Device For mental wellbeing and focus on demand

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Abstract

This paper presents a detailed analysis of electroencephalography (EEG) device that can read brainwaves from an individual, analyze the data, and use the result to send a wireless signal using Arduino. Here we used AgCl (silver chloride disc electrodes) to get the brain signals. One of the goals is to read EEG data with a higher sampling frequency than a previously manufactured EEG device. People are often tempted by external factors which lead to decreased attention. The analysis is carried out in accordance with IEEE standards and summarized to present the reasons and possible remedial measures for prevention of the inability to focus, which creates obstacles for learning and decreases one's ability to learn. However, using the proper recovery method, attention can be restored, thereby improving learning effectiveness. Thus, how to measure a student's attention level precisely, and how to provide an effective attention recovery method for are topics worth attention in the field of learning. An attention level assessment model based on EEG analysis is developed to measure subjects' attention level precisely during learning exercises. The study also observes the relationship between brain wave changes and varying attention levels during learning, and provides attention recovery methods that can help students restore attention and improve their learning efficiency. The study finds that napping is a good recovery method which can help male and female leaners recover their focus states. Conversely, adopting a recovery method which the participant finds more attractive (e.g., playing mobile games or watching YouTube) leads to increased focus on the more attractive activity, and fails to restore attention to the original task. Focus is so important because it is the gateway to all thinking: perception, memory, learning, reasoning, problem solving, and decision making. Without good focus , all aspects of your ability to think will suffer... Here's a simple reality: "If you can't focus effectively, you can't think effectively.

Keywords:-*Electroencephalography (EEG) device, silver chloride disc electrodes, focus, recovery methods.*

1. INTRODUCTION

EEGs are a noninvasive way to look into your brain. While the brain is extremely complex, areas of it can lock into circular firing patterns, resulting in telltale brain waves that one can observe with the right equipment. Intensity of these waves change depending on your internal state. Rather than sending signals through many long wires, transmitting a wireless signal is a much easier way to monitor brain activity because it ultimately gives the patient being monitored a full range of motion. Once EEG (Electroencephalography) measurements are made wirelessly, it would also open the door to many more applications related to brainwave monitoring. The waves we will be most easily able to distinguish are alpha and beta waves -- alpha waves occur at around 8-12 Hz and when measured from the frontal lobe provide an estimate of how relaxed a person is, while beta waves are around 12-30 Hz and correspond to how much a person is concentrating or how alert they are. This paper presents an in-depth guide on how to make your own simple EEG circuit. Along with monitoring brain wave concentration,The circuit will use 3 electrode - 2 to measure a voltage difference across your scalp, and one as a reference to ground. The study showed that their skill level was correlated to the EEG patterns of their brains, which means that scientific monitoring of brain signals could help athletes improve their consistency and accuracy in a particular sport.For sports that require a lot of free range of motion, a wireless way to transmit waves using Arduinos and from an EEG probe would be the only way that these athletes could perform without any interference from wires connected to the EEG probes. Interpreting brainwaves also has many more applications such as controlling a computer interface. Having been confined to four walls over a period of time, lines were blurred between personal,academic and professional lives, A drastic and unnatural increase in screen time brought with it an equally devastating state of mental health and focus. The result of our work shall find great use among distracted individual, but it could also give certain people with disabilities a better way to interact in this growing world of technology. Thus, EEG signals can be used for health monitoring and also as a way for humans to interact with.

2.SYSTEM ARCHITECTURE

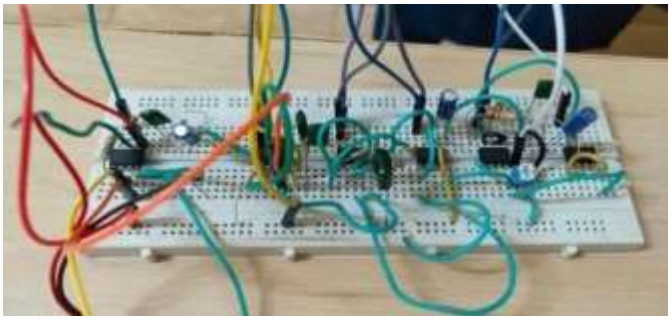

Fig-1 : System architecture

2.1 Instrumentation Amplifier

An instrumentation amplifier takes as its inputs 2 voltages, and outputs the difference between the two multiplied by some gain, G. Instrumentation amplifiers, however, are not perfect. On real amplifiers, the output is slightly skewed if both input voltages are offset the same by some amount. A perfect amplifier would take as inputs 2.1V and 2.2V, and output 0.1V*G. A real one is influenced by this common offset, and will changethe output slightly accordingly. The Common Mode Rejection Ratio (CMRR) is a value given to the amplifier that corresponds to how well it ignores the common offset between inputs. A higher CMRR is better, and will output something closer to what a perfect amplifier would. It is possible to make your own instrumentation, but unless you make it with precision resistors, it will suffer from a low CMRR. I personally couldn't get a good reading with a self-made instrumentation amp.

