Safeguarding Viewers from Epileptic Triggers: Detecting Seizure Inducing Scenes in Videos

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Abstract

With the escalating consumption of digital media, the risk of exposure to seizure-inducing stimuli is a significant concern, particularly for individuals with photosensitive epilepsy. This paper introduces an innovative system designed to enhance digital media safety for individuals with photosensitive epilepsy. By integrating advanced computer vision algorithms with a user-friendly web interface, we have developed a method for real-time detection and mitigation of seizure-inducing stimuli in video content. Leveraging the capabilities of the Python library OpenCV, our system analyzes uploaded videos to detect luminance fluctuations that surpass the safe limits established by the Web Content Accessibility Guidelines (WCAG). Upon identification of potentially harmful scenes, the system offers users two tailored options: skipping the triggering segment entirely or viewing it in a modified grayscale format to reduce intensity while maintaining narrative continuity. These interventions are crucial for minimizing the risk of epilepsy-related incidents without compromising the viewer's engagement with the content. Our results show that this method effectively minimizes the risk of seizures triggered by flashing images and patterns, making digital spaces safer and more inclusive for all viewers, particularly those vulnerable to photosensitive epilepsy. This work not only advances the field of epilepsy safety but also contributes significantly to the broader discourse on digital accessibility and inclusivity.

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1. Introduction

In an era where digital content is ubiquitous, ensuring the safety of media consumption for individuals with photosensitive epilepsy (PSE) remains a pressing challenge. Photosensitive epilepsy, a condition where visual stimuli such as flashing lights can trigger seizures, affects an estimated 2% of the 65 million people living with epilepsy worldwide. Despite advancements in digital accessibility, certain media content still poses significant risks due to rapid flashes and patterns that are not preemptively moderated. While some content warnings exist, they are often too broad, failing to pinpoint the exact moments when sensitive viewers should avert their gaze or skip sections. Prompted by these challenges and inspired by insights from Professor Katy Siek at Indiana University, who emphasized the need for a localized solution capable of detecting and notifying users about specific strobing effects within digital media. Our work seeks to create a robust tool tailored for the detection and management of seizure-inducing stimuli in digital media. Leveraging state-of-the-art computer vision technologies, our system meticulously scans video content to identify and highlight segments that could potentially trigger seizures. Once these segments are flagged, our system offers two critical functionalities designed to empower users with photosensitivity: the ability to skip hazardous scenes or alternatively, to view them in safer formats such as grayscale or with reduced intensity. This dual-option approach not only enhances the accessibility of digital media but also allows individuals with photosensitivity to partake more fully and safely in digital media experiences. This initiative integrates the latest developments in image processing and adheres to established guidelines such as those set forth by the Web Content Accessibility Guidelines (WCAG). Our efforts aim not only to mitigate the risks associated with photosensitive triggers but also to broaden the inclusivity of digital environments, ensuring that media can be enjoyed safely by a more diverse audience. It stands as a testament to the application of technology in protecting and improving the quality of life for those with photosensitivity, addressing both the direct and indirect challenges they face in the digital age.

2. Background and Related Work

Historically, measures to protect against seizure-inducing content have revolved around guidelines like those proposed by the **Web Content Accessibility Guidelines (WCAG)**, which suggest limits on flashing frequencies. Research, such as that conducted by South et al. (2021) [1], has revealed the shortcomings of reliance solely on content creators for implementing these guidelines, indicating a need for consumer-driven protective systems that can operate independently of creator compliance. Furthermore, advancements in machine learning, as discussed by Usman et al. (2017) [3], have facilitated the prediction and detection of epileptic seizures from physiological data, suggesting potential crossover applications for video content.

We extend these methodologies to the realm of video media, using a combination of image processing techniques and user-centered design to dynamically identify and alter seizure-inducing content. Our approach is informed by a deep dive into current technologies and the latest academic research, ensuring that our solutions are grounded in proven scientific principles while innovating on their application.

3. Methodology

Embarking on the task of constructing a digital safeguard for individuals with photosensitive epilepsy, our initial plan was to utilize pre-existing datasets of videos known to contain seizure-inducing stimuli. However, we were met with the realization that such datasets were not readily accessible due to the ethical considerations and internet content regulations that govern the distribution of potentially harmful media. This obstacle catalyzed a shift in our strategy: we resolved to create our own repository of video clips that exemplified the seizure-inducing flashes we sought to detect and mitigate.

It involved an exhaustive search for video content across various social media platforms, such as WhatsApp, Instagram, and Reddit, to gather a diverse array of clips containing potential seizure triggers. Each selected video was carefully watched and time-stamped to document exact moments of seizure-inducing flashes. Through this, we assembled over 40 videos that were representative of the visual stimuli we aimed to detect with our tool.

