ANALYZING AND PERSONALIZING THE LEARNING PERFORMANCE FOR SPECIAL NEEDS STUDENTS USINGMACHINE LEARNING AND DATA ANALYTICS

Eric Xiong[1], Yu Sun[2]

[1]Crean Lutheran High school, 12500 Sand Canyon Ave, Irvine, CA 92618
[2]California State Polytechnic University, Pomona,
CA, 91768, Irvine, CA 92620

ABSTRACT

We design a server-client system that collects students' engagement information and reports it to a centralized server to help teachers assist neurodivergent students in order to provide a visual representation of students' engagement status aiming to promote an equal learning opportunity for neurodivergent students [6].

In recent years, everyone throughout the globe are all seeking higher education, either for themselves, or for their children. Students are learning an increasing amount in classes and have needed to spend a lot more effort and attention to succeed. In this race for higher education, a specific group of underrepresented minorities has been left behind. This group being the neurodivergent population, specifically high-functioning people with ASD(Autism Spectrum Disorder) [7]. These students often require more attention due to hypersensitivity, and a shorter attention span than the neurotypical populace. These students have all that's necessary to learn and understand the material, although teachers are often stuck to a faster pace curriculum that does not easily allot so much attention to a singular student. Due to this problem many teachers believe that a efficient way to passively gauge these students attentiveness would significantly benefit their education. This paper develops a server-client system that collects students' engagement information and reports it to a centralized server to help teachers assist neurodivergent students in order to provide a visual representation of students' engagement status aiming to promote an equal learning opportunity for neurodivergent students. We applied our application to [Class] and conducted an Evaluation of the approach based on the qualitative data collected from the students.

KEYWORDS

Facial features, information collection, Education

1. INTRODUCTION

1.1. Engagement Detection

What did this paper do, what does it contribute, and why did we not choose this one (what does it do, their conclusions,why we didn't use it.)

David C. Wyld et al. (Eds): CCNET, AIMLA, CICS, IOTBS, NLTM, COIT - 2023
pp. 117-125, 2023. CS & IT - CSCP 2023 DOI: 10.5121/csit.2023.130409

1.1.1. Paper 1

This paper attempts to use a students facial expression, head position, and eye gaze to calculate a students engagement level using computer vision and machine learning. The results from their algorithm showed to be 10% from their baseline. We did not select this model to continue because we believe we could find something with higher accuracy, or can be directed towards a more general case, because everyone disengages in different ways, especially for members of the neurodivergent community.

1.1.2. Paper 2

The paper uses the features of the subjects face such as eye gaze, and head pose using OpenFace to gauge the engagement levels of the subject [8]. The results from their program claims to have a 90% accuracy. We decided we did not select this model because the algorithm is too complex, since many students, especially neurodivergent ones, have different ways of disengagement leading to a more simplistic model being more general and effective.

1.1.3. Paper 3

This paper reviewed many methods of determining student engagement levels during the course of an educational environment. The paper concludes that although promensing the computer vision process of determining engagement is still bound by many limitations. We did not select this model because it does not actually present a model of its own instead reviewing previous and established methods presenting their benefits and flaws.

1.2. Neurodivergent Students Education

The neurodivergent, specifically people with autism, typically show certain characteristics that can be considered as a hindrance in mainstream education [9]. Some of these traits include difficulty focusing, hyperactivity and unpredictable mood changes. Many establishments have already attempted to accommodate such needs, but there is still a widespread demand for methods and aids to fit aforementioned accommodations.

1.2.1. Project 1

Special attention is typically needed for teachers to assist neurodivergent students, although many times, especially in standard classroom settings design for neurotypical students, the teachers are not equipped with the necessary methods or tools to assist the students [1][10]. This has led to an increasing demand for teachers to be better trained about students with autism both in education and behavior management.

