Auxilia: Assistive Learning Tool for Children with Down Syndrome

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***Abstract*—A third copy of chromosome 21 results in the incurable genetic disease called Down's syndrome. A medical term for having an extra copy of a chromosome is 'trisomy' and hence is also referred to as Trisomy 21. Children with Down syndrome often have IQs in the lower range and speak more slowly than other kids their age. The project aims to target children under the age of twelve who have issues in learning and getting introduced to new concepts (learning disabilities). The teacher determines the child's preferred technique of learning, and then the best teaching approach is used. The project consists of three sections: the application which is both teacher's and student's phone, an audio comparison module and provision for biotelemetry. The software application consists of activities ranging from LEVEL 1 to LEVEL 4 which helps the child to initially develop interest in the activity and then perform the activity. The audio comparison module compares the voice of the child and the audio it has. The biotelemetry module checks BP, pulse rate, oxygen level and temperature. Thus, AUXILIA will act as an overall assistance guide and a health monitoring device for Down's syndrome students.**

Keywords—Down Syndrome, learning disability, IQ, assistance

I. Introduction

A third copy of chromosome 21 results in the incurable genetic disease called Down's syndrome. A medical term for having an extra copy of a chromosome is 'trisomy' and hence is also referred to as Trisomy 21. Children with Down syndrome often have IQs in the lower range and speak more slowly than other kids their age. The project aims to target children under the age of twelve who have issues in learning and getting introduced to new concepts (learning disabilities).

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II. Related Work Or Literature Review

A. Wearable device for literacy activities with people with down syndrome

The study by D.A.A. Santos et.al[1], examines how wearable computing is being used to create technologies that can support educational activities. In order to achieve the persistence of vision effect, they suggest an embedded system in the shape of a smart glove. This enables the display of words and letters in literacy exercises. The system now has additional features, like a laser emitter for interacting with the classroom setting and Bluetooth capability for remote programming. Other technologies in the environment, including multimedia projectors, can also be controlled by the glove. The tool suggested in this work was initially assessed for literacy exercises with Down's syndrome patients. AffDex performed the automated usability testing. This software

allowed for the quantification of attention and engagement during activities.

B. Wearable device for literacy activities with people with down syndrome

Authors P. Záviška et al., [2] provide an extensive review of audio declipping algorithms . For each algorithm, assumptions that are made about the audio signal, the modeling domain, and the optimization algorithm are presented. Furthermore, the paper provides an extensive numerical evaluation of popular declipping algorithms on real audio data. Evaluation of each algorithm in terms of the signal-to-distortion ratio and also using perceptual metrics of sound quality The article is accompanied by a repository containing the evaluated methods.

C. A fully automated health-care monitoring at home without attachment of any biological sensors and its clinical evaluation

In order to investigate the applicability of health condition monitoring, the authors K. Motoi et al.,[3] have developed a new monitoring system which can automatically monitor and store the health condition data. In this study, by evaluation on 3 patients with cardiac infarct or sleep apnea syndrome, patients' health condition such as body and excretion weight in the toilet and apnea and hypopnea during sleeping were successfully monitored, indicating that the system appears useful for monitoring the health condition during daily living.

D. Web application to track student attentiveness during online class using CNN and eye aspect ratio

Authors D. Deepa et al. [4] the higher suggested in their paper that due to more bandwidth consumption of the audio and video streaming, students can't be compelled to unmute the audio and video when the teacher delivers the content. So, there is no option for the teachers to observe the student's activity. With the advancement of technology and enhanced image analysis capacity of deep learning techniques, a system is proposed to compute the student's activity and can report it to the teachers during the- class time itself. Drowsiness detection is tested using CNN based segmentation on our own set of 5000 images collected from 1000 students. The observed result shows 90 percent accuracy in predicting the drowsiness of the student by observing the student's face pattern without streaming the video to the teacher's device.

III. Proposed Methodology

The architecture of the proposed solution is given below. The solution will have the following components:

- Software application in the child's phone which is categorized into LEVEL 1 to 4 that can help to learn concepts.
- Software application in the teacher's phone to monitor progress
- Audio comparison module to compare the audio of the teacher and the child.
- A module for biotelemetry that checks the temperature, BP, oxygen rate and pulse of the child and notifies the reading to the parent.

