Novel Mind Controller to Assess Student Concentration with Connected Vehicles: ALIVE Mind

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Abstract – **The attention span of children today is deteriorating greatly, which is causing an easier loss of focus. To tackle this issue, particularly in schools, we need to find ways to captivate students' concentration. In this paper, we proposed a scheme, called ALIVE Mind, to discover what makes a student more attentive to a subject and what could lead to a loss of focus. To make this discovery, we built and designed a circuit board called ALIVE Mind Controller (AMC), which allowed us to read brain waves. We then created tools that made it possible to study and analyze cerebral activity. Therefore, we gathered data by conducting simulations using several subjects in various situations and environments, for instance, while taking a quiz, while watching videos, and while programming. Finally, with these values, we ran a competitive race with the ALIVE cars. The higher the subject's attention is, the faster his car goes, thus winning the race. Preliminary results show the effectiveness of the ALIVE Mind project, which increased the average student's concentration by 39.45% from a resting task and by 18.77% from a programming task. This project has been presented in an elementary school, and we hope that this project reaches many other schools in the near future.**

Keywords: ALIVE Mind, controlling physical vehicle brain, waves, AMC, concentration, ALIVEcode.

I. Introduction

With technology now, more present than ever, schools and education facilities face a big challenge, keeping the attention of the students. More than ever our focus and attention can be easily lost by a call, music, or a notification that pops up on our phone`s home screen. Those are the first things that come to mind when thinking about a form of distraction. However, what we want to know is how much it affects us while, for example, solving math problems. For this reason, we built the ALIVE Mind Controller (AMC). It is a custom Printed Circuit Board (PCB) that allows us to retrieve data from the brain's wave reader device. Then, the data is sent to the ALIVE server to analyze while the student is performing, for instance, math problems. We even made it more appealing for a student to use by controlling the ALIVE Car [7] with his mind. The ALIVE car moves on its own, depending on how concentrated the student is.

Our contributions to this paper can be summarized as follows: (1) We created and designed a custom PCB the ALIVE Mind Controller (AMC); (2) We implemented the ALIVE mobile application to get the headset information by Bluetooth and send it to our server; (3) We developed a racing game with multiple cars that can be controlled using our AMC; (4) We made it so that the racing game can be operated using only one ALIVE car and so that the student can physically see the car moving as he is concentrating; (5) We designed and programmed on our existing ALIVEcode platform [11] tools to record and analyze brain waves; (6) We analyzed cerebral waves, in multiple scenarios, received by the AMC to pinpoint where a student loses focus compared to when he is hyper-focused.

Section II gives a brief overview of related tools and compares them to our ALIVE Mind project scheme. Section III describes our whole project: the headset, the circuit board, the mobile application, the motorized vehicle, and the web platform we have designed and developed. Section IV shows and discusses the analytic results collected during our experiment in an elementary school. Section V concludes the paper.

II. Tools using Printed circuit board comparison

Several projects in this field have been made, and we have chosen two among these studies [1-4]. We explain each project, and we compare them to ours. We highlight the differences between these projects, and we display their advantages and disadvantages. Commonly with all these projects, they aim to facilitate the interaction between humans and machines, by creating a stand for Brain-Computer Interface called BCI [1].

A. The Link project vs AMC project

The first project is called "The Link" it is a neural implant made by Neural Link [2]. The main difference between this project and ours is that they think of implanting the electrode directly in the brain, unlike our project and most of the other projects, where we use helmets with electrodes. The Link will use the Bluetooth protocol to control either an IOS device, a mouse, or a keyboard with the Neuralink app.

B. The muse project vs AMC project

The second project is the Muse. Muse is a company that manufactures headbands with electrodes. The purpose of Muse is to promote relaxation and improve sleep for users. The headset is linked with BLE [3] protocol to a mobile application. The app shows graphs of the different brain signals and plays music to help meditate. For our project, we are temporarily using a helmet called Mindflex. It has a single electrode placed in a specific place to obtain the concentration and attention data of the brain in the form of several waves. With the headset, we use an AMC [4] to transmit the data from the electrode to our mobile application. We are currently able to do vehicle races with two headsets through the internet.

The main difference between all these projects and ours is the price difference. The Link is the least affordable, as it will require brain surgery. Such an operation can cost tens of thousands of dollars. On the other hand, the Muse project is much more affordable, and you can get it for around $ 300. Still, it is a high

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cost for the very little functionality it offers. Finally, we have our project, and as it is now, we can set up two headsets with an AMC module for around $ 100 as we plan to create our headsets to reduce the cost and make it even more accessible.

