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Detecting Photoepileptic Content: Enhancing Safety

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Abstract: Photosensitive epilepsy is a recognized medical condition that affects a sizeable portion of the population, putting individuals at risk for having convulsions triggered by flashing lights or contrasting patterns. Due to its impact on their ability to carry out daily activities and function normally, those who suffer from this condition face a significant challenge. Despite technological advancements and the expansion of the entertainment industry, the prevalence of flashing lights and symmetrical patterns persists, making it imperative to address this issue. This paper seeks to shed light on photosensitive epilepsy and explores a possible solution for detecting photoepileptic content in videos using video processing algorithms with predefined parameters aligned with recommended standards for tolerance levels in photosensitive epilepsy patients. The algorithm takes into account factors such as the luminance, brightness, and duration of flashes deemed safe for people with photosensitive epilepsy. There are currently no automated tools for detecting photoepileptic content in online videos. Some creators manually provide warnings regarding the presence of such content, highlighting the need for a detection tool to protect viewers with photosensitive epilepsy. This paper addresses the lack of regulatory software required to effectively monitor the entertainment industry's rapid evolution. This research contributes to mitigating the effects of photosensitive epilepsy and promoting a safer environment for individuals with this condition by increasing awareness.

Keywords: Photosensitive epilepsy, Video processing, Flash patterns, Social Media, and Frames per second (FPS)

I. INTRODUCTION

Photosensitive epilepsy is a World Health Organization (WHO)-recognized disease that puts 1 in 4000 people at a sure-shot risk in terms of their basic lives. Like any other seizure, it hampers the ability of a person to work in the sense of being a fully functional human being. From minor lightheadedness all the way to death, Photosensitive epilepsy (PSE) is an obstacle for a niche set of people. Fast-flashing lights, repetitive patterns, or patterns that flash can all induce a seizure with relative ease, making it essential to address the concern. With the growing entertainment industry and the clear advancements in technology, it has become easily apparent that flashing lights or symmetrical patterns aren’t going anywhere. Be it an action movie, an anime, or recordings of a club, all the way to RGB-lit keyboards and flashy 3D animations created for events, everything can cause a seizure if not inspected with proper care. The victims often consider seizure-inducing videos the equivalent of an assault, and the 21st century is no place to stand quietly when someone feels assaulted. Photosensitive epilepsy-related cases have existed for a while now, and people don't understand that it's an actual struggle. People like Zach Eagling, who was cyberbullied after participating in a walk for an epilepsy awareness organization, are examples. This is a basic cyberattack, and if laws exist to prevent other cyberattacks, it should be investigated. The paper aims to bring to light Photosensitive epilepsy and theorizes a possible solution to detect photo epileptic content in different videos using video processing, which works on an algorithm having predefined parameters that are in accordance with the recommended standards with respect to the tolerance range of a photo epileptic person. Certain parameters like luminance, brightness, and the duration of flashes tolerant to the eyes of a photo epileptic person are considered in the algorithm. Till now, there has not been any effort with respect to the automatic detection of photoepilepsy content in videos available online. In some videos, the creator manually puts in a warning at the start of the video that warns the viewer about the presence of photoepilepsy content in the video, so it is important in this regard to have a detection tool like this so that people can check if the content that they are uploading is safe for viewers suffering from photoepilepsy.

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II. PROBLEM STATEMENT

Photosensitive epilepsy refers to the induction of seizures due to flashing lights or contrasting light and dark patterns. Flashing or patterns tend to disorient people regardless of photoepilepsy, making them uncomfortable or unwell. A discovery for cure of photoepilepsy is yet to be seen. However, there are ways in which it can be avoided. Photoepilepsy has been a largely overlooked issue in the mainstream medical community.

The problem this paper plans to address is one that has an imminent gap in today's day and age. The problem is that there is a lack of regulatory software that can keep the ever-progressing entertainment industry in check.