2.2 60 Hz Notch Filter

The biggest source of noise in our system will be centered at 60 Hz, due to power line interference. Evenif you use batteries to power your circuit, your circuit will still experience this noise. For this reason, we will have 2 "notch" filters - filters that have a severe reduction of gain around 1 particular frequency. We willuse one now, to cut out as much interference as we can before we apply any more gain to our circuit, and one at the very end, to cut out any more interference we may have picked up. The notch filter is most sensitive to changes in the 12ohm resistor. To ensure the notch is centered at 60Hz, take a reading (detailed on the last stage) at the end ofthe instrumentation amplifier, then do so again once the signal has gone through the notch filter. You should see a significant reduction in the amplitude of the 60Hz (light grey) frequency band. If it is not centered at 60Hz, try a 10ohm resistor, or even a different 12ohm one, as at thatresistance it can easily vary by a considerable amount.

2.3 7Hz High Pass Filter

As we are measuring data across the skin, our final data will also contain voltage from our galvanic skin response across our head. This will obscure the brain data we want, and as this interference is primarily low frequency, it can be fairly easily filtered out with a high pass filter (HPF).The trade-off doing this is that we also filter out a lot of gamma/delta wave data (the brain waves that are about 8 Hz and less), but if our main focus is alpha/beta wave monitoring, this isn't much of problem. This filter is a 2-pole HPF with a cutoff frequency of 7.23Hz. A cutoff frequency of 7.23Hz.As it is a high pass filter, frequencies above this cutoff will approach a gain of 1, while frequencies below will be continually reduced. The filter having 2 poles means that in the region below the cutoff frequency, the gain falls off much faster than a simpler resistor/capacitor circuit. More specifically, in this circuit, our double pole design reduces data by a factor of about 56 by the time it gets to 1Hz, while a single pole would only reduce it by a factor of about 7.5.

2.3 1Hz Low Pass Filter

we want to filter out data above the frequencies we are interested in. More specifically, as beta wave information stops out at 30Hz, we want to get rid of anything above that, as combined it can contributea good amount of noise to our data. The circuit design is very similar to the high pass filter from stage 3 - it has a gain of .71 at 31.23Hz, and decreases from there at a rate such that by 300Hz it has attenuatedthe data by about a factor of 100.

2.4 1Hz HPF and Gain of 83-455

The beginning of this circuit contains a quick HPF of cut off frequency 1Hz (Fc = 1/(2*pi*R11*C11), just for some extra attenuation of unwanted noise. On the other end, the resistor and capacitor in parallel provide some extra filtering of high frequencies (Fc = 1/(2*pi*10nF*100kΩ) = 160Hz on a low-passfilter).The main purpose of this section, however, lies below this, with the 220Ω resistor and potentiometer (pot for short). This op-amp is a non inverting , and so has a gain of G = 1 + R12/(R13+R14), (ignoring the 10nF capacitor, as it's a small value and won't contribute much to the gain). The potentiometer is a variable resistor - when the input is connected to the first pin and the output to the second, turning the wiper changes its resistance linearly between 0 and 1000 ohms. This means that when the pot is turned all the way to the left, the gain of this circuit is G = 1 + R12/(R13 + 0) = 1 + 100k/(220 + 0) = 455. When it is turned all the way to the right, the gain is G = 1 + R12/(R13 + 1000) =1+100k/(220+1k)=83. Remember, this 83-455 gain is on top of the 89.2x gain from the instrumentation amplifier. Alpha wave amplitude varies from personperson, from about 10 to 30 uV. Using a middle value of 20 uV, this means the ending voltage reading could range from *83*89.2*20e-6 =148V* to *455*89.2*20e-6 = .81172V*. Once you've started taking readings, adjust the potentiometer such that when you're not moving at all, voltages don't fluctuate offscreen (over 1V). It doesn't have to be maximized such that the amplitude is the highest possible without clipping - just know that if you make it too small, you'll increase the error incurred from digitally reading the data into the computer.