C. Arduino vs AMC circuit

For our project, we decided to design our own microcontroller. We were first inspired by Arduino Uno as a starting ground, and we then adapted it to our needs. The Arduino is a microcontroller that uses a microprocessor named ATmega328-PU. It has several features that we have decided to remove to improve battery life and to minimize the interferences in the reception of data from the brain. As for the microprocessor, we use the same one but with our own code [5]. We have removed the unnecessary pin inputs, the LED's, the reset button, the voltage regulator, the ATmega16U2 [6], and the USB type B port, as we will not need to modify the code. The various unnecessary parts that we have removed also reduce the manufacturing costs of the AMC circuits.

D. ESP-32 vs AMC circuit

The ESP-32 was our second option as a basis for comparison. In the beginning, we had to think about transferring the data by Wi-Fi. The ESP-32 uses an ESP WROOM32 [10] and has a built-in Wi-Fi antenna. It is 3 times cheaper than the Arduino Uno, but it is still more complicated to program and by transferring the data using Wi-Fi we would have to modify the code to update the network information. That is the main reason why we decided to switch to Bluetooth.

III. ALIVE Mind Project

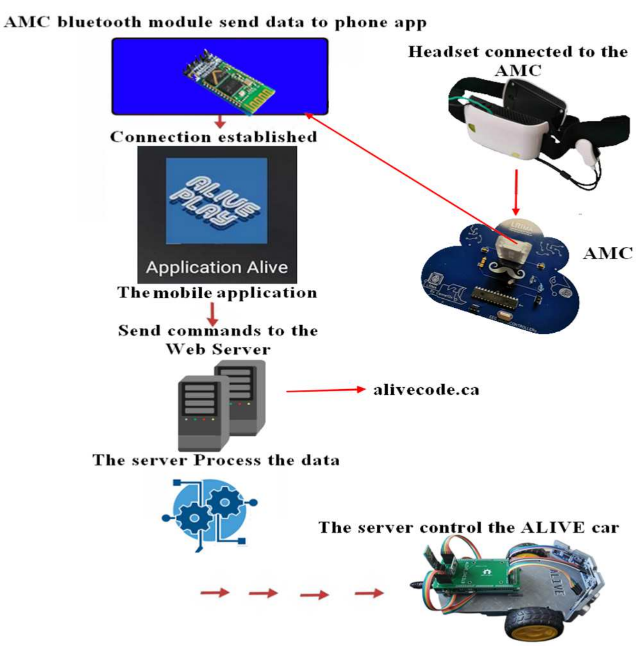

Fig.1 Architecture of ALIVE Mind

The ALIVE Mind project is the name given to all the components tied together in order to make every feature of this project fully functional and help us write this paper. The complete architecture of the ALIVE Mind project can be seen below (See Fig.1).

A. Headset

The headset transmits multiple data, including signal strength and five different wave types, Delta, Theta, Alpha, Beta, and Gamma (See section IV). They represent the electrical diagram occurring in the brain of the headset user. We are currently using our server ALIVEcode to manually analyze the captured data of the headset (See section E below). We are still considering using artificial intelligence to better understand the data and get better results.

Fig.2 Student with the Headset

B. ALIVE Mind Controller Circuit (AMC)

The AMC circuit has been designed to facilitate the data transfer from the brain to our server ALIVEcode (more details about ALIVEcode in section E). It is like an Arduino Uno but specially designed to carry the waves intercepted by the electrode of the helmet.

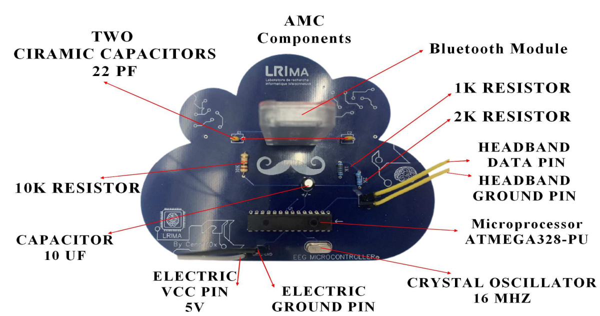

Fig.3 ALIVE Mind controller (AMC)

The circuit is composed of an AtMega 328-PU, the microprocessor in the Arduino Uno, three capacitors, including one 10uF capacitor and two 22pF ceramic capacitors. There is also one crystal oscillator of 16 MHz, like in the Arduino. Additionally, there are three resistors, one of 10k for the microprocessor and two other resistors of 1k and 2k, to reduce the Bluetooth voltage from 5V to 3.3V. Finally, there is the well-known Bluetooth module and the input/output pins. The following Fig.3 shows the list of components. For the design of the AMC circuit, we used the EasyEDA software. It allowed us to draw a diagram with the desired electronic components and to arrange it in 3D in order to be able to send it to production. Fig. 4 below shows the final schematic of AMC version 1.