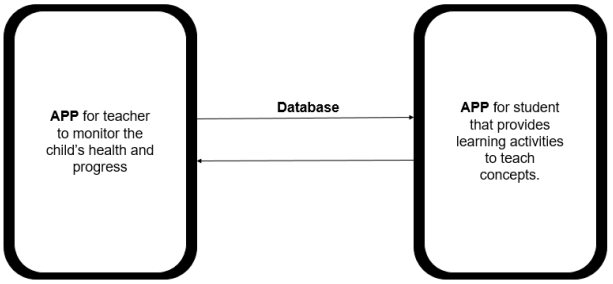

Fig. 1. Architecture of the System

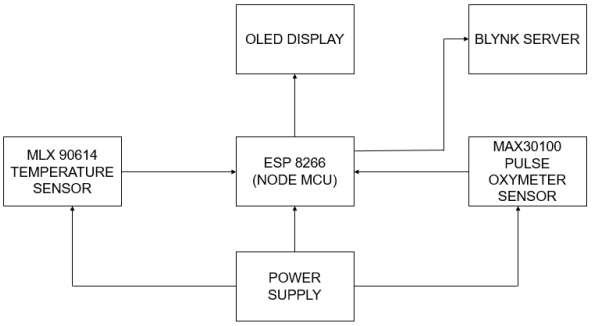

Fig. 2. Block Diagram for Biotelemetry

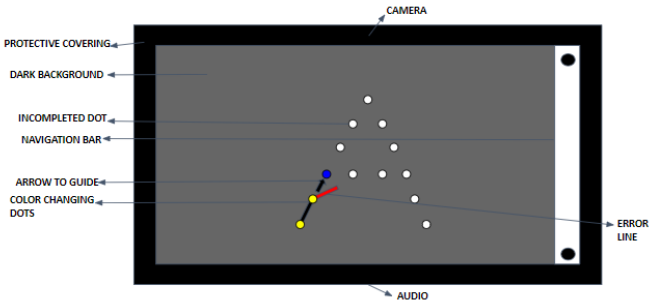

Fig. 3. Display Board

A.Mobile Application

The software application is on both child and teacher's phone and hence has two logins available. According to where the user logins, the dashboard of their respective role appears. There will be a session key to keep the child logged in continuously. The child will have four levels which will help in initially developing interest and then teaching the concepts.

Level 1 focuses on bringing hand eye coordination and is to get familiarized with the gadget and color. According to the questionnaire, the child is mapped to the respective levels. The child is asked to scribble on the board for a particular time. After a part is completed, a reward in the form of stars/claps

will be provided. After certain stars are collected, they will be taken to the next level. The child will be given primary colors and will be asked to choose the colors and fill in the box. This activity is done to identify the colors used and to recognize boundaries or where to limit their hand movement.

Level 2 focuses on identifying colors and sizes. For this colorful bead counting is used. The child is asked to keep each of the beads on top of one another. This helps the child to learn counting and can distinguish between sizes.

Level 3 focuses on alphabet and sound familiarization. This is the first official step for the child to learn alphabets and numbers. The song will have 3 seconds lag between each alphabet as the time for grasping a letter is different from a normal child. The child can understand the structure of each alphabet and can color the alphabet from different colors provided in the palette.

Level 4 focuses on writing the alphabet and pronunciation. the child needs to trace the alphabet which is provided on the screen and after completion of that, the audio with respect to the alphabet will be provided. The child needs to repeat the audio which will be played for 2 or 3 times and the correctness of the pronunciation is checked.

B.Audio Comparison

In order to improve the speaking ability of children with Down Syndrome, Auxilia performs speech analysis and audio comparison of the teacher's and students' audio.

Preprocessing: The collected audio samples are passed through a low pass filter with a cut-off frequency of 2.5 kHz and an order of 50 to eliminate the ambient noise.

Feature selection: Six temporal parameters were selected to classify the audio. They are mean, energy, zero-crossing rate, crest factor, standard deviation and impulse factor.

Feature extraction: A threshold was determined by comparing the values from the teacher's and child's audio.

ML classifier: The threshold of each parameter will be loaded to a ML classifier, with which it will be trained.