III. BACKGROUND

Epilepsy is a chronic, non-communicable brain disease that affects approximately 50 million people worldwide. It is characterized by recurrent seizures, which are brief episodes of involuntary movement that may involve a part of the body (partial) or the entire body (generalized). Photosensitive epilepsy occurs when seizures are triggered by flashing lights or contrasting light and dark patterns. [1] It may sound like an urban myth, but it is possible for video games to cause seizures in children or in adults who are into gaming. This condition is known as photosensitive epilepsy, and affects three percent of children who have seizures. [2] Flashing lights of certain intensities and some patterns can become trigger agents. Some sources, such as strobe lights or emergency lights, may seem obvious as potential triggers. But visual patterns and effects, like frames of a video or a mere checkered shirt digitized, can all be agents as well. This phenomenon is more common in children as compared to adults.

IV. RELEVANCE

With the advent of social media, technology, and the booming gaming industry, especially with the concept of 15-second video clips called reels on Instagram and a wide variety of content and videos available on YouTube, there have been instances where certain sections of these videos or parts of video games contain photo epileptic content that may cause photosensitive epilepsy. So, it is important at this time to moderate or filter this content or provide proper warnings related to it.

V. UNDERSTANDING PHOTO EPILEPTIC SEIZURES

A. The Consequences of Photo Epileptic Seizures

In a given scenario, they can cause accidents; it can be as simple as lights flickering through trees or disco lights. They can cause people to fall, hit their heads, or suffer a serious injury. Some people are known to suffer from memory issues and emotional disorders like anxiety or depression, which is more than inconvenient for them There are also longer-term risks. People with epilepsy frequently suffer from memory issues or emotional disorders such as anxiety or depression, which can be quite incapacitating. Epilepsy can be detrimental to one's quality of life. There is also the possibility of sudden unexpected death in epilepsy (SUDEP), in which a person with epilepsy dies suddenly, with or without seizure evidence. According to the U.S. Centers for Disease Control and Prevention, for every 1,000 people with epilepsy, there are an average of 1.16 cases of SUDEP per year. People with uncontrolled seizures are more likely to die than those with controlled seizures. [3]

B. The Evolution of Photo Epileptic Seizure Warnings

The existence of photo epileptic seizure warnings can be traced back to as early as the 1990s, when a 9-year-old succumbed to a seizure while playing Super Mario 64. She fell to the ground and started jerking and shaking. With nerve-wracking descriptions from Jessica’s father about her eyes rolling up and the panic caused by the scenario, it became obvious that there was a problem to address. Following the incident and a set of similar occurrences, Nintendo of America Inc. announced that the company would issue a warning on all of its products that are sold internationally. Since mid-1991, all video games and associated hardware in the United States have carried the warning to "consult your physician before playing video games if you have an epileptic condition." Sega soon followed in Nintendo’s footsteps. Photosensitive epilepsy was again brought to public attention in December 1997 when the Pokémon episode "Denn Senshi Porygon" ("Cyber Soldier Porygon") was broadcast in Japan, showing a sequence of flickering images that triggered seizures simultaneously in hundreds of susceptible viewers (although 12,000 children reported symptoms that may be attributable to mass hysteria).[4]

The incidents only increased from March 1997, the 25th episode of an anime series called YAT Anshin![5] Uch Ryok, where red and white flashing lights hospitalized four kids, to Cyberpunk 2020’s braindance.

C. History of photosensitive epilepsy

Photosensitive epilepsy rose to prominence in the 1950s as a result of the introduction of television. Photosensitive epilepsy affects 1 in 4000 individuals. The incidence is 1.1 per 100,000 per year; however, the incidence among 7–19-year-olds is more than five times higher. It is twice as prevalent in females as in males; onset is around puberty, but less than 25 percent of patients lose photosensitivity by their twenties. Patients are examined using intermittent photic stimulation in the EEG laboratory. 49 percent of patients are sensitive to 50 flashes per second, which explains their sensitivity to PAL television systems.

