AN INTELLIGENT MONITORING AND REWARDING SYSTEM TO ASSIST THE TENNIS TRAINING USING SENSOR-BASED DETECTION AND IOT SYSTEM

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ABSTRACT

Coronavirus started in 2019 and it's still a major problem today [1]. This disease led to the start of pandemics around the world, in which some students are still using online learning platforms today, and their guardians leaving them unattended to provide for their families [2]. However, with the lack of supervision children are taking advantage of these times to perform unproductive activities such as gaming. During school days, there are also many breaks provided for students to relax and reset their mentality, which allows a student to be focused during class, but this doesn't seem to be the case students are spending this time indoors after many hours of staring at a device, instead spending it outdoor can relax their eyes also preventing eye damage. This paper proposes software that tracks a student's productivity based on their tennis racket movement and speed using a particle board, accelerometer, and tracker [3]. With a tracker, guardians would be able to get constant updates on their children's activities. We applied our application to a real-life scenario and conducted a qualitative evaluation of the approach. The results show that students spend less time indoors performing nonproductive activities, students spend more time outside playing their sport of desire, and parents are less stressed about their children's educational and physical health.

KEYWORDS

Pandemic, C++ and HTML, Mobile APP.

1. INTRODUCTION

The education of a student is very important, it is a key factor that makes a person successful in the future. However, a deadly disease known as the Coronavirus, sent our world into a global pandemic, and many schools diverted to online teaching, but there are many wrongs about online teaching [4]. For example, due to the long amount of screen time, eye damage could be a possibility [5]. Even though schools provide many breaks and passing periods for students to relax and stop looking at their screens, many students don't take this seriously. Instead of spending this time outside taking a breather or playing a sport, students are spending this time indoors playing video games or going on social media. Another factor contributing is the number of distractions, because students are at home, teachers really don't have an idea of what they are doing. Study shows that about sixty percent of the class don't pay attention to the class, instead spending this time doing other things. By solving this problem parents and teachers would no

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longer have to worry about their students and children facing potential physical or mental health issues. Parents also no longer have to worry about their children not learning the curriculum.

Some of the related systems and tools that have been proposed to the public are security cameras, which allow the users to get live updates on their houses [6]. Another tool that has been proposed to the public is fitness tracker watches, which provide the user with a daily report of their activities, step count, heart rate, etc. However, these proposals assume that their users are productive and use their product as intended, which is rarely the case in practice. Furthermore, there are many ways to beat the system. For example, security cameras can be moved to a different area where they lose visuals of the intended section of the house, and fitness tracker watches could be taken off and can no longer track your daily activities [15]. Their implementations are also limited in scale. Some studies had also found methods in keeping student production. For example, some studies found that in order to keep yourself from doing unproductive activities you must obtain a study habit, but this rarely seems to be the case, students/children are often distracted because of something they want or something they want to do.

In this paper, we follow the same line of research by demonstrating our product to answer the previous problems mentioned. Which is, How can we reduce the number of unproductive activities being performed by students and prevent them from being distracted during their online learning sessions, while also balancing their indoor activities and their outdoor hobbies [7]. Our goal is for our product to show positive results in the education market, and also help aid those families that are struggling during these times. Our method is inspired by the discussions of parents during this pandemic, many of them mentioning how their children are being distracted during online learning, which results in them failing classes. There are many good features of our product compared to existing tools available. First, compared to existing tools available to the public, our product will be able to track the user's activity by tracking the speed at which the racket is moved. Second, our product will have a guardian alarm, whenever the user is doing something unproductive a message would be sent to their guardian. Third, their daily performance would then be displayed on their own profile when signed up with our website, and their activities would be analyzed providing a better outcome. Therefore we believe that our product will be the answer to the number of nonproductive activities being performed during this pandemic.

Our product went through various scenarios of testing in order to receive positive results, we demonstrated how the above combination of techniques decreases the number of unproductive activities being performed at home and balanced it with each child's favorite outdoor activity. First, we show the usefulness of our product by testing it among various families that felt like their children were falling behind in their classes due to the number of distractions and the unproductive activities being performed. The student's activity would be tracked whenever the designated sport they want to play is in action. For example, if a student wants to play tennis, then our product would be attached to it and the speed at which the racket is moved would be tracked and logged to the firebase [8]. The activity would then be sent to their guardians. Our product could also be attached to different sport-related items, such as a baseball bat, golf club, etc. After a majority of families tested our product, the results show that students are able to balance their day between indoor activities and outdoor activities, therefore reducing the amount of device screen time and also reducing the possibility of potential eye damage. Second, we also analyzed the results being sent to each guardian, the results show that their children spend a few weeks with the product, and spending time outdoors, spending time outdoors starts to become a habit, and also show more engagement in their classes.