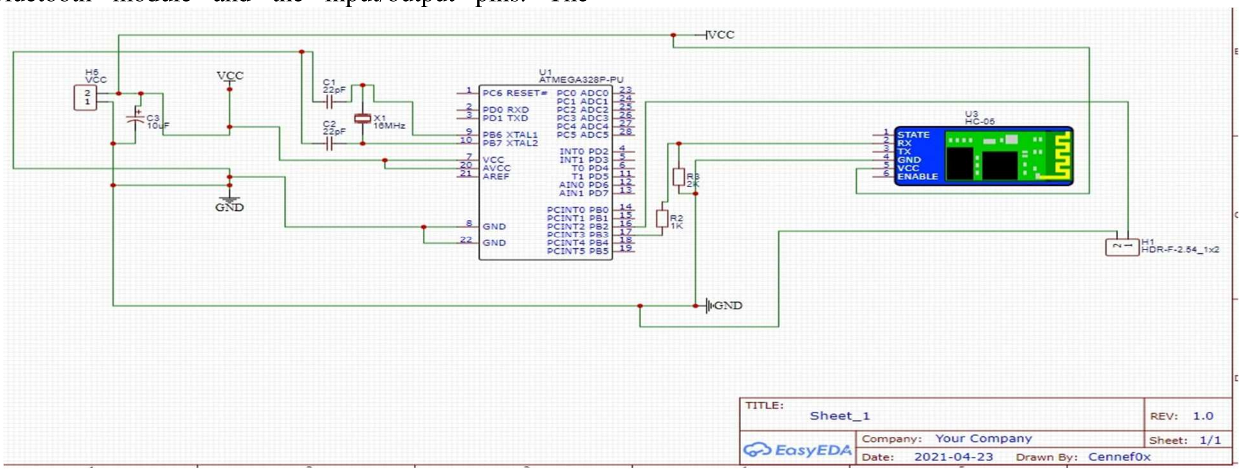

Fig.4 AMC schematic

C. ALIVE mobile application

The ALIVE mobile application act as a gateway between the AMC and ALIVEcode. The mobile app connects to the AMC using a Bluetooth protocol, and the Bluetooth module on the AMC sends all the cerebral waves of the user to the mobile application, as shown in Fig. 5. The data is then displayed on the mobile application and directly sent to the server with the proper preprocessing it requires.

Fig.5 ALIVE Mobile Application

The mobile application also enables further improvements or modifications to the communication between the AMC and the server. For instance, if one day we decide to change the way the connection is handled, all that is necessary is to publish an update to the app instead of having to recompile a new program into the AMC, making it easy for the users to update when necessary. For a specific example, we plan on adding features such as: directly linking an ALIVE account to the mobile app to make it easier to connect to your device, setting a custom and unique identifier to the AMC in the mobile application interface, and more.

D. ALIVE Car

Fig.6 ALIVE Car

The ALIVE Mind project utilizes real and physical miniature vehicles (See Fig.6) to better grasp students' attention, thus making learning easier. The ALIVE Car was made in the research laboratory LRIMa [7-9]. The purpose of this car in our project is to represent the student’s concentration by altering its speed depending on their level of concentration. It allows students to stimulate their brains in a fun and interactive way, thus giving us quality data to analyze. Further explanation on the race will be given in section E. The vehicle can react to the student’s brain waves by connecting with an esp32, integrated into the vehicle, to ALIVEcode, our web platform that handles all the connectivity and communications between our connected devices. The ALIVEcode platform will be presented in the next section.

E. ALIVEcode

ALIVEcode [11] is the official ALIVE website and has many facets such as ALIVE PLAY, ALIVE Mind, ALIVE Artificial Intelligence, ALIVE Internet of Things. All the code written for our platform ALIVEcode is open source [12]. Nevertheless, for this paper, we will only be focusing on the ALIVE Mind facet of our platform [13]. On this part of the website, you can see an in-detail explanation of our AMC and its pieces, an image gallery, all the data that has been recorded for this paper, and the mind racing game page.

Fig.7 ALIVE Mind home page

1. Data Analysis

Firstly, ALIVEcode offers the possibility to record all of the brain waves captured by an AMC device during a chosen period. You can create datasheets that save the brain waves gathered during the recording. The data can then be viewed and analyzed in real-time or afterward in the graph generated by the datasheet. The graph allows you to show or hide certain brain waves that you might not need for a specific study case. All these features allowed us to monitor and analyze lots of data on the concentration of students in a practical and efficient way. All the data we gathered is available on ALIVEcode [14].