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In 1993, broadcasting guidelines were established, limiting flash rates and screen areas, as well as the use of long-wavelength red. Currently, real-time analysis systems are being developed to test materials for compliance with regulations.[6]

D. Flash Pattern Detection

Flash pattern detection is an essential feature that identifies and manages content that may cause seizures or harm photosensitive individuals. It ensures conformance with accessibility standards such as WCAG 2.0, which recommend limiting flashing content and giving users the option to adjust or disable it. Flash pattern detection helps create a safer and more inclusive browsing experience for all users by analyzing web content.[7]

E. Incidence, Triggers, and Characteristics of Epileptic Seizures

About 0.3 to 3% of the population experiences photosensitivity, an abnormal EEG response to light or pattern stimulation. About 1 in 10,000 people, or 1 in 4,000 people aged 5 to 24, are thought to experience seizures as a result of light stimulation. There is a 2-14% probability that light or a pattern will cause an epileptic seizure in a person with epilepsy. When red-blue flashes appeared on broadcast television during the Pokémon anime incident in Japan, 685 kids went to the hospital. The percentage of people who had a seizure while watching the cartoon was only 24%. Although photic or pattern stimulation has the ability to cause seizures in those who are predisposed to them, it is not known to raise the risk of developing epilepsy in the future.

Intensities between 0.2 and 1.5 million candlepower can cause seizures. Although the range is 1–65 Hz, frequencies between 15 and 25 Hz are the most stimulating. Red color and light-dark boundaries can both cause pattern-sensitive seizures.[8] Multiple forms of entertainment (TV Shows, YouTube), natural occurrences such as tree leaf patterns, and public digital billboards can all induce seizures.

F. Social Media and Photoepilepsy

In today's day and age, a total of 2.6 billion people use YouTube, and 1 billion people access Instagram. These platforms offer a plethora of videos and short snippets that are very capable of inducing seizures in anyone and everyone afflicted with the issue. If we were to consider that a third of the population had access to YouTube, it would bring the number to roughly 600 thousand people, which is no small unit. TikTok recently even changed their interface to enable skipping of such videos as well.

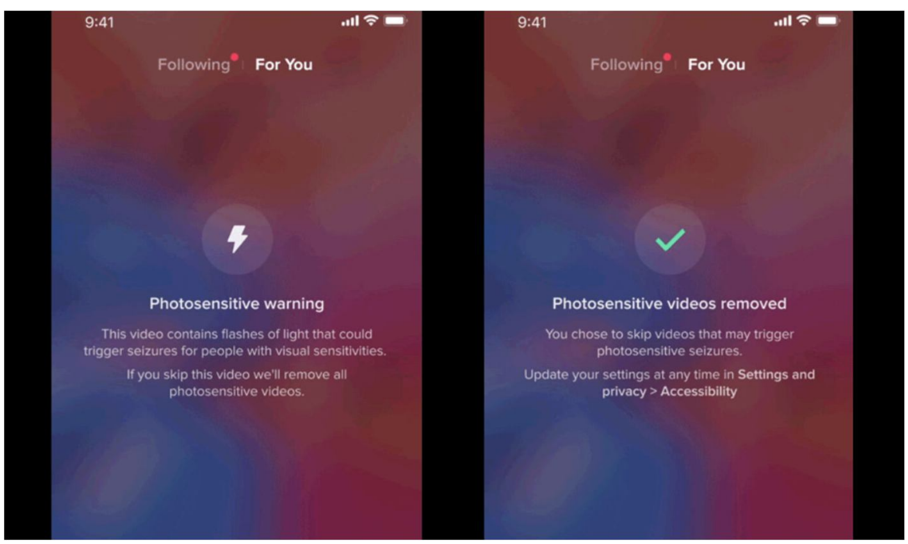

Fig 1. Photoepilepsy warning displayed by TikTok

G. Addressing the Need for Online Safety

Sophie Harries, a 22-year-old dietitian from Somerset, reported a film trailer containing glowing lights to Instagram, but the company stated that the video did not violate its terms of service. She continued by describing the area as a minefield. The Epilepsy Society desires that the government's new plans to combat "online harms" include recommendations for warnings regarding flashing images on social media. The Epilepsy Society suggests that anyone found guilty of intentionally posting harmful images should be prosecuted for assault. Regarding the issue, the government stated that it would consult with the charity.

The government did not take any significant action, as Instagram has not yet added a report feature for photoepilepsy despite having one for eating disorders and spam (without diminishing either issue). Neither the victim nor the charity was acknowledged, as is the case with every widespread plea for aid.[9]

Today, several countries have established guidelines for broadcast material to prevent the airing of video content that may contain patterns or stimuli that could potentially trigger epileptic seizures in a large audience. For example, in the United States, the Federal Communications Commission (FCC) has regulations in place to minimize the risk of photosensitive seizures caused by television content.[10] Similarly, the United Kingdom's Ofcom has established guidelines that set thresholds for flashing content and recommend protective measures.