The rest of the paper is organized as follows: Section 2 describes the details of the challenges that we faced during the experiment and the design of our product; section 3 focuses on the details of our solutions corresponding to the challenges that we mentioned in section 2; section 4 presents the related details on the experiment we did, following by presenting the related work in section 5. Finally, section 6 will conclude our study and experimentation as well as point out the future works on our project.

2. CHALLENGES

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

2.1. Keeping our Prototype Attached to the Item

One major problem we had during our testing phase was attaching our prototype to an item without it getting knocked off, damaged, or affecting the player. For example, if we had a tennis racket we tried attaching it above the handle where it could calculate the speed of the racket when swung more effectively. However, attaching it to the racket could lead to multiple problems. First, if we decided to attach it to the rim of the tennis racket there's a high possibility our product will fly off when swung, and distract the player. Another problem if we placed our product on the rim, it could resist the air leading to a slower tennis swing. After multiple tests on the placement, which negates all of the above problems the best, was attaching our prototype to the handle. When our product was attached to the handle of the racket, it seemed to prevent air resistance, the chances of it falling off were slim, tracking the speed was still sufficient, and it felt less distracting.

2.2. Sending the Data to the Firebase

Another major problem we dealt with during the production of our prototype was setting up the firebase. Creating the firebase was one thing, but constantly sending the data to our website is another. We had to figure out multiple code strings in order for our data to be sent to the firebase and work properly. However, by sending the data constantly to the firebase we started receiving restrictions, at one point when the accelerometer was in action, not a single data point was being recorded. To fix this we started lowering the amount of time the data was being tracked from once every second to once every minute. Another problem we had with the firebase was the connection and power. In order for our accelerometer to track the data and send it toward our firebase, it needed a stable connection and battery. Instead of needing a wire to charge and send a connection to our database, we decided to use a battery attachment. This battery provided both constant power and connection.

2.3. Beating the System

Our product basically reduces the amount of nonproductive activity being performed at home by placing a tracker on a sports item/tool and urging children to spend time outside more by balancing the time and activities being spent indoors and outdoors. However, many children figured out a way to beat the system, instead of actually playing the sport, they would take the item and just swing it around every minute to keep the tracker going, therefore the data being tracked would be sent to their guardian's email, leading to the guardians believing they are actually spending time outside when in reality they are just indoors playing games or going on social media. In order to fix this problem, the code string tracking the speed for when a specific speed is reached is raised higher. Therefore, children can't just swing the racket at ten mph and

the data would be tracked instead they would have to perform regular tennis swings around 80 mph.

3. SOLUTION

Our product (Smart Racket) is a software and application that allows a guardian to track their children's activity. Smart Racket could be represented as a nanny cam but has a greater effect on children. During online school learning, students are given many breaks and many students decide to play video games or go on social media during this time even though they may have just attended five-hour learning sessions, without these breaks from their digital screens may cause eye damage or even worse blindness, because of this our product was designed [9]. During these breaks, if students decide to continue with their nonproductive activity, emails would be constantly sent to their guardians. In order to track the student's outdoor activity, the Boron and Accelerometer would be attached to a student's tennis racket. Whenever the tennis racket is in motion the accelerometer would calculate the speed at which the racket is swung. When the racket reaches that speed the data would then be sent to the firebase, then transferred to our website. Our application is written using C++ and HTML. There are four main components of our product. First, the particle networking development tool (Boron) is the main way to keep our project running in areas where there is no WIFI or unreliable internet. Second, the Accelerometer tracks the speed and movement of the tennis racket when swung and sends the data to the firebase. Third, is the firebase, which stores and logs all the data collected from the Accelerometer. Lastly, the Website, there are multiple web pages inside our website, a profile tab, home page, data tab, and much more [10]. The visual below describes these components in detail and also gives a great visualization of how our product works.