2. Mind controlled race while answering a quiz

Secondly, as you connect the AMC device, you can see all the data appear on another page of ALIVEcode and partake in a race against another person using another AMC device to test who has the better concentration as shown in Fig.8. To make the vehicle move faster, the person using the AMC must show a higher concentration. The concentration is evaluated on a range from 0 being the lowest to 100 being the maximum. This racing game was created to compare the concentration level of two to four students while making it enjoyable. A general knowledge quiz was made for the occasion so that the student had something to focus on. Additionally, to captivate the students even more, we decided that instead of solely relying on a simulation, we would use real motorized vehicles, the ALIVE Cars (See Fig.6).

3. In Detail Explanation of the AMC

Lastly, you can see an in-detail explanation of the AMC and its components alongside images and schemas. This page on our platform allows anyone to learn the intricate functioning of the ALIVE Mind Controller [15].

(a) **(b)** **(c)**

Fig.8 ALIVE Car moving while taking the quiz

IV. Analytics results

1. Generated data

The headset transmits multiple data, including signal strength and five different wave types, Delta, Theta, Alpha, Beta, and Gamma. They represent the electrical diagram occurring in the bearer's brain. In the following, we describe these electrical activities as follows:

A) Delta: Slow waves present during a state of deep meditation or a state of dreamless sleep. They can also characterize some brain lesions.

B) Theta: Waves present during deep sleep or certain states of drowsiness, hypnosis, or meditation. They are also present when memorizing information.

C) Alpha: Waves that characterize a calm state of consciousness. They are mainly emitted when the person has their eyes closed.

D) Beta: (1) Calm awakening: When a person is in a state of attention without a specified mental task while having their eyes closed; (2) Active awakening: When a person with his eyes open is busy with a mental task. These waves are present when the person's attention is engaged by cognitive tasks (e.g., decision making, problem-solving, etc.).

E) Gamma: Fastest waves. They are associated with the processing of information by different regions of the brain (i.e., the synchronization of several regions of the brain). They are also present in conditions requiring a high level of attention or concentration.

2. Curves

We recorded a vast amount of cerebral activity [14] during different activities to compare the different concentration levels. We analyzed three types of tasks. First, we recorded brain waves while doing restful activities, like watching a television show (See Fig.9). Second, we gathered data from a more brain-demanding task such as programming (See Fig.10). Finally, we collected brain waves from a student that was using our platform to control the moving car (See Fig.11) while answering our quiz. In the best-case scenario, the student moving a real vehicle with its mind will be more attentive and concentrated on doing the quiz. Here are some of the graphs we gathered doing those three types of tasks.

During an activity that did not require a lot of concentration as shown in Fig.9, the attention average for the student was **51.42** (while the maximum is 100). Compared to when the student was asked to do a more complex task, for this instance programming, (See Fig.10) where the student had an average attention of **65.22**. It is worth noting an increase of **26.83%** of concentration, which makes sense since programming requires more concentration than watching a television show that does not require a lot of concentration to follow along.

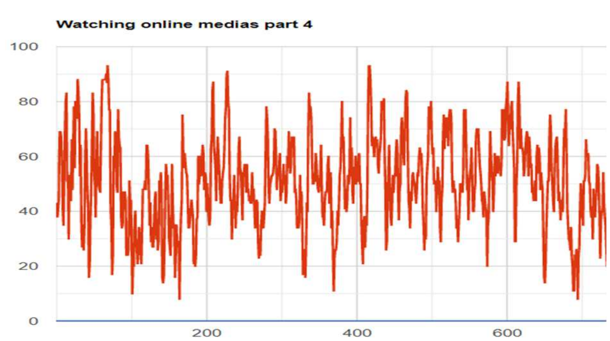

Fig.9 Cerebral activity of a student doing a restful activity (watching television shows)

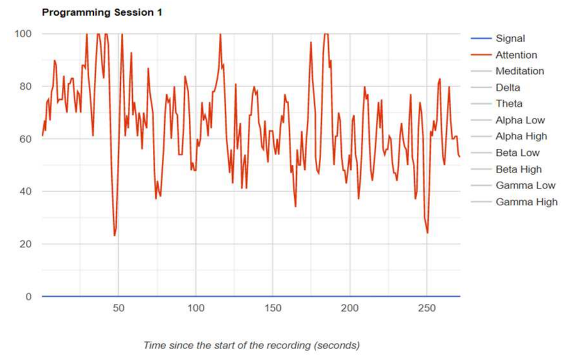

Fig.10 Cerebral activity of a student doing a more complex task for the brain (programming)