H. Importance of Gamma

Unlike cameras, our eyes do not receive light the same way. A digital camera's sensor receives twice as much signal when twice as many photons hit it (a "linear" relationship). Pretty clear-cut, yes? Our eyes do not function that way. Instead, we only see a small increase in brightness when the amount of light is doubled, and this effect gets worse as light intensities increase (a "nonlinear" relationship). We are significantly more sensitive to changes in dark tones than we are to equivalent changes in bright tones when compared to a camera. This oddity has a biological explanation since it allows human vision to function over a wider range of luminance. Otherwise, the spectrum of light we often experience outside would be too overwhelming.

I. The Global Legal Scenario

The World Wide Web Consortium's Web Content Accessibility Guidelines (WCAG) Version 2.0, produced in 2008, specifies that content should not flash more than three times in any one-second period. However, it does allow flashing above this rate if it is below the "general and red flashing thresholds", which means if the effect is small or low-contrast enough, it is acceptable, which is not the correct approach and requires amendments.[11]

A photo epileptic person can be affected by flashing lights with a frequency range of 3–30 hertz, and it may go up to 60 hertz as well.[12] Patterns may also have an impact on a person.

The provided guidelines offer very little defense against them because lights that flash three times in a second or patterns that use the red threshold can easily cause a person to have a seizure. Innumerable lawsuits ranging from 1993's 15-year-old Laura Moceri's case to 2013's John Ryan Mclaughlin's Elder Scrolls 4 case have been seen in action, and while No consumer has won a product liability or personal injury case against a game manufacturer whose video game triggered seizures It is evident that there is an issue to be addressed. While some gaming manufacturers, like Steam, have yet to introduce warnings of any sort, it is slowly becoming a need of the hour. Some laws, like Zach's law named after a victim, have been proposed but have received no recognition, i.e., no legal protection exists for the photo epileptic community.

J. Treatment For Photoepilepsy

No cure is available for PSE, although the sensitivity of some people may diminish over time. Medical treatment is available to reduce sensitivity, with sodium valproate being commonly prescribed. Patients can also learn to avoid situations in which they might be exposed to stimuli that trigger seizures and/or take steps to diminish their sensitivity (as by covering one eye) if they are unavoidably exposed. These actions together can reduce the risk of seizures to almost zero for many PSE patients. [11]

VI. COMPONENTS TO CONSIDER FOR SOLUTION APPROACH

A. Video

A video is a sequence of images displayed quickly to create the illusion of motion. The frame rate determines how many frames are shown per second, with common rates being 24 fps for movies, 30 fps for TV and online videos, and 60 fps for games and sports. Pixels are the individual units that make up an image or frame, consisting of red, green, and blue components. The pixel resolution indicates the total number of pixels in a frame, with higher resolutions providing sharper and more detailed video. Common resolutions that are used in various devices and video streaming platforms include 720p, 1080p, and 4K. A single pixel is a mixture of three components: red, green, and blue (RGB). Each component represents a specific intensity level of its respective color. A different number of combinations of the values of red, green, and blue yield a variety of colors that can be used as desired. The RGB values of each pixel determine its color and brightness. So, when you see an image or video on a screen, it is composed of millions of pixels, each with its own RGB values, working together to form the complete visual representation.

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B. Color Space and RGB

Color space is a mathematical representation that specifies a range of colors that a device or system can display or capture, offering a standardized way to describe and manipulate colors for various applications.[12] One of the most commonly used color spaces is RGB (Red, Green, Blue), which is widely employed in digital imaging and display technologies.[13] Red, green, and blue primary colors are mixed to create colors in the additive RGB color model. In the RGB color space, each point represents a specific color, with the intensity values ranging from 0 to 255 in an 8-bit representation. The RGB color model has a relatively large gamut, allowing it to represent a wide range of colors, but it does have limitations in accurately reproducing certain shades. Some of the applications in the industrial sense where RGB is used very widely and in varied instances are in digital imaging, computer graphics, and display technologies. It serves as the primary color model in electronic displays. Color space conversions, such as converting between RGB and other color spaces like CMYK or HSL, are common for accurate color reproduction across devices. For image manipulation and to work on videos or any visual displays for that matter, Understanding the color space and RGB is essential, as someone with the base knowledge can work better on the data and give better outputs.