Having established this database, we directed our focus toward the algorithmic intricacies required to discern and address the seizure-inducing content within these clips.

Frame Rate Acquisition: The second phase focused on the technical analysis, beginning with the frame rate acquisition of each video using the OpenCV library. Accurately capturing the fps was crucial, as it dictated the temporal resolution of our subsequent analysis.

Video Preprocessing: With the frame rate established, we proceeded to preprocess the video data. This step involved converting the RGB frames to grayscale, which is a critical simplification that reduces the complexity of the data while preserving the essential luminance information necessary for our analysis. This conversion facilitated a more streamlined computation of the luminance values for each frame, setting the stage for the application of our dynamic thresholding algorithm.

Dynamic Thresholding: We then employed a dynamic thresholding algorithm, which adjusted sensitivity based on the average luminance of each frame. This adaptive approach allowed us to minimize false positives while accurately identifying frames that posed a genuine risk.

Flash Prediction and Moving Window Mechanism: Central to our detection strategy was the predict_flashes function, which utilized dynamic thresholds to identify significant luminance changes. To optimize our flash detection, we incorporated a 'moving window' mechanism. This feature was crucial for managing sequences of closely occurring flashes, merging them into a single event when they fell within a predefined time window. This approach was designed to prevent the rapid toggling between modified and unmodified content, which itself could trigger photosensitive responses.

Visualization: To validate and refine our system's performance, we incorporated visualization techniques into our analysis. We crafted a plotting function that generated graphical representations of luminance changes throughout the video timeline. Detected flashes were clearly marked against the calculated dynamic threshold line, offering an intuitive visualization of the points at which the video content was flagged. This not only served as an internal tool for algorithm refinement but also provided a transparent rationale for our system's decisions, which could be communicated clearly to stakeholders.

API Development: The final phase of our methodology was the development of an API, shifting from a local user interface to a more scalable and accessible solution. Users are invited to upload their videos onto our platform, where our model processes the footage, assesses luminance values, and precisely detects the timings of seizure-inducing flashes, see Figure 5. This user-oriented API signifies a significant advancement in our project, extending the reach of our solution and ensuring a protective shield is cast over the digital viewing experience of our users.

By executing this multi-faceted approach, we were able to create an algorithm that was not just theoretically sound but also empirically validated. The end-to-end process, from frame rate acquisition to the visualization of our detection algorithm's output, encapsulated a thorough and meticulous journey to achieving our goal of detecting seizure-inducing stimuli with precision and reliability.

3.1. Flowchart

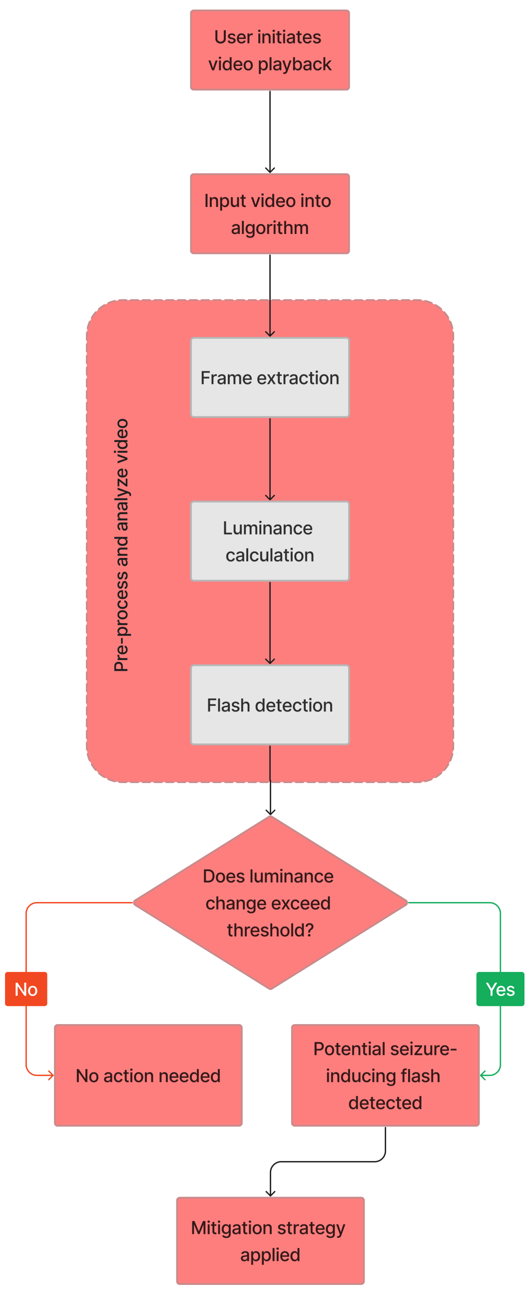


Figure1: Flowchart of our algorithm flow for detection and mitigation of potential triggers.

