSMO and how it was implemented.

A. Use of COSMO in EdTech and Therapy.

The symbiotic relationship between data and the decision-making process has been observed throughout various industries and domains over a long period of time. Companies and organizations are increasingly relying on data to make critical choices for themselves. Data also serves a pivotal role in augmenting educational technology with assistive capabilities. By utilizing data, educational technology can tailor learning experiences to the individual needs of students with disabilities. This includes personalized learning paths that adapt content and pacing, early intervention through data-driven identification, and real-time progress monitoring. Furthermore, assistive technology can be utilized to analyze data, adapt instructional materials for accessibility, and provide immediate feedback, enhancing engagement and skill acquisition.

With the target of creating an inclusive learning environment, assistive technology plays an integral role in EdTech. There are diverse learning conditions in a SEND environment and assistive technology bridges the gap between various kinds of learning. One such hardware, a Bluetooth-enabled switch COSMO also known as Cosmoids developed by Filisa Interfaces Ltd can work alongside an iOS application to give access to multiple training and learning activities, or each Cosmoid can be customized to register a keystroke to control 3rd party devices and apps. This functionality provides an added benefit to the use case of this device as being able to use the buttons as switches for keyboards can help people with disabilities requiring less external support and improve their confidence [12]. The company works with various Occupational Therapists and schools where these devices are used in therapy and educational settings.

When used with the iOS application, up to 6 cosmoids can be connected concurrently to be used with various activities. Each cosmoid is represented with different colors for identification and tracking. The iOS application gives access to various activities which range from simple cause-and-effect to math. The devices also consist of dynamic touch and force sensors which are used for this experiment to collect data on how quickly a user can press the button and how hard they press the button after a visual cue is provided.

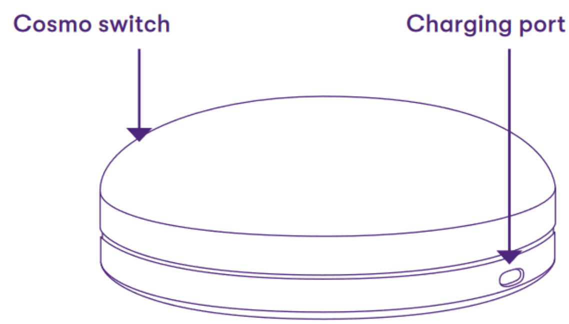

Figure 1. Cosmoid Top View.

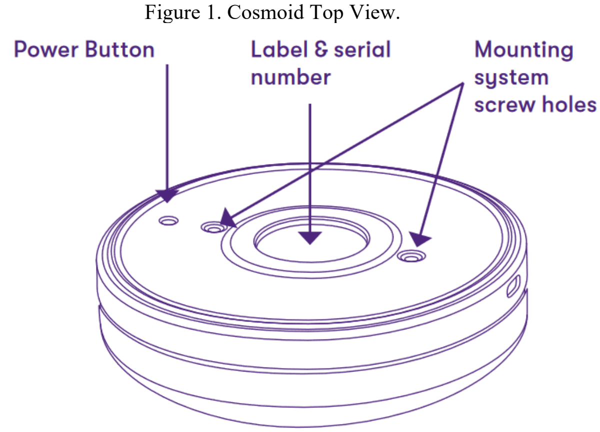

Figure 2. Cosmoid Bottom View.

Figure 1 and Figure 2 show the Cosmoid button/switch in which its outer hardware specification is detailed from the top and the bottom, respectively.

B. *Methodology: Progress Tracking using COSMO*

The cosmoids work in conjunction with the iOS application (Cosmo Training) to provide various activities to the users. One such activity – Sequence, was developed from scratch with its data insights being useful for both the company and the user. The core concept for this activity came from discussions on how the hardware and data generated from it can be integrated with a therapy session and the kind of interpretation that can be extrapolated to aid in the progress tracking of a patient.