C. Luminance

Luminance refers to the physical intensity of light emitted or reflected from a surface, measured in units of candela per square meter (cd/m^2) or units. It represents the actual amount of light energy. Brightness, on the other hand, is the subjective perception of how intense or "bright" a visual stimulus appears. Beyond luminance, other factors that affect it include the surrounding environment, contrast, adaptation, and individual differences in visual perception.

While brightness is a perceptual experience that depends on a variety of factors, luminance is a measurable physical quantity. The human visual system's sensitivity to different wavelengths of light and variations in color can also affect perceived brightness, even when luminance values are the same.

D. Relative Luminance

Relative luminance is a fundamental concept in the field of color science, particularly in the context of display technologies and visual perception. It refers to the perceived brightness or intensity of a color relative to a reference white point. When comparing colors of similar size, understanding their relative luminance can help determine their relative brightness and contrast.

In the RGB color model, relative luminance is typically calculated using a weighted sum of the red, green, and blue color channels. The following equation is used to determine relative luminance:

$$Y = 0.2126 * R + 0.7152 * G + 0.0722 * B \quad -(1)$$

Where R, G, and B represent the normalized values of the red, green, and blue color channels, respectively, their values ranging from 0 to 1.

By comparing the relative luminance values of different colors, we can assess their perceptual brightness and make informed decisions regarding their use in design, visualization, or information display. Higher relative luminance values indicate brighter colors, while lower values suggest darker colors. It is worth noting that relative luminance calculations are primarily applicable to color models like RGB, which are based on additive color mixing. Other color spaces, such as CMYK or HSL, may require different formulas or transformations to accurately determine relative luminance. Relative luminance is an essential concept when comparing colors of similar size, as it helps evaluate their relative brightness and contrast. By considering the relative luminance values, designers and developers can make informed decisions about color choices, enhancing visual hierarchy, legibility, and accessibility in various applications.

E. Gamma Correction

Gamma correction is a technique used in digital image processing to account for the non-linear response of the human visual system to brightness. It involves applying a power-law function to adjust pixel values in an image. Gamma encoding compresses the pixel values using a gamma value, optimizing storage or transmission. Gamma decoding reverses the process, restoring the pixel values to linear RGB values. This ensures an accurate and artifact-free display on linear devices like monitors. Gamma correction is crucial for achieving visually pleasing and accurate representations. Different systems and standards may use varying gamma values, and advancements like HDR displays may require additional considerations. To convert gamma-compressed non-linear RGB values to linear RGB, the following equation can be used:

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$$V(u) = \begin{cases} \dfrac{u}{12.92} & \text{if } u \leq 0.0405 \\ \left(\dfrac{u + 0.055}{1.055}\right)^{2.4} & \text{otherwise} \end{cases} \quad -(2)$$

where u is either the value for red, green, or blue. For this equation to be valid, the red, green, and blue numbers must be between 0 and 1. Since the majority of RGB values range from 0 to 255, they must be divided by 255. [15][16]

F. *Perceived Lightness*

Perceived lightness is the subjective perception of the brightness or lightness of a color by the human eye. The luminance of the color, contrast with nearby colors, and general lighting conditions are a few factors that affect it. Colors with higher luminance tend to appear lighter, while colors with lower luminance appear darker. The contrast between a color and its background or neighboring colors also affects perceived lightness. Furthermore, the overall lighting conditions, such as the amount and quality of ambient light, play a role in how we perceive lightness. It allows for the manipulation of colors to achieve desired visual effects and optimize the overall aesthetic appeal of designs.