1.2.2. Paper 2

PRT as a a method, and how it is helpful. Pivotal Response training(PRT) is claimed as a behavioral treatment of Autism based on the principles of Applied Behavioral Analysis(ABA) [2]. This process is initiated by the child and typically involves the use of games to aid in the process. This process attempts to develop communication and language skills, increase positive social behaviors and provide relief from disruptive self-stimulatory behaviors.

Our tool can helps PRT in terms of social intervention through the process of real-time providing student’s engagement info

There have been intensive studies on detecting human emotion and engagement status through facial expressions cite(1,2), where the paper uses … … … to detect. It provides a general overall interface but yet it lacks usability due to a missing interface and updating system. A secondary problem is that such algorithms only detect a single user at a time.

Server-client based engagement detection dashboard integrated with xxx's paper on engagement detection [3].

1. real-time update on dashboard
2. class-student hierarchies
3. adjustable algorithm and devices
4. alert when disengaged

In this paper, we will server-client based engagement detection dashboard integrated with xxx's paper on engagement detection. Our goal is to keep the students in a more attentive state for a longer period of time. This will aid students in their education while also helping teachers make their classes more fruitful and entertaining by understanding when the students are disengaged. Some Useful features of our tool are that it updates on a dashboard in real-time, class-student hierarchies, adjustable algorithms and devices, and alert when disengaged. Therefore, we believe that the tool would allows teachers to better manage their classes of neurodivergent students.

In two application scenarios, we demonstrate how the above combination of techniques increases student engagement and teacher efficiency. First, we show the usefulness of our approach by a comprehensive case study on the evolution of student engagement. This will be accomplished by using the algorithm on Multiple classes of different students and then asking for their engagement directly, with a reward to encourage honesty. Once these values are obtained we will calculate the percent error of the detected result from the alleged result to measure the accuracy of the algorithm. Second, we analyze the teacher feedback using the System usability scale. This will be accomplished by surveying the teachers after use of the system. This will measure the helpfulness, effectiveness and quality of the system.

1. student's engagement accuracy validation

use algorithm on students for a day, measure their average engagement, and at end of class, ask is the average correctly reflected their engagement status

2. teacher engagement assisting

how much time does it save you in terms of monitoring engagement with/without this tool Introduction of the background, open problem, solution and special contribution, and paper structure The rest of the paper is organized as follows: Section 2 gives the details on the challenges that we met during the experiment and designing the sample; Section 3 focuses on the details of our solutions corresponding to the challenges that we mentioned in Section 2; Section 4 presents the relevant details about the experiment we did, following by presenting the related work in Section 5. Finally, Section 6 gives the conclusion remarks, as well as pointing out the future work of this project.

2. CHALLENGES

In order to build the project, a few challenges have been identified as follows.

2.1. Understanding Neurodivergent Student's Attention Span

Our first challenge was understanding Neurodivergent student's attention span is inherently difficult because of its diversity and differences with the general neurotypical population. This is because every case of Neurodivergence is different both in severity and in symptoms. Often Students may have other issues that also hinder attentiveness such as ADHD(Attention deficit/hyperactivity disorder) [11]. This also makes attentiveness incredibly difficult to track because of its individual nature. Most neurodivergent students disengage in different waysleading to the tracking of disengagement also difficult. Most solutions are also not universal and only work on the people it was specifically designed for. Many people have overcome this issue with their own methods to become famous.

2.2. Designing A Online Learning System that Reflects Students' Engagement Status in Real- Time

Our second challenge was designing an online learning system that reflects students' engagement status in real-time [12]. Real time was significant for our program because it is needed for this system to achieve its fundamental purpose. If the system did not update the engagement of the students in real time, it would not be possible for the program to inform the teacher that some of the students are disengaged. It takes quite a bit for make a system real time instead of non-real time. The front end would need to send out a request to the and update the results based on the server. This would need to continuously happen every second while the program is active. The Database likewise would need to update in real time to reflect the students engagement status to be then reported. This would cause difficulties in the system because of the processing speed this would require and in many places the system could have errors.