To that end, the activity was designed with various predefined configurations to minimize the external factors that could skew the measurements of the experiment, but users are still given the flexibility to create custom configurations as they see fit. The predefined configurations consider the number of devices, the duration of the session and distance between the devices to ensure the experiments generate consistent data. In an experiment the following key metrics are collected so that it may be used in progress tracking:

1. Number of Trials: The number of times in an experiment where a sequence of all devices was pressed.
2. Total Duration: The time the experiment was conducted.
3. Response Times: The time it took to press each cosmoid in each trial. This value is later used to calculate the average response time for each cosmoid.
4. Force Values: The force with which each cosmoid was pressed in each trial. This value is later used to calculate the average force value for each cosmoid.

Other metrics are also tracked and collected for processing, but the above-mentioned metrics are key for interpreting progress in a patient.

C. *Implementation of solution*

The proposed solution which is implemented in this paper is visualized in Figure 3. In the workflow, the data generated by the cosmoids is stored using the existing iOS application (Cosmo Training) along with other user data into a NoSQL database (Cloud Firestore) in this instance and utilize the serverless capabilities provided by the Google Cloud Platform to execute the necessary processing of the data and the generation of the visualizations. At the same time, the iOS app also sends the data to a third-party analytics platform which is used for reports and insights necessary for internal decision-making.

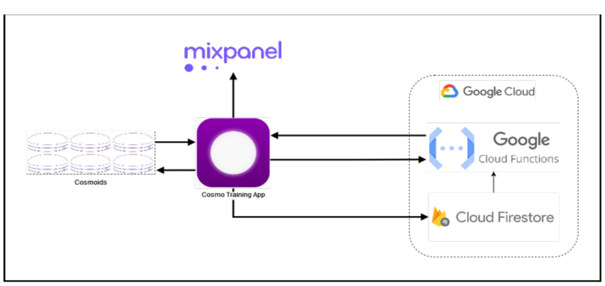

Figure 3. Process Workflow.

On the iOS application end, user events are stored in Firestore. When the visualizations are accessed, the app calls the serverless function API, which then starts processing the required data and generates the relevant graph. Within the functions which are written in Python, the data is accessed from the Firestore database and stored as a Pandas Dataframe. This data frame is then subjected to various data processing techniques to prepare the data for further analysis. This includes cleaning and formatting of the data before new values are calculated using the existing data such as the average response times and average force values. After this point, the prepared data is processed and plotted against different progress-tracking models by taking the number of trials, total duration, response time, and force values into consideration. The plotting of the charts is handled using Plotly. The serverless function then responds to the iOS application with a graph with is rendered on the app.

IV. Results: Visualization & Interpretation

This section showcases the results that were achieved from the data analysis and how they can be interpreted to visualize progress tracking.

A. *Insights for Company*

The data sent to the analytics platform can be used for various business intelligence scenarios such as calculating Active Users, User retention, activity usage analysis and so on.

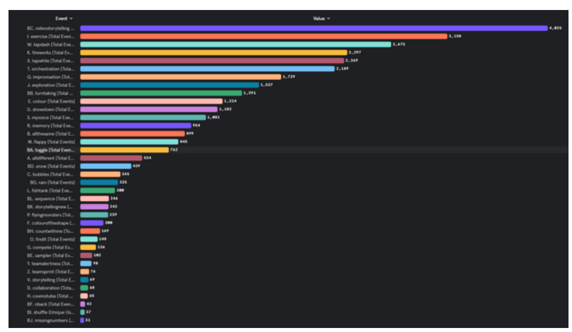

Figure 4. Comparison of metrics of different activities.

B. *Interpretation for Progress Tracking*

When the user selects any previous experiment/ session they are presented with the graph in Figure 5, which shows them the time it took for them to complete each individual trial in each session. Since the configurations of the session remain consistent any change in time can be assumed to be because of the patient. Here, lower times denote better performance and vice versa. The variance in times can be an indicative metric of the patient's progress. This chart is independent of all other sessions (except for the average trial time) meaning that this can be used for immediate feedback of the patients.