2.5 Another 60Hz Notch Filter (and Into the Computer)

Even with all the previous filtering stages, the data will still at this point contain a good amount of 60 Hz noise. To fix this, we will process it through another notch filter centered at 60 Hz, identical to the previous one. The final data will still have a small amount of noise, but that can be ignored through software.To get the data into the computer, we will be using a 3.5mm male-to-male cable (this is the same size ending as any headphone jack). On the cable, the first 2 notches are the right and left channels, and the one furthest down is GND. As shown in the picture, you should connect the end of the cable between the 22k resistor and 220nF capacitor (the yellow alligator clip), and the base of the cable to the GND line of your circuit -- the same line you connected your GND electrode to (the red alligator clip in the image). I suggest connecting the other end of these alligator clips to jumper wires, inserting these into their appropriate place in the circuit. Connect the other end of the cable into the microphone port of your computer, and you're good to go.

3.BLOCK DIAGRAM AND WORKING

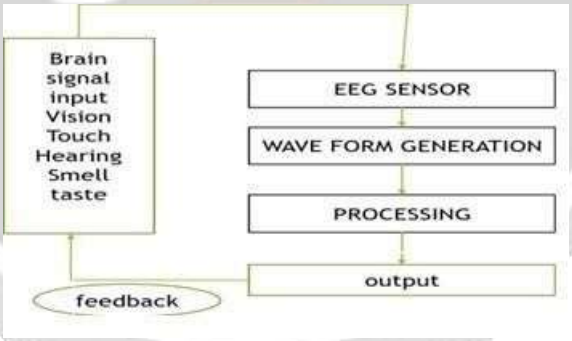

Fig-2 : Block diagram and working

3.1 WORKING:

AgCl EEG Disc electrode is used to get brain waves from frontal lobe of brain. Data is collected through Arduino Uno, and later filtered for removal of noise and for certain frequency. Instrumentation Amplifier INA118P is used for amplification of electrical signals. Later data is collected with the help of a software COOLTERM. We transfer data to Excel,and then calculate the delta value and then decide whether brain is in focused state or distracted. According to this data, we started Training by help of someinput sound as awarning mechanism.

3.2 ALGORITHM:-

Step1: Take the brain signals as an input.
Step 2: Brain signal is passed to EEG sensor.
Step 3: Output of EEG sensor is measured.
Step 4: Values are recorded and we calculate the Delta value.
Step 5: Based on that delta value we are using some input sound to improve the mind state.

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4.METHODOLOGY

4.1Getting Electrodes, and Proper Placement EEG

EEG is basically the recording of electrical activity in the brain. Each EEG probe that is used acts as a conductor and sends a current directly from the brain to the amplifier circuit for further modifications. This current can then be translated into something that a computer can read and quantify as a signal, but it must be sent through a very complicated circuit during this process. There are different types and varieties of these EEG probes, but the ones used for this experiment were small Agcl disc electrodes as seen in the fig 3.

Fig-3 : Agcl disc EEG Probes

All parts of the brain have a different function, and the part of the brain used for this experiment was the frontal lobe for its function of movement and location near the scalp. Fig. 3 shows the different sections of the brain and what each section does. In order to quantify the data, we have used 1 EEG probe that must be used to find a differential voltage across the brain.

Humans have only five different types of brainwaves.They can be divided into four categories: theta, delta,alpha, and beta. Each one represents a different state of mind that someone is experiencing at a particular time. Delta waves have a frequency of 3Hz or lower and have the highest amplitude around 50μV. They occur when individuals are in deep sleep. Gamma waves are the fastest brain waves. They mainly occur when you are highly alert and conscious the range from 30 to 80Hz Theta waves have a frequency between 3.5and 7.5Hz and are characterized by slow-paced activity. Alpha waves are brainwaves between 7.5 and 13Hz, which occurs during relaxation. The last type of waves are beta waves, which have the lowest amplitude and the highest frequency, 14Hz or higher, and are associated with normal waking consciousness. For this project, the waves that were seen the most were beta waves because subjects were awake.