3.2. Graphs

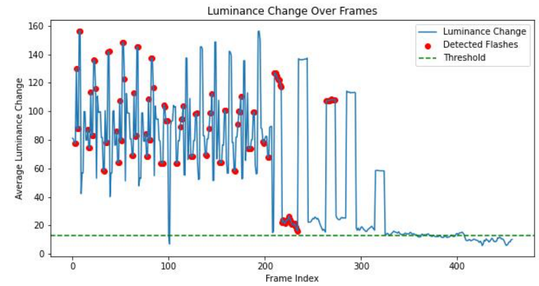


Figure 3(a)

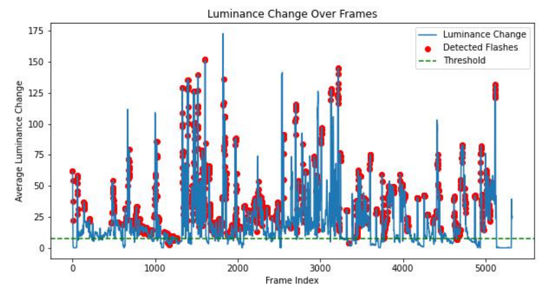


Figure 3(b)

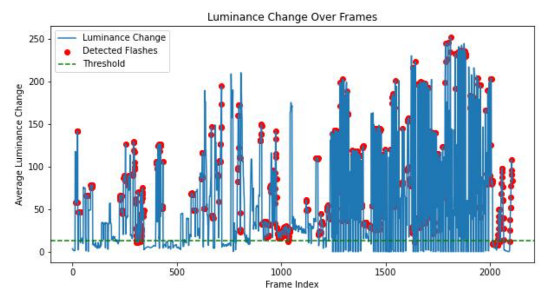


Figure 3(c)

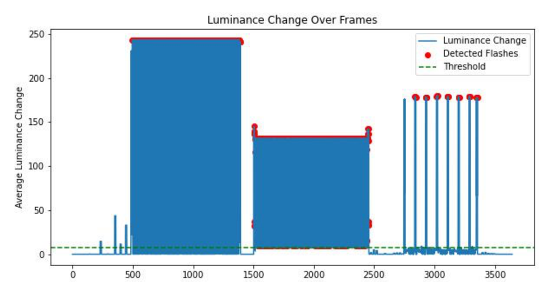


Figure 3(d)

Graph 3(a), 3(b), 3(c), 3(d) show Luminance Change Over Frames with Dynamic Threshold for some of the sample videos we have taken.

4. Results

To illustrate the practical impact of our seizure-inducing stimuli detection system, we present a series of before and after screenshots. These images serve as a visual testament to the algorithm's capability to identify and modify seizure-inducing content within digital media as shown in Figure 4(a) and 4(b).

Figure 4 (a): Before and After scene for popular Iron Man franchise

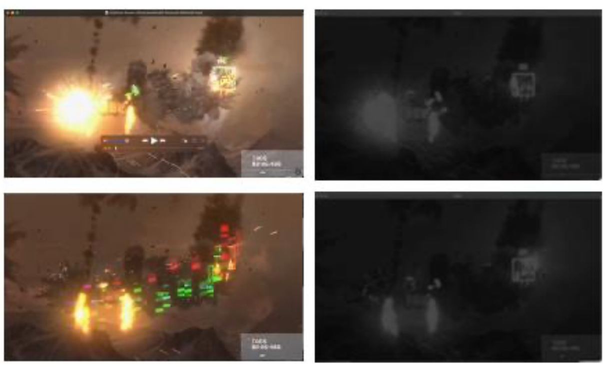
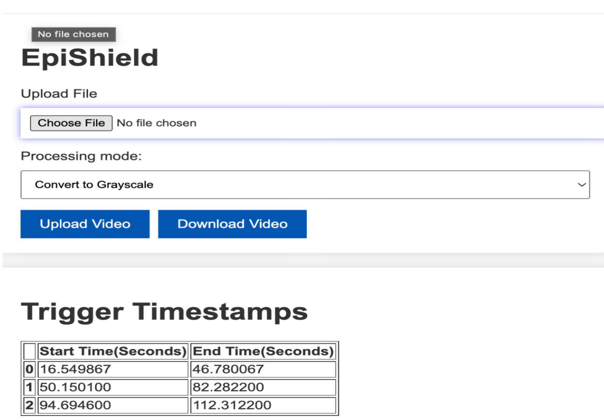


Figure 4 (b): Before and After scene for a video game sample.