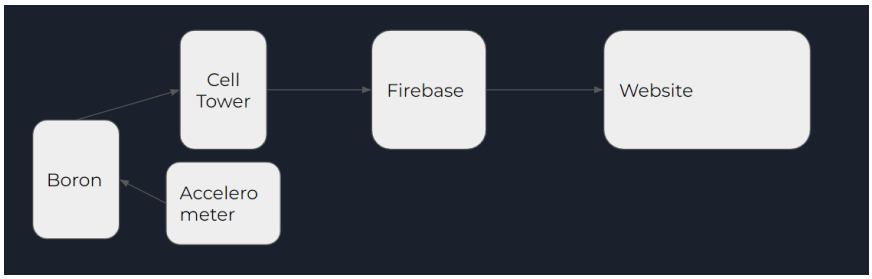

Figure 1. Overview of the solution

During the production of our product different tools, algorithms, and services were used to create our final product. Tools such as a Particle Boron, Accelerometer, Tennis Racket, etc. Services such as Replit, Particle, etc. Our coding is written in C++ and HTML. Image A shows part of our coding implemented into the accelerometer in order to track an average tennis racket swing. However, in order to start tracking the speed at which the racket is swung, we had to start from the basics, by calculating gravity and the minimum speed at a tennis racket is swung normally which is around 60 mph. When the racket is in motion and the X-axis Acceleration + Y-axis Acceleration + Z-axis Acceleration doesn’t reach the minimum speed that the racket is supposed to swing at then the data wouldn’t be logged. However, if it does exceed the limit then the current Acceleration at which the racket is swung would be logged. In image 2, you can see part of our website design for how the data looks every time a data point is logged. However, the website is still in production and it isn’t fully developed yet. Currently, we are implementing different ideas into our website such as a profile page, login credentials, etc.

```
void loop() {
    // read raw accel/gyro measurements from device
    motionstatus = accelgyro.getMotionStatus();
    accelgyro.getMotion6(&ax, &ay, &az, &gx, &gy, &gz);
    Serial.print(ax); Serial.print("\t");
    Serial.print(ay); Serial.print("\t");
    Serial.print(az); Serial.print("\t");
    Serial.print(gx); Serial.print("\t");
    Serial.print(gy); Serial.print("\t");
    Serial.println(gz); Serial.write("\n");
    //Serial.println(accelgyro.getMotionDetectionThreshold());

    //Serial.println(motionstatus);
    delay(1000);

    xAccel = ax*ax;
    yAccel = ay*ay;
    zAccel = az*az;
    currentAccel = xAccel+yAccel+zAccel;
    Serial.println(currentAccel);

    //Particle.publish("Looped");
    if (currentAccel>604000000)
    {
        toggleLed();
        char buf[256];
        snprintf(buf, sizeof(buf), "{\"data\":%d}", currentAccel);
        Serial.printlnf("publishing %s", buf);
        Particle.publish("motionStatus", buf, PRIVATE);
    }
    lastAccel = (ax*ax)+(ay*ay)+(az*az);
}
```

Figure 2. Screenshot of code

Figure 3. Screenshot of homepage

4. EXPERIMENT

4.1. Experiment 1

In order to accurately show our results, we collected 300 data sets from 10 different guardians that have experienced this problem with their children. Most of these children are spending their time during this pandemic inefficiently. In order to show the results of our product, we conducted multiple experiments to test and verify our product: How long a student spent outside per two days out of 10 different children, the number of students that actually spent time outside compared to the number of students that stayed indoors. After all, the experiments were completed, the guardians of each child/student were satisfied with our product, most of them saying their children were spending time outside learning how to play tennis with their friends.

A. The Number of Students That Went Outside vs Day #

Figure 4 illustrates the number of times a student went outside per day regarding the weekends. As you can see in the graph, in the beginning, when each student was given our product, not that many students took it seriously. However, as time passed, positive results started showing, students were going outside more as days passed. Showing the effectiveness of our product.

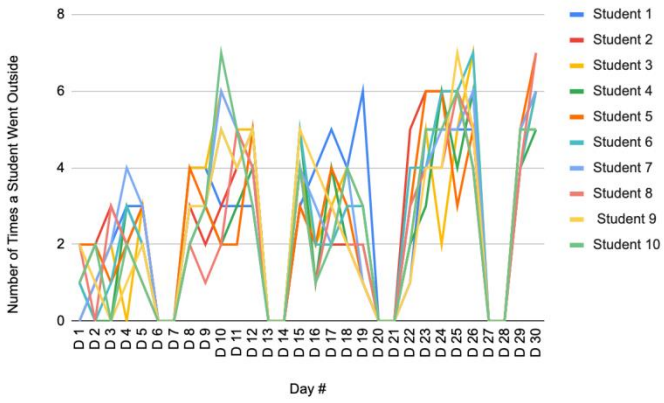

Figure 4. The Number of Students That Went Outside vs Day #

4.2. Experiment 2

Figure 5 shows how long each student went out in minutes for every two days. As the same as figure 4, in the beginning, students and children didn't spend much time outside, most of them around 30 minutes every 2 days. However, as time passed students started to spend around 80 minutes outside per 2 days. Showing the effectiveness of our product.