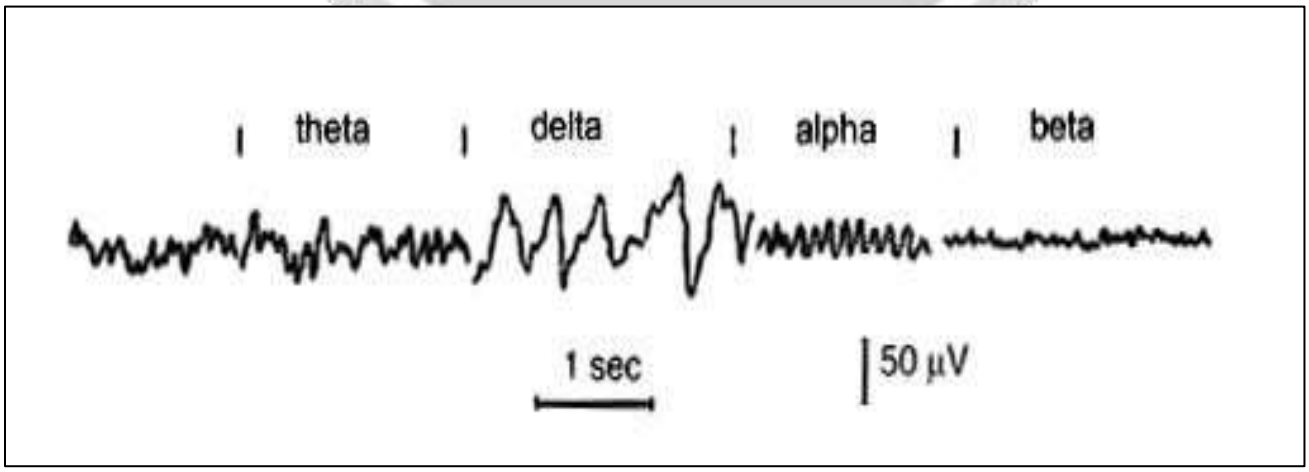

Fig-4 :Different types of brainwaves

4.2 Using Arduino to Get Inputs

Arduino is a fairly new programming platform that was created in 2005 at the International Design Institute. The software uses a programming language that is very similar to the C programming language, and this hand sized electronic device can easily be programmed from the basic software available on the Arduino website (http://arduino.cc). Fig. 6 is a picture of an Arduino uno that is used to perform certain tasks based on the given input.

Fig-5 : Arduino Electronic Device

The creation of Arduino has begun a new age of electronics. What makes them unique is that they are affordable and simple to use for anyone with a basic programming and electronic knowledge. In fact, "Arduino has become the most influential open-source hardware movement of its time" Arduino can be used to perform tasks. Once a program for a particular task is written it is uploaded to the Arduinohardware, which in turn performs the desired task. The tasks can be performed from a few feet away to all the way on the other side of the world via the internet. All of the software is free and requires a basic knowledge of the C programming language and some practice from the examples that are given on the Arduino website. The Arduino hardware is very affordable and requires a basic knowledge of how to put it together from examples that are provided for free online; however, creating a network that performs a particular task can be very time-consuming due to the several components involved in finishing a project.

4.3 EEG sensing system development

The methods used for this project required two separate parts. The two parts are the software and hardware implementation. For the hardware implementation, an amplifier circuit had to be built, which made data acquisition from the EEG probes possible since EEG signals occur at an extremely low voltage, 20µV, and low frequency, 20Hz.Typically, EEG values are unreadable by the Arduino Microprocessor and the Oscilloscope; however, after the EEG signal passed through the Amplifier Circuit, it could be read by both.
For the software implementation, the data had to be filtered on python Idle for analysis due to the large noise that was added by the breadboard. this was done, large samples of the data were collected for analysis, and the data also had to be averaged to be interpreted by theArduino.

4.4 Processing the Data

The electrical signals which comes from brain is in microvolts from Arduino. This electrical signals is in the form of microvolts VS Time This waves are sent To a tool kit such as mne python where we perform Fast Fourier transform (FFT) method .This method employs mathematical means or tools to EEG data analysis. Characteristics of the acquired EEG signal to be analyzed are computed by power spectral density (PSD) estimation in order to selectively represent the EEG samples signal.However, four frequency bands contain the major characteristic waveforms of EEG spectrum, The PSD is calculated by Fourier transforming the estimated autocorrelation sequence which is found by nonparametric methods. After calculating power spectrum density, we can differentiate the brain signals into Alpha and Beta waves.We perform many experiments where we calculate the delta values for the waves then we do the comparison where if delta value is less then we consider it as focus if it's more then we consider as distraction. If there is a distraction then we give a warning through sound or vibration or light this willtrigger the brain to come to focus.