G. *Saturation*

In the RGB color space, saturation refers to the intensity or purity of a color. It determines how vibrant or dull a color appears. Saturation is calculated by comparing the intensity values of the primary color channels (red, green, and blue). A fully saturated color has one or more color channels at maximum intensity while keeping others at a minimum. Saturation can be calculated using the formula (Cmax - Cmin) / Cmax, where Cmax is the maximum channel value and Cmin is the minimum. The result ranges from 0 (unsaturated) to 1 (fully saturated). Adjusting the RGB channel values allows control over saturation, with higher values increasing it and lower values reducing it.

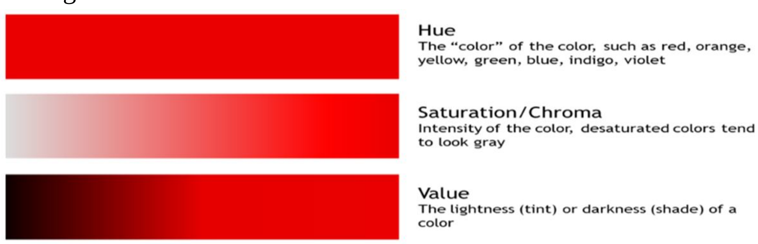

Fig 2. Pictorial Representation of Saturation

H. *Recognizing a flash and its frequency*

Recognizing a flash and determining its occurrence based on average luminance involves accessing frames individually or in sets and analyzing their average luminance values. Average luminance refers to the overall brightness level across a frame or set of frames, providing a measure of the intensity of light present. By examining the frames captured before, during, and after the flash event, it becomes possible to identify significant changes in average luminance that indicate the occurrence of a flash.

When accessing frames individually, the focus is on analyzing the changes in average luminance within each frame. A flash typically results in a sudden and significant increase in brightness, causing a notable spike in the average luminance value. By comparing the average luminance of frames, it becomes possible to pinpoint the frame(s) where the flash occurred and differentiate it from the surrounding frames. On the other hand, when analyzing sets of frames, the average luminance values are examined collectively to establish a broader context. The comparison between frames in the set allows for a more comprehensive assessment of the changes in average luminance. The flash event can be identified by observing a distinct and consistent increase in average luminance across multiple frames in the set.

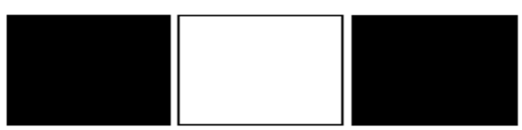

Fig 3. Depiction of a flash

By calculating and analyzing the average luminance, it becomes easier to differentiate a flash event from regular variations in lighting. This approach helps in accurately recognizing the occurrence of a flash and distinguishing it from other visual elements or artifacts. Moreover, by examining multiple frames and sets, it becomes possible to gain insights into the duration, intensity, and frequency of the flashes, providing valuable information for further analysis and interpretation.

VII. CONCLUSION

Photosensitive epilepsy is a serious condition that affects a considerable portion of the population. Seizures induced by flashing lights or contrasting patterns can result in catastrophic outcomes, including accidents, injuries, and even death. Despite its widespread prevalence, photoepilepsy has received little attention from the general medical community, and there is a lack of regulatory software to keep up with the entertainment industry's rapid growth. This research paper has highlighted the need for video processing algorithms to detect photoepileptic content in videos. Creating a detection tool that takes into account the luminance, brightness, and duration of flashes that people with photosensitive epilepsy can tolerate will ensure the safety of viewers. Currently, there are insufficient efforts made to automatically detect photoepileptic content in online videos; it is essential to address this gap. In addition, the history of photosensitive epilepsy, the evolution of photoepileptic seizure warnings, and the effects of photoepileptic seizures have been discussed. It has shed light on the prevalence, triggers, and characteristics of epileptic seizures, highlighting the significance of addressing online safety in the age of social media and digital platforms. In addition, the global legal landscape surrounding photoepilepsy has been examined, revealing the existing protection guidelines and their limitations. Lawsuits and proposed legislation have demonstrated that the photoepileptic community requires legal protection. Despite the lack of a cure for photosensitive epilepsy, it is possible to take preventative measures such as taking medication and avoiding trigger agents. These may prevent epileptic seizures and save lives. In conclusion, it is essential to develop regulatory software and guidelines that can automatically detect and filter video content containing photoepileptic stimuli. This will protect individuals with photosensitive epilepsy from potential harm and ensure their participation in the digital world on an equal basis. The collaboration of stakeholders, including content creators, social media platforms, and regulatory bodies, is required to address this pressing issue and promote inclusivity and safety for all photosensitive epilepsy patients.