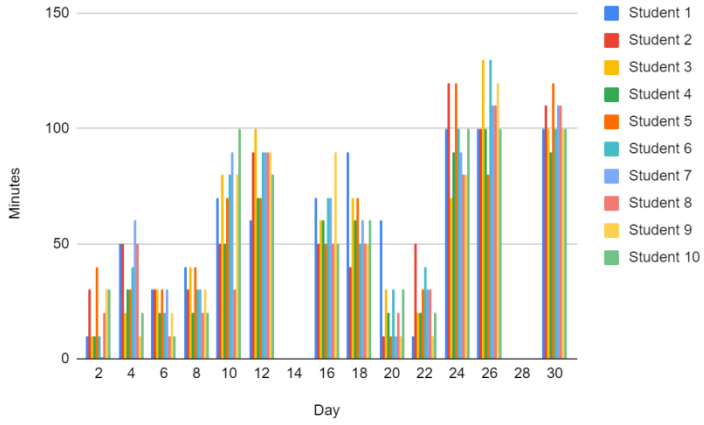

Figure 5. How long a student went outside in minutes every two days

After both experiments were finished, the results seem to solve all of the challenges listed in section 2. Before our product was developed we set out a goal, which was to balance a student's/children's indoor activities with their outdoor activities and limit the amount of nonproductive activity being performed indoors. The results of our experiments show that students are spending more time outside than before, and also went outside more when they didn't use our product. Even though there are times when a student doesn't spend much time outside or doesn't go outside much, the average of all ten students shows a positive result.

5. RELATED WORK

Tuan.N. et al summarized the challenges of online learning and the negative, mixed, and null findings of online learning. As a result, the author proved that online learning is not at least as

effective as traditional learning [11]. Additionally, the author provided multiple examples of the negative impact on students due to online learning. Related to this paper, we added to their research by proving the negative side of online learning using an accelerometer and a tennis racket. We were able to demonstrate that online learning has many flaws, such as not knowing what a student is doing at all times and the nonproductive activities many students perform. Rather than providing the facts about the flaws of online learning, we were able to solve these problems by creating an application that allows students' parents to see their productivity and also balances students' indoor activities and outdoor activities.

Brian.G. et al presented an application that uses a three-dimensional accelerometer sensor to measure a human hand motion [12]. By using a three-dimensional accelerometer sensor the author was able to track the movement of the hand such as sign language. Instead of using an accelerometer sensor to measure a human hand motion, we coded it into measuring the speed at which a tennis racket is swung to reduce the amount of nonproductive activity being performed by students during online school learning. Our experiment results show that students were able to balance their time spent indoors and their time spent outdoors.

Sian.L. et al explore the topic of movement recognition using the accelerometer in smartphones [13]. By including an accelerometer sensor in a smartphone, they were able to recognize common movements such as walking, standing, sitting, etc. Instead of using an accelerometer sensor in a smartphone to recognize movement, we attached an accelerometer sensor on a tennis racket to recognize the speed at which the racket is swung and also record that data onto a database. Both papers use an accelerometer to track movement to solve a specific problem.

6. CONCLUSIONS

In this project, we proposed software that limits the number of unproductive activities being performed during online learning for students and also balances their indoor activities and outdoor activities by tracking the speed at which a tennis racket moves [14]. A website has also been developed to log all the data collected by the accelerometer that tracked the movement of the tennis racket. The data will then be sent to their guardian through email or phone showing their child's daily performance. The results show that our prediction is correct. After using our product for a couple of days students are able to balance the activity and time they spent indoors with the activity they spent outdoors. Before students tend to spend more time indoors than outdoors but after a few days students with our product they're more active outdoors and seem to be more energized and engaged than before.

As for our product, a limitation related to our application is that it doesn’t show the performance of these tennis players, such as how well they played, what they need to work on such as backhand groundstroke, or a forehand groundstroke, and what steps they should follow to correct it. Another limitation is that our product is only limited to tennis rackets, which could be expanded in the future to different sports that are harder to track, such as basketball or soccer.

In our future updates, we plan on adding new ideas to our website, such as showing a visual demonstrating how the user swung their racket, what they are doing wrong in their tennis games, and what they can do and work on to improve their own inner game of tennis. We also plan on creating a better design for our software/product so that it isn’t limited to just tennis rackets instead it would work on all sports items, such as basketball, soccer ball, etc.

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