5.RESULTS

5.1 EXPERIMENTATION TO IDENTIFY BRAIN STATESUSING VIDEOS

We have performed many experiments like guided meditation videos, funny videos, used social media, scary videos, we played focus-based games, we have watched certain technical videos, etc., we have also performed with binaural beats.From the guided meditation, social media and focus based video we can see that the waves are almost stable and there are not much spikes associated with that wave. Researchers at the Columbia universitymedical center claim meditating can change the structure and function of the brain through relaxation, which can reduce stress, anxiety and depression. increased focus and learning concentration it also improve memory and attention.Focused meditation involves focusing on something intently as a way of staying in the present moment and slowing down the inner dialogue. Unlike classic meditation, where you focus on nothing to quiet yourmind, with focused meditation, you still remain in thepresent, but focus wholly on one thing. Typically, you focus on sensory stimuli like sounds, visual items, tactile sensations, tastes, smells, and even your own breathing— much like mindfulness meditation techniques.Social media's impact on attention and focus has long been debated.It's now well- established that social media consumes or exhausts attention resources and detracts attention from other more important life activities like work, education, and personal development.Binaural beats are a new technology of brainwave entrainment intended to put the brain into the similar situation as when someone is performing meditation using traditional methods. Some of the modern researches appeared in the past few years show that meditation actually produces changes that can be measured. It is already proven by EEG signals called brainwaves.

5.2 EXPERIMENTATION TO IDENTIFY VALUES FOR FOCUS AND DISTRACTION

We performed many experiments like reading books, using social media, watching reels, watching YouTube, reading stories, listening to songs, meditating for a time span of 20 to 30 minutes each. We recorded the brain states during these experiments, We recorded the data with the help of Arduino Uno and we also used the software called as coolterm.Coolterm helps in saving the data which we get fromArduino in the form of a text file. This data are saved to excel sheet for the calculations like for calculating the delta values that is the difference between each consecutive values recorded from our brain. We plotted a graph and calculated delta value for two consecutive values. We found that when the delta value is less the brain is in focused state while, when the delta value is moderate the brain is in distracted state, when the delta value is more there is a movement.