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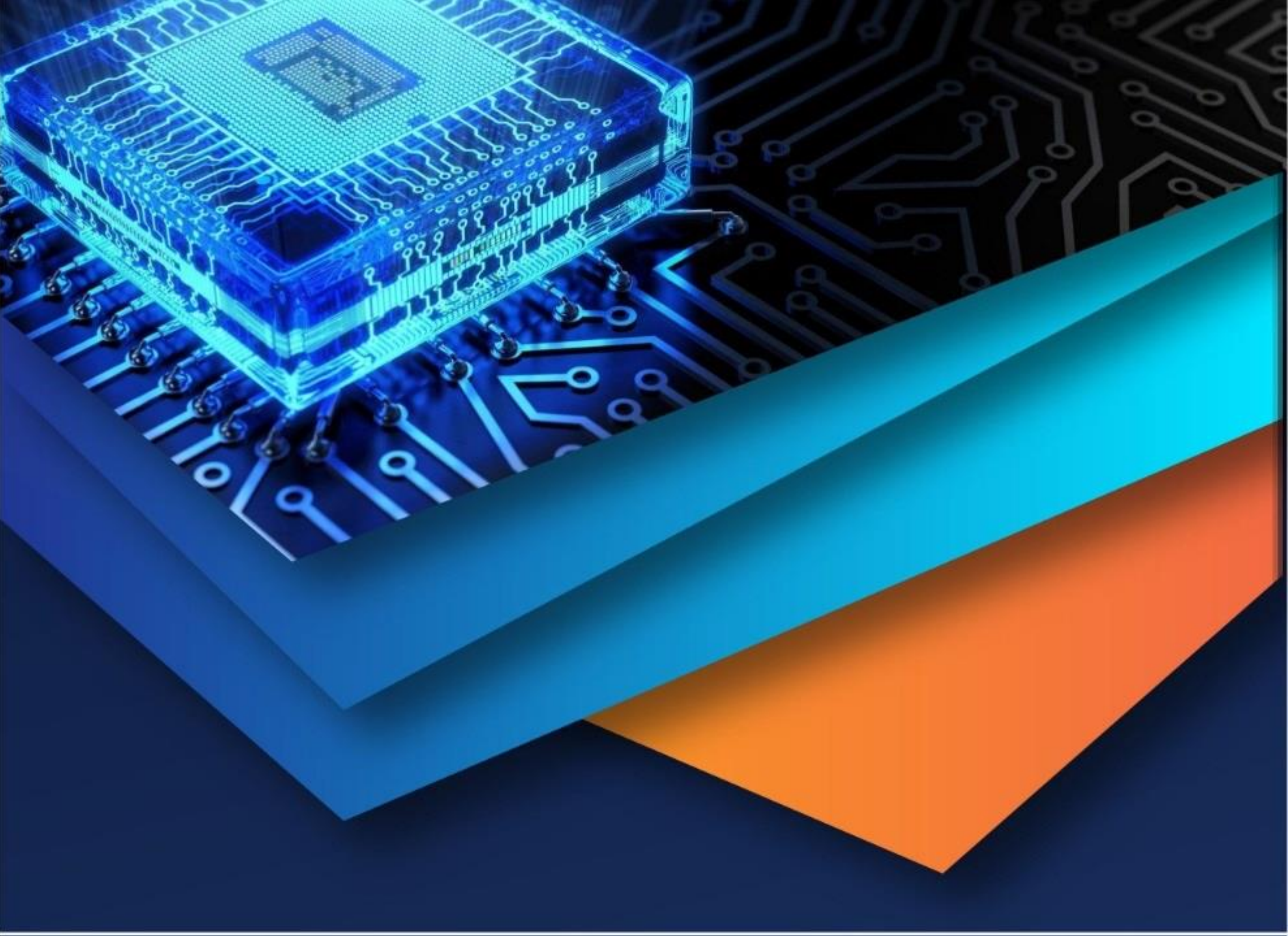

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