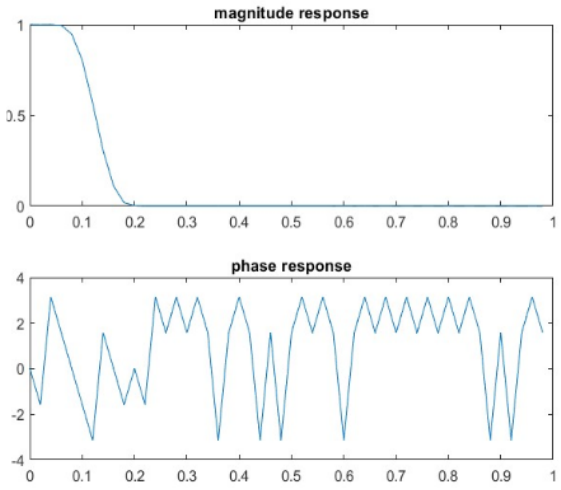

Fig. 4. Preprocessing

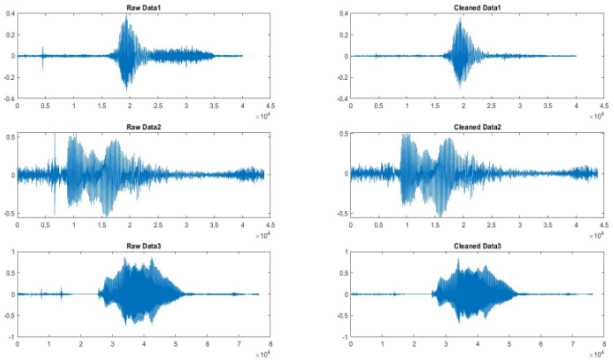

Fig. 5. Feature Selection

C. Biotelemetry

Children with Down Syndrome can have varying health conditions and hence monitoring health parameters is very important. Analyzing those, we can detect the probability of sleep apnea or similar disorders that can hamper the child's life. Here, we are only providing a method for obtaining the readings from various sensors. The sensors have to analyze four health parameters namely: blood pressure, pulse, oxygen level and temperature. The system is built in such a way that the readings are forwarded to the parent and the teacher so as to analyze the child's health. All these parameters are measured from the child's fingerprint.

IV. Experimental Analysis

A.Mobile Application

The application is developed using Flutter and the backend is written using Firebase.

For LEVEL 1 which includes the questionnaire and activities like scribbling and coloring inside the box; the implementation is done using Flutter Canvas. This focuses on bringing hand eye coordination. If the child has scribbled 30% of the screen provided, he/she will be provided a reward and promoted to the next level. The progress is stored in the database and it is fetched to the teacher's dashboard. This is done using MySQL.

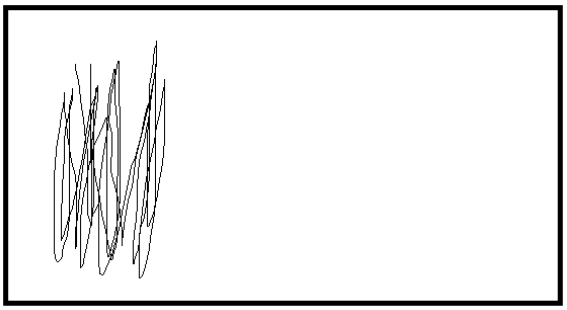

Fig. 6. LEVEL 1: Scribbling

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Fig. 7. LEVEL 1: Color in the box

For LEVEL 2 which includes bead counting, for which a demo module from Unity is used.

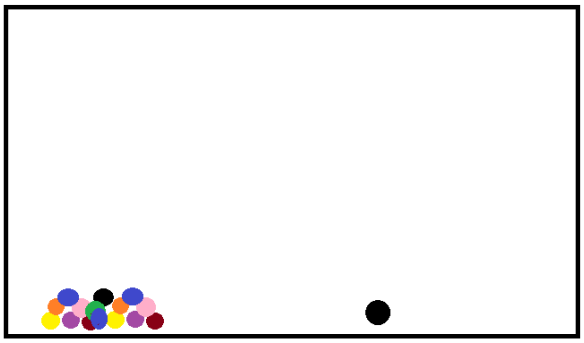

Fig. 8. LEVEL 2: Bead Counting

For LEVEL 3 which includes listening to songs and developing interests, a set of videos are taken (those are selected by the teacher) and are induced by a delay of 3 to 4 seconds after which the next alphabet will be introduced. This can be implemented using system calls which can create delay.

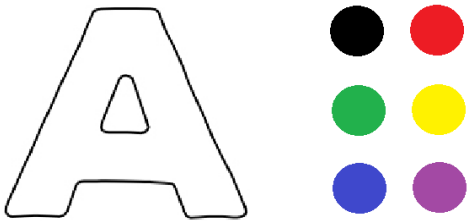

Fig. 9. LEVEL 3: Color within the alphabet

For LEVEL 4 which includes writing the alphabet; an original picture of the alphabet is clipped with the canvas displayed on the screen. This is implemented using Java and Clippath. The frames are set by which the path to draw is identified and if there is a change in the condition which is set, errors will be shown.