2.3. Finding Effective Engagement Detection Algorithm

Our final challenge was to find an effective engagement detection algorithm [13]. We went through a lot of papers. Some papers appear to be good yet have no effective evaluation methods. Others did not have their own training data sets. Since we lacked our own training data we could not sufficiently train our own algorithms. A combination of these factors and more made choosing detection algorithms difficult.

3. SOLUTION

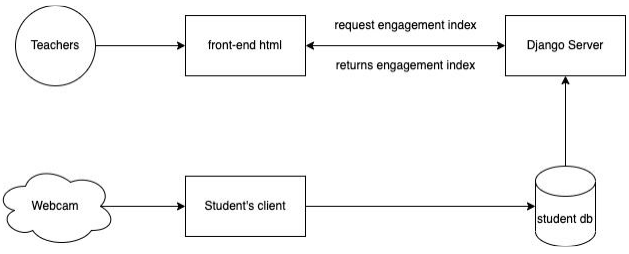


Figure 1. Overview of the solution

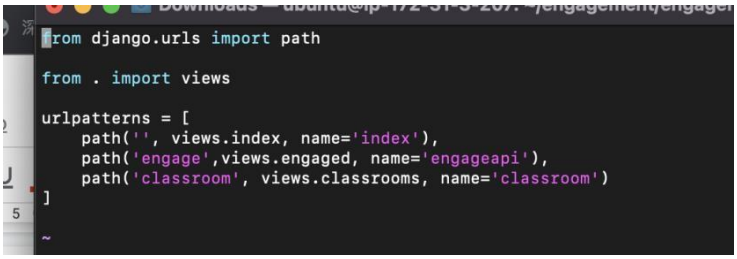
Our solution is a web based interface based on a student side run algorithm. The process begins with multiple users, 1 teacher, and 1 or more students. First the student side client uses the webcam to collect the raw data. This data is then passed through the engagement algorithm which processes the data into student engagement. The student engagement is then sent to a student database where it will be stored for this session. The student database then gets stored onto a Django Server where it can be more readily accessible. The teachers side of the solution is a web page where each student is listed by name with an index next to it to demonstrate engagement. To better assist the teachers in recognizing when a student disengages, The font and color of the row the student's data resides on will change to better visually alert the teacher. This front end web site is in constant communication with the Django server requesting engagement indexes. The Django server which is constantly being updated with new data from the student database will then provide the front end by returning the requested indexes. This new data is then shown on the web page which then alerts the educator to any potential disengagement from the students.

```
                gaze_weights = 2

# Concentration index is a percentage : max weights product = 4.5
        concentration_index = (
            emotionweights[self.emotion] * gaze_weights) / 4.5
        print("this is raw ci: ",concentration_index )

        self.conn.sendStudentEngagementInfo("Eric", concentration_index)
        if concentration_index > 0.65:
            return "You are highly engaged!"
        elif concentration_index > 0.25 and concentration_index <= 0.65:
            return "You are engaged."
        else:
            return "Pay attention!"
```

Figure 2. Upload the weight to the server

```
from django.shortcuts import render
from sever.models import student, raw_reading, event_table, classroom
# Create your views here.
from django.http import HttpResponse


def index(request):
    stu = student.objects.all()
    print(stu[0].name)
    cla = classroom.objects.all()
    return render(request, 'class.html',{'students':stu, 'classrooms':cla })



def engaged(request):
    stu = request.GET['stu']
    print("student name from sever: ",stu)
    student_1 = student.objects.filter(id =stu)
    print("studnet status:"+ str(student_1[0].engagement))
    return HttpResponse(student_1[0].engagement)

def classrooms(request):
    classes = request.GET.get('classroom')
    stu = student.objects.filter(classroom__name = classes)
    cla = classroom.objects.all()
    return render(request, 'student.html',{'students':stu, 'classrooms':cla})
#   return HttpResponse("Hello,"+ stu[0].name )
~
~
```