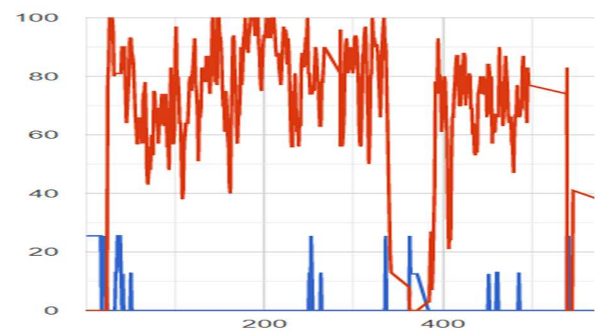

Fig.11 Cerebral activity of a student controlling the ALIVE Car in the race as shown in Fig.8

During the programming session, fluctuations in concentration are shown. In the first 2 minutes, the concentration average is **71.4**. After those **2 minutes elapsed**, the concentration dropped by **15.44%** to reach an average of **60.37**. Not losing focus easily is a big challenge in the current days where everything around us can be a distraction. Therefore, we wanted to address learning in a different approach. The ALIVE Mind project was meant to stimulate the student in its education and hopefully, it will provide a reliable new way of learning.

Our results confirm the effectiveness of our experimental educational method. As the graphic shows in Fig.11, there is a high attention being read from the student when he controls the ALIVE Car with the AMC device while answering a quiz (See section III.A below). The average attention is **71.71** and even reaches the **maximal attention** of 100 **multiple times**. That constitutes a **39.45%** increase in attention from doing a restful task and an **18.77%** increase from doing a more complex task after 2 minutes elapsed.

3. Case study (Elementary School workshop)

To gather the data from the mind-controlled race (See Fig.11), we conduct a workshop in an elementary school in Montreal. The students were introduced to coding using ALIVEcode and then we recorded their cerebral activity while they were answering the quiz [16] for the mind-controlled race. Additionally, at the end of the day, they were asked to fill a feedback form and to indicate how their programing experience was.

A. Quiz

The quiz they responded to while gathering our data (See Fig.11) contained thirty questions. Some of the questions were about things they learned during the day about programming, some were more fun questions in between tough ones, and the rest of the questions were school subjects of their level that needed good concentration to answer correctly.

B. Feedback

After learning about programming and controlling the car with the mind, the students answered an online form. This form shows the amount of interest that our teaching method produced. The results are illustrated in Table.1.

Table. 1. Feedback received after our workshop in the elementary school

Level (1-5)	Difficulty experienced (5 being really hard)	User Satisfaction (5 being really enjoyable)	Interest to continue (5 being high interest)	Programmed before (5 being yes, 1 being no)
1	14	18	2	9
2	4	0	0	0
3	0	0	0	0
4	0	0	0	0
5	0	0	16	9

The feedback results confirm the effectiveness of our experimental educational method. As the table shows, students had little to no trouble learning to program and resolving more complicated tasks with the help of the ALIVE Car, which stimulated them to learn. In addition, every student had a great time learning with our platform, and 16 out of 18 students showed interest in continuing their learning.

V. Conclusion

To conclude, the ALIVE Mind project utilized many components and layers of technologies to read and analyze data to study a student's attention. Our goal was to find a better and more captivating educational method in an attempt to fix the problem of disinterested students. We proved that our educational method, using a physical vehicle, was an effective way to rectify this problem. We aim to provide in the near future more captivating activities like the ALIVE Car and make our solution more accessible to everyone. For further improvements, we would like to make the AMC device faster and provide more tools to analyze the received data, for instance, machine learning.

ACKNOWLEDGMENT

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[10] ESP WROOM32 is the microprocessor used in ESP-32

[11] Link to our platform ALIVEcode: https://alivecode.ca

[12] The code of our platform ALIVEcode is fully open source and available here: https://github.com/MoSk3/ALIVEcode

[13] ALIVE Mind home page http://24.202.54.51:8000/

[14] All the data gathered for this paper: http://24.202.54.51:8000/mind/analyze?id=4

[15] Explanation and images of the AMC device: http://24.202.54.51:8000/mind/fonctionnement

[16] Link to the quiz. Important notice, this is the old version of ALIVEcode, therefore the connection is not secured. Do not put any important password when creating an account: http://24.202.54.51:8000/playground/quiz_choices.