B.Audio Comparison

In order to improve the speech and pronunciation of the children with down syndrome, Auxilia performs speech analysis and comparison of the real-time audio input from the child and the pre-recorded audio by the teacher. As of present, the dataset collection is done where the data is classified into good and bad data. The preprocessing of the audio is done using the FIR(Finite Impulse Response) Filtering. LPF (Low Pass Filter) with cut-off 2.5kHz is used as filter and the order is 50. Since the child's audio needs to be compared with the teacher's audio; certain features must be selected. The features selected are Energy, Entropy, Mean, RMS(Root Mean Square) value, Impulse Factor, Crest Factor and Standard deviation.

TABLE I. Feature Extraction Dataset 1

Letter	Zero-crossing	Energy	Mean	Std Dev	Crest Factor
Good A	0.032	1500	2.6	0.12	4.3
Bad A	0.043	1380	4.2	0.1	4.79
Threshold	0.0375	1440	3.4	0.11	4.54
Good B	0.021	1520	4.8	0.11	5.8
Bad B	0.034	1470	7.5	0.8	4.4
Threshold	0.028	1495	6.15	0.95	5.1
Good C	0.025	1310	8.50	0.1	5.01
Bad C	0.044	820	7.76	0.67	5.14
Threshold	0.034	1070	8.13	0.385	5.075

TABLE II. Feature Extraction Dataset 2

Number	Zero-crossing	Energy	Mean	Std Dev	Crest Factor
Good 1	0.029	1850	4.5	0.06	7.7
Bad 1	0.034	1270	4.4	0.1	5.35
Threshold	0.031	1565	4.45	.08	6.52
Good 2	0.039	1200	4.02	0.07	7.27
Bad 2	0.04	860	2.15	0.15	5.6
Threshold	0.0395	1030	2.58	0.11	6.43
Good 3	0.045	1190	3.78	0.04	6.05
Bad 3	0.052	745	2.02	0.11	5.16
Threshold	0.0485	970	2.9	0.075	5.60

C. Biotelemetry

Children with Down Syndrome can have varying health conditions hence monitoring of their health parameters is very important. By daily monitoring and recording their health, the doctor, teacher and the parent will get an idea about their health condition and they can take sufficient actions. Here, we are only providing a method for obtaining the readings from various sensors. The sensors have to analyze four health parameters namely: Pulse rate, Oxygen saturation level and Body temperature. The MLX 90614 IR Temperature sensor measures the body temperature of the student. The MAX 30100 pulse oximeter sensor measures the pulse rate and also the oxygen saturation (SPO2) level. The data from the sensor will be sent to the Blynk server using the ESP8266 Node MCU.These three data will be displayed lively on the OLED Display and from the Blynk server it will be sent to the Teachers and the Parent's mobile number. The data will be

stored in the mobile application on their phone for future references. This module is a stand alone device that requires a separate power supply. All these parameters are measured from just one finger punching.

V. Conclusion

Down syndrome is a common genetic condition that can be identified at an early stage. The idea intends to give the children a platform to learn in a more interactive way. It lessens the effort of teachers and therapists and aids in the improvement of children's speaking abilities. It also keeps track of the child's health and academic development. The approach lessens the amount of repetitious work that teachers must do. Our system offers a fresh approach to learning and a comprehensive learning solution for kids with Down syndrome. It was observed that the children with down syndrome were attracted to bright colors and music. So we decided to design an interface based on that. We also found out that learning skills of Down Syndrome students are very low compared to normal children and thus they lack their intellectual skills. But they are good at other activities like dancing, stitching etc. Hence engaging them in interesting activities can bring the best out of them. Auxilia follows a pattern that adds interest for the concept the children are learning. The various levels can increase the attention span of the child and hence can help them learn more. We are sure that Auxilia can act as a best friend for them in their development. It will act as a helper or guide in all aspects. Auxilia will act as an assistive tool for their learning disability, speech disability and it will act as a daily health monitor for them. Through Auxilia we are showing our social commitment to the society.

Acknowledgment

We were overwhelmed by the capability of students to learn different concepts if the topics were introduced to them in a better manner. We always wondered the role we, as students, could play in helping them do the same. So, by these, our vision was to create a learning platform which can better their attention span and a health monitoring system that can help children with Down Syndrome.

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