	Start Time(Seconds)	End Time(Seconds)
0	16.549867	46.780067
1	50.150100	82.282200
2	94.694600	112.312200

Figure 5: EpiShield Interface and Seizure-Inducing Flash Detection Results

5. Discussion

Our research aimed to develop a system capable of detecting seizure-inducing stimuli in video content with high accuracy, thus providing a tool that enhances digital safety for individuals with photosensitive epilepsy. The results demonstrated that our system could successfully identify these stimuli in approximately 90% of our test cases, using our manually curated dataset. This high level of accuracy directly addresses our primary research question, confirming that it is feasible to detect and mitigate seizure-inducing flashes in video content using automated computer vision techniques combined with dynamic thresholding and a moving window mechanism.

The findings of our study contribute significantly to the broader field of digital accessibility and health. By demonstrating that automated systems can effectively identify seizure-inducing content, we provide a basis for further research and development in this area. Our work supports the ongoing efforts to make digital environments safer for all users, particularly those vulnerable to epilepsy. Moreover, the successful implementation of a moving window mechanism to manage the detection and presentation of problematic stimuli opens new avenues for developing more sophisticated, user-friendly systems that ensure continuous and dynamic adaptation to the viewer's needs.

The construction of the API represented a significant stride towards real-world application. By processing user-uploaded videos and returning the timing of detected flashes, the API provided a user-friendly platform for content analysis. Our tool’s performance in detecting and alerting users to seizure risks within these videos was robust, aligning with our goal to facilitate safer media consumption for individuals with PSE.

5.1. Limitations

Our dataset, while meticulously curated, is limited by its size and the diversity of content. Since it was manually assembled, it may not encompass all types of seizure-inducing visual patterns that can occur in wider media. Therefore, the system's effectiveness in real-world scenarios across a broader range of video content remains to be fully validated.

The accuracy of 90% was achieved on a dataset specifically designed and annotated for this project. While promising, these results might not generalize perfectly to all types of video content found across different platforms and media types. Further testing with more diverse and extensive datasets is needed to truly validate and refine the system.

Our system's performance depends significantly on the input video's frame rate and resolution. Variations in these parameters could potentially affect the detection accuracy, as the system was calibrated for the specific characteristics of our test dataset.

While the 'moving window' mechanism helps to smooth out transitions and reduce the risk of inducing seizures through rapid changes, it may also delay the application of protective measures slightly. This could be problematic in scenarios where extremely fast flashes occur.

6. Conclusion

Our endeavor to ensure safer digital media consumption has made commendable progress with the creation of an automated system and a versatile API that empowers users with photosensitivity to navigate digital content securely. Users can choose to skip seizure-inducing segments or view them in a protective grayscale mode and then download the adapted content, highlighting the convenience and user-centric nature of our system.

6.1. Contributions of the Project

We developed a sophisticated system utilizing advanced computer vision techniques, dynamic thresholding, and a moving window mechanism to accurately identify seizure-inducing flashes in video content.

Our team compiled a manually curated dataset from various digital media sources, filling a critical gap in available research resources and laying a solid foundation for the algorithm's development.

We introduced an API that not only allows users to upload and analyze videos but also provides them with options to skip detected seizure-inducing segments or watch them in a safer grayscale mode. Once processed, users can conveniently download the modified video, ensuring they can enjoy media content with an added layer of safety.

6.2. Potential Impact on Science and Society

The broader implications extend into both the scientific domain and societal well-being. It enhances the safety of online environments, particularly benefiting those vulnerable to epilepsy. By integrating this tool into the standard processes of digital content creation and distribution, we can promote a more inclusive approach to media production. Furthermore, this project enriches the academic and practical understanding of applying computer vision to address health-related challenges, fostering further innovation in digital health solutions.

7. Future Work

To build on the current work's successes, several enhancements and expansions are envisioned:

Broadening the dataset will improve the system's generalizability and ensure its efficacy across a wider range of media formats and visual triggers.

Implementing machine learning could refine the detection mechanisms, making them more adaptive and personalized based on diverse user experiences and feedback.

A significant aspiration for the project is the development of a browser extension that would offer real-time protection. This extension would analyze video streams, to predict and display warnings about upcoming seizure-inducing flashes within the content being viewed. Such a capability would allow individuals with epilepsy to engage with streaming services and broadcast media seamlessly, with the extension alerting them in advance to the presence of potential triggers.

Another one will be partnering with digital content creators and streaming platforms to embed this technology at the source could significantly reduce the prevalence of problematic content, streamlining the content consumption process without the need for user intervention.

References

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