Figure 3. Screenshot of code 2



```
from django.urls import path

from . import views

urlpatterns = [
    path('', views.index, name='index'),
    path('engage',views.engaged, name='engageapi'),
    path('classroom', views.classrooms, name='classroom')
]
```

Figure 4. Screenshot of code 3

```
"""
from django.contrib import admin
from django.urls import path ,include

urlpatterns = [
    path('admin/', admin.site.urls),
    path('' , include('sever.urls')),
]
```

Figure 5. Screenshot of code 4

```
        seconds = 1
      var stu{{student.id}};
        stu{{student.id}} = "{{ student.id }}";
        setInterval(function () {
      $.ajax(
      {
          type:"GET",
              url: "http://13.57.184.27:8000/engage",
          data:{
                  stu: stu{{student.id}}
          },
          success: function( data )
          {
              console.log(data);
              if (data == "False") {
                  $(".stu{{student.id}}").css('color', 'red');
              }
              else {
                  $(".stu{{student.id}}").css('color', 'black');
              }

              $(".stu{{student.id}}").text(data.toString());
              //$( '#message' ).text(data);
          }
          })
       }, seconds * 1000)
```

Figure 6. Screenshot of code 5

4. EXPERIMENT

4.1. Experiment 1

This experiment would be completed during a small group class where all students are on the engagement algorithm. The class would be completed as usual and the student's average engagement will be gathered by setting engaged as 1 and disengaged as 0 and finding the average for each student. After the session is completed, Students will be asked for how engaged they were during the class on a scale of one to ten. These two percentages will be used to find the percent error of the detected engagement value to determine the accuracy of the algorithm.

Class 1	Student 1	Student 2	Student 3
Detected result	74.1	38.2	86.4
claimed result	80	60	90
%Error	-7.375	-36.33333333	-4

Figure 7. Table 1

Class 2	Student 1	Student 2
Detected result	68.3	58.9
claimed result	60	70
%Error	13.83333333	-15.85714286

Figure 8. Table 2

As the Data shows, The algorithm used is mostly effective at detecting the engagement of the students. There are some outliers in the data, but due to the previously mentioned diversity in Neurodivergent engagement, this was to be expected.

4.2. Experiment 2

This experiment will be accomplished in the form of a survey after a few classes with the system. Teachers will be asked to answer a few questions about their experience with the tool, and answers will be recorded on a scale of Strongly disagree to Strongly agree. This survey will include Questions about the system effectiveness and usability. We will be using the System usability scale.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
I think that I would like to use this system frequently.	X				
I found the system unnecessarily complex.				X	
I thought the system was easy to use.			X		
I think that I would need the support of a technical person to be able to use this system.		X			
I found the various functions in this system were well integrated.		X			
I thought there was too much inconsistency in this system.				X	
I would imagine that most people would learn to use this system very quickly.		X			
I found the system very cumbersome to use.					X
I felt very confident using the system.		X			
I needed to learn a lot of things before I could get going with this system.				X	

Figure 9. Survey

In the above two experiment we have proved that our tool accomplished it intended work by being accessible to teachers and decently accurate for the students.

5. RELATED WORK

This work is a good work on the effects of autism spectrum disorder [4]. The paper generally talks about the experiences and effects living with ASD while our paper is specifically on a possible way to better aid the education of neurodivergent children. Our paper does not specifically touch on the actions implications of ASD, we do give a generalization of ASD, especially the effects it has on a child's education and their ability to function in a learning environment.

This is the paper which contributed the algorithm of the paper [3]. The related paper was entirely on creating an algorithm which can detect a students engagement in a classroom setting. This is done through a combination of eye gaze and facial expressions. Our paper is less about the

detection algorithm and more about the web based interface and how it benefits neurodivergent students. Their work is better for understanding engagement detection and how it works, while ours is more focused on the application in education.

This work is a good work on the correlation of engagement and education [5]. This work mainly focused on the connection between a student's engagement in a class, and their ability to retain the information they learned about. Our paper on the contrary is about how to get the students to be more engaged in a classroom setting. Both papers deal with the concept of education and by nature places education in a place of high importance.