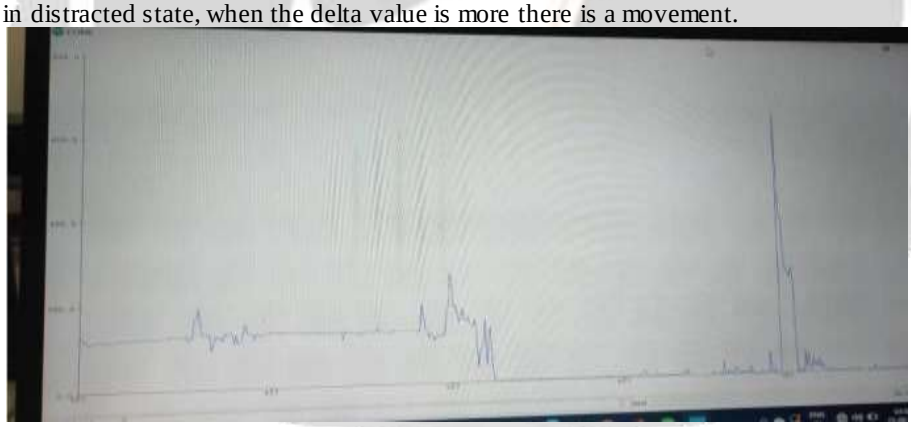

Fig-6 : observation 1

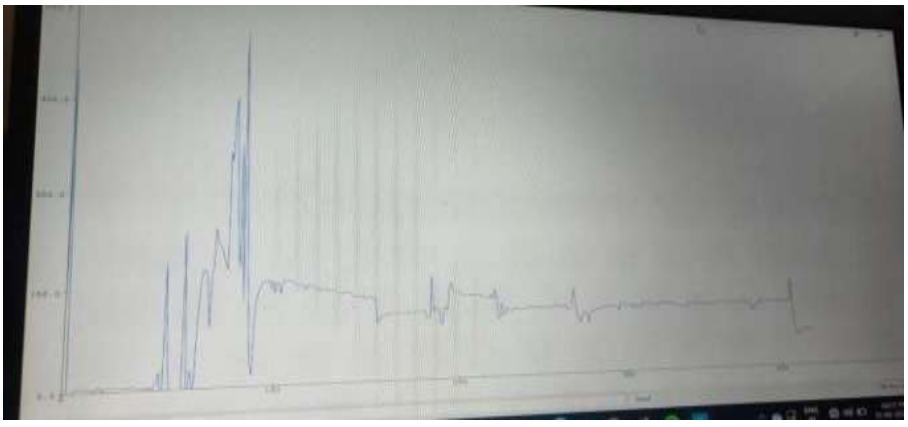

Fig-7 : observation 2

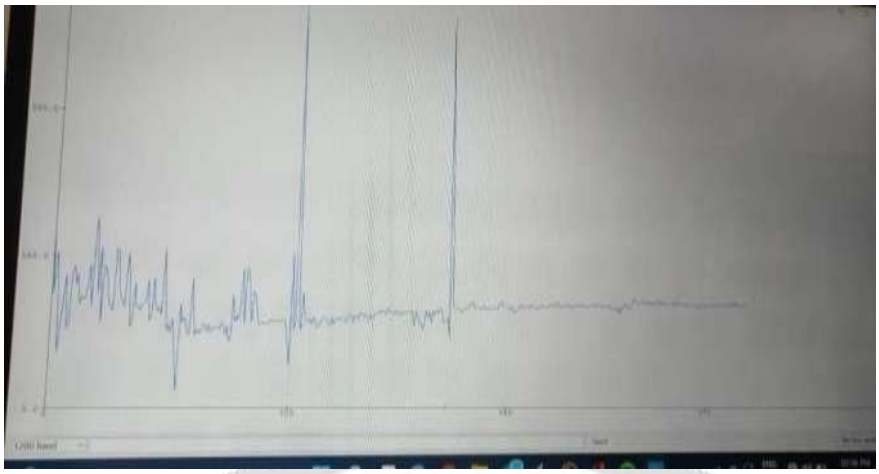

Fig 8 : observation 3

5.3 EXPERIMENTATION TO ESTABLISH WARNING MECHANISM

After calculating the delta values for each consecutive data. For each gathered data we performed warning mechanism such as sound, vibration, buzzer etc. for training purpose, we found that if the delta value is less the brain is in focus state while if delta value is more then the person is distracted. This training period is for 90 days. Starting when the brain was in focus state, we train the brain with particular sound. Later when the person is distracted, we play the same warning sound so that the person regains the focus.

6.CONCLUSION

Overall, the objective of the project was accomplished successfully. The project required that an EEG signal be read and processed so that it collects electrical signals from brain. The hardware implementation of the data was difficult but it was completed successfully. After amplifying, filtering and offsetting the eeg signal, the Arduino successfully read the analog data and output its readings to the computer. This allowed the computer to collect several hundred samples of eeg data for processing.After that the signal was filtered using notch, high pass, lowpass filters. And then tested to see if it accurately represented the brain waves of the human being. Then we performed various experiments to detect the brain state whether it is in focus or distracted state. We did this by calculating delta values for each consecutive data. Depending on the delta values if differentiated focus and distracted state.If delta value was more then the person is distracted and then we send a warning sound to that person so that he can regain focus state.

7.FUTURE SCOPE

It can be inferred from the proposed experiment that a real- time attention-based neurofeedback can be used to improve the average attention levels of the users. The application can be used as an E-learning utility tool by the users to monitor their attention levels on an individual level and improve it over a period of time. A significant investment in creating online educational courses can be justified if they are evaluated on the basis of attention-based ratings and not simply user ratings. Moreover, they can receive feedback on user attention while watching their curriculum material. In Driving simulations, potential drivers can test their reflexes and attentiveness while utilizing this tool.This can assist the instructors in determining the capability of drivers. Furthermore, a user-interactive game application can hence be used in order to increase the attention of users helping them to focus completely. An alternative domain that can be explored is by correlating stress and attention. An Optimum level of stress can boost attention and thus the performance of an individual as per Yerkes- Dodson Law .By mapping attention at different levels of external stress situation simulated for the user, we can predict the optimum attention level for a user in a stress situation. This work can be expanded further by correlating creativity and attention. Creativity can boost attention by forming a link between abstract thoughts and thus improve the performance of anindividuals. Several

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