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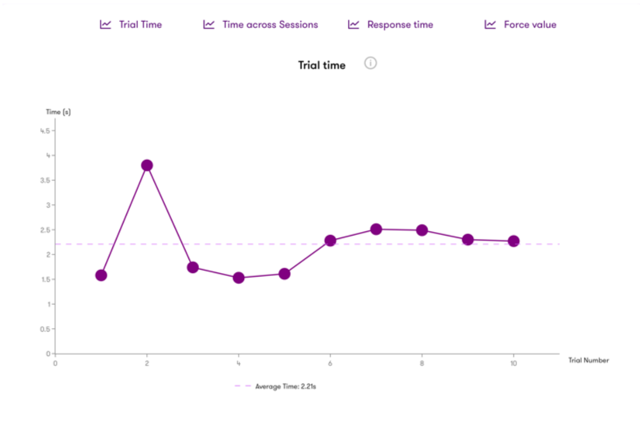

Figure 5. Trial Time.

In Figure 6, the graph represents the average time for a patient to complete a trial over multiple sessions. This can be an overall indicator of progress since the time taken is plotted against the date the session it was conducted on. Therefore, it can be used for tracking whether there has been progress over a certain duration of time. This can be useful in a therapy setting or for students who play the sessions in schools where sessions are conducted weekly provided the same configurations are replicated for each session.

Figure 6. Time Across Sessions.

Another measure of progress that can be calculated is by using the key metric - response time. The response time denotes the time taken to press a specific cosmoid after it was lit up. For the experiment, the cosmoids are always lit up in a specific color palette making it easier to track response time over multiple sessions. These response times are all tracked for each session and a final average response time for the entire session is calculated alongside the average response time of all other sessions with the same configuration. The average of all sessions is then plotted against the average of a specific session to see the difference in response times for each cosmoid collected.

Figure 7. Response Time.

In Figure 7, we see two distinct types of plots can be seen paired up by color. For example, a larger dot (Selected session average response) and a smaller dot with just an outline (average of all similar sessions) of the same color are plotted and joined by a line of the same color. Here, we see a comparison between the average response time of one specific session versus the overall average of similar sessions. If the average response time of the selected session is lower than the average response time of the overall sessions it can be interpreted as positive progress in that session.

Figure 8. Force Values.

Similarly, the final measure of progress is calculated using force value. The force value denotes the force with which a specific cosmoid is pressed after it was lit up. The calculations are performed in the same way for force values where the average of the session and the average of all sessions are calculated and compared. This can be seen again in Figure 8, where two distinct types of plots can be seen paired up by color. The larger dot (Selected session average force value) and a smaller circle with an outline and dot in the middle (average of all similar sessions) of the same color are plotted and joined by a line of the same color.

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Here, we see a comparison between the average force value of one specific session versus the overall average of similar sessions. Positive progress for force value can be interpreted if the value of the larger dot is less than that of the smaller circle denoting that the cosmoids have been pressed harder.

V. Conclusion and Future Work

This paper presents the research that was carried out to highlight the potential of assistive technologies and how a data-driven approach can be leveraged for critical decision-making processes while at the same time also providing useful insights to the users. To explore this potential, research was done on previous case studies related to assistive technologies and how the data they generate are being used. To add to that, a personal experiment was conducted alongside Filisia Interfaces Ltd with their assistive technology implemented in an EdTech setting. Data was collected from therapy sessions/ learning environments where the relevant metrics (response time, force value, and trial duration) were built into the activities to facilitate progress tracking for the users. These metrics were processed and analyzed and rendered as graphs. The visualizations provide a means of progress tracking for the therapists and schoolteachers for a particular user by interpreting the metrics of a particular session individually or with all conducted sessions to gauge physical or cognitive progress depending on the user's condition. To summarize, the experiment focused on the viability of the data collected from their device for critical internal decision-making and at the same time provide a means of progress tracking to their users in a therapy/ school environment.

To add to this, from a technological perspective, this same model can also be used in conjunction with different ML models for adaptive gaming where the data will be processed to predict and adjust the difficulty and/or configurations of a user based on how they are performing in them. From a research perspective in SEND, this approach can be utilized to discern if there are any specific markers in the data for certain physical or cognitive conditions that can be recognized and potentially be used for predicting said conditions which is one way to address the gap in terms of research and development.

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