6. CONCLUSIONS

In Summary we have created a Tool which is specifically designed to assist in the education of the neurodivergent youth. This program uses A simplistic Engagement detection algorithm to provide a general estimate of student engagement and provides this engagement data to the teacher in real time to assist the teachers in keeping students as engaged as possible to help them be as efficient as possible in the learning process [14]. We then put this tool to the test in two different experiments to demonstrate the accuracy of the system on the students end and the ease of usability on the teachers end. Both of these result proved to be satisfactory and showed that our tool is effective and not difficult to maneuver.

Although our Solution is effective in most scenarios, it is not without its flaws and issues. One of these issues is that due to the natures of the attentiveness within the community of the neurodivergent youth, this program could not possibly work for all cases.

Due to this limitation we decided to choose a very simplistic algorithm as it could apply to more people and could be less affected by the individual quirks of the students' engagement or disengagement [15]. Due to this simplistic algorithm, the programs in certain cases could really return false positives and negatives with students attentiveness. Additionally, The practicality of the system can still be wildly improved as it currently takes downloading the software onto the student devices meaningthat setup time can be the length and riddle with bugs.

Most of these limitations can be solved with more time and resources. Some solutions can be currently investigated include creating a more accessible student user interface to make setup easier, creating delineations to allow multiple classes to be ran at the same time, or even to move the entire system online so no downloads are required making new student initiation much simpler and faster.

REFERENCES

[1] Bryson, Susan E., Sally J. Rogers, and Eric Fombonne. "Autism spectrum disorders: early detection, intervention, education, and psychopharmacological management." The Canadian Journal of Psychiatry 48.8 (2003): 506-516.
[2] Harrower, Joshua K., and Glen Dunlap. "Including children with autism in general education classrooms: A review of effective strategies." Behavior modification 25.5 (2001): 762-784.
[3] Sharma, Prabin, et al. "Student engagement detection using emotion analysis, eye tracking and head movement with machine learning." arXiv preprint arXiv:1909.12913 (2019).
[4] Lord, Catherine, et al. "Autism spectrum disorder." The lancet 392.10146 (2018): 508-520.
[5] Jablon, Judy R., and Michael Wilkinson. "Using engagement strategies to facilitate children's learning and success." YC Young Children 61.2 (2006): 12.
[6] Spiel, Katta, et al. "Adhd and technology research–investigated by neurodivergent readers." Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems. 2022.
[7] Spiel, Katta, and Kathrin Gerling. "The purpose of play: How HCI games research fails

neurodivergent populations." ACM Transactions on Computer-Human Interaction (TOCHI) 28.2 (2021): 1-40.
[8] Sibert, Linda E., and Robert JK Jacob. "Evaluation of eye gaze interaction." Proceedings of the SIGCHI conference on Human Factors in Computing Systems. 2000.
[9] Spiel, Katta, et al. "Adhd and technology research–investigated by neurodivergent readers." Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems. 2022.
[10] Sasson, Noah J., et al. "Neurotypical peers are less willing to interact with those with autism based on thin slice judgments." Scientific reports 7.1 (2017): 1-10.
[11] Biederman, Joseph. "Attention-deficit/hyperactivity disorder: a selective overview." Biological psychiatry 57.11 (2005): 1215-1220.
[12] Moore, Joi L., Camille Dickson-Deane, and Krista Galyen. "e-Learning, online learning, and distance learning environments: Are they the same?." The Internet and higher education 14.2 (2011): 129-135.
[13] Kramer, Thomas R. "Pocket milling with tool engagement detection." Journal of Manufacturing Systems 11.2 (1992): 114-123.
[14] Kramer, Thomas R. "Pocket milling with tool engagement detection." Journal of Manufacturing Systems 11.2 (1992): 114-123.
[15] Kahn, William A. "Psychological conditions of personal engagement and disengagement at work." Academy of management journal 33.4 (1990): 692-724.