Detection and Mitigation of Strobing Effects in Media for Photosensitive People

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A. Abstract

Our project addresses the pressing issue of photosensitive epilepsy (PSE) triggered by strobing effects in digital media content. The need for effective strategies for prevention is evident due to its severe consequences, which could sometimes be fatal. Our work introduces a comprehensive system that detects and mitigates strobing effects in various types of media content, focusing on real-time processing and integration into communication platforms like Slack. Leveraging Python and OpenCV, the system detects rapid changes in video brightness and color, identifying potential strobing intervals. Mitigation strategies include black and white conversion and frame averaging to reduce flash intensity, applied in real-time during video processing.

B. Introduction

Epilepsy affects around 65 million people globally, with 3% experiencing seizures triggered by specific visual stimuli, known as Photosensitive Epilepsy. Children and adolescents are more susceptible, with females affected more than males (60% vs. 40%) [6]. Encountering seizure-inducing patterns or light sequences can lead to severe consequences, including migraines or, in extreme cases, sudden unexpected death.

In a notorious Pokémon episode called "Dennō Senshi Porygon" (Cyber Soldier Porygon), Pikachu's Thunderbolt triggers chaos, causing seizures in Japanese viewers. Over 600 were hospitalized, prompting a global broadcast ban [7]. The episode aired once on December 16, 1997, and remains unseen since. In November 2019, hackers posted strobing GIFs from the official Epilepsy Foundation Twitter account, triggering seizures and migraines for numerous followers with photosensitivity [3]. Similarly, in May 2020, a coordinated attack targeted the Epilepsy Society, with six users sending triggering GIFs to associated accounts, including one strobing GIF sent as a reply to a tweet celebrating 263 days without a seizure [5]. In order to prevent malicious attacks, it is imperative that photosensitive risk detection systems be driven by consumer needs. They should proactively safeguard users while they browse online content.

Warnings are typically found in the beginning of media content, such as movies, TV shows, and video games. Previous work in this field proposes algorithms that alerts users about content that may cause photosensitive discomfort. There are systems in place which might aid the user in skipping the dangerous segments of the video. However, alternative solutions which neutralize the strobing content for safe viewing are few, such as PhotosensitivityPal.

We propose a comprehensive system that can not only detect strobing effects in various types of media content but also mitigate the effects to empower users to navigate it safely by integrating it into Slack channels.

C. Background and Related Work

C.1. Background

Photosensitive epilepsy is a condition where seizures are triggered by flickering lights or sharp contrasts between light and dark designs. While it's not overly common, it can be detected through an EEG test. Flashing or intricate patterns can cause sensations of disorientation, discomfort, or illness in individuals, whether they have epilepsy or not. However, experiencing these sensations doesn't necessarily confirm the presence of photosensitive epilepsy.

The common rates for triggering seizures range between 3 to 30 Hertz (flashes per second), although this can vary from person to person. While some individuals may be sensitive to frequencies up to 60 Hertz, sensitivity below 3 Hertz is uncommon. Geometric patterns with contrasting light and dark, like stripes or bars, can trigger sensitivity in some individuals. Dynamic patterns, changing direction or flashing, are more likely to provoke reactions compared to static or slow-moving ones [1].

A combination of frequency of the flash, brightness, contrast with background lighting, distance between the viewer and the light source, wavelength of the light, whether a person's eyes are open or closed can trigger a photosensitive reaction in individuals [2].

C.2. Related Work

An algorithm [4] for detecting flashing video content, following ITU-R Rec. BT.1702 guidelines, converts luminance to screen brightness using a lookup table method. Detection of luminance flashes involves analyzing average screen brightness per frame, variations between consecutive frames, and accumulated brightness changes, considering local extremes and flash characteristics such as intensity, evolution, duration, and luminance of frames.

"PhotosensitivityPal," [8] [9] a browser extension helps users with photosensitivity by scanning for and blocking potentially harmful content. This tool represents a consumer-driven approach to protection. The algorithm uses a rule-based approach to detect triggering sequences, making it well-suited for identifying flashes and red transitions.

PEAT, the Photosensitive Epilepsy Analysis Tool, automatically detects photosensitive risk factors in visual content like GIFs and videos, categorizing them as pass or fail. It identifies dangerous flashes and red transitions but doesn't detect dangerous repeated patterns [9].

Another system [10] detects potential epileptic seizure inducers in videos by analyzing characteristics such as high-frequency patterns, flashing lights, and contrasting colors. It involves processing the video frames to calculate luminosity levels, detecting brightness differences, and identifying flashing events based on frequency thresholds. The system then marks segments with potentially seizure-triggering content, allowing users to skip those intervals when viewing the video.

D. Methodology

D.1. Detection of Strobing Media Conditions

In our project, we implement the detection of strobing effects using Python. To process and analyze video data, we utilize OpenCV (Open Source Computer Vision Library), a highly optimized library specifically designed for real-time computer vision applications. This combination of Python and OpenCV allows us to efficiently process video frames, compute changes in pixel intensity, and identify periods of rapid changes indicative of strobing. The choice of these technologies ensures that our solution is both robust and scalable, suitable for handling various video formats and sizes while providing reliable strobing detection capabilities.

1) Frame Acquisition and Conversion: The video is processed frame by frame. Each frame is converted to grayscale, simplifying the computation by focusing solely on intensity values rather than color information. This conversion reduces computational complexity and focuses the analysis on luminance changes, which are crucial for detecting strobing.

2) Computing Frame Differences: For each frame, the absolute difference from its preceding frame is calculated using OpenCV's cv2.absdiff() function. This function computes the pixel-wise absolute difference between two images, which highlights areas of significant change in pixel intensity.

3) Thresholding Intensity Changes: The average of these differences is computed across the entire frame. This average represents the mean change in intensity between the two frames. A predefined threshold is set (default value is 15), and if the mean difference exceeds this threshold, it is indicative of a potential strobing effect. The threshold level determines the sensitivity of the detection, with a lower threshold increasing sensitivity.

4) Marking Strobing Intervals: The algorithm monitors when the intensity changes surpass the threshold to identify the start of a strobing effect. If subsequent frames continue to show significant differences above the threshold, the effect is considered ongoing. Once the intensity changes drop below the threshold, the end of the strobing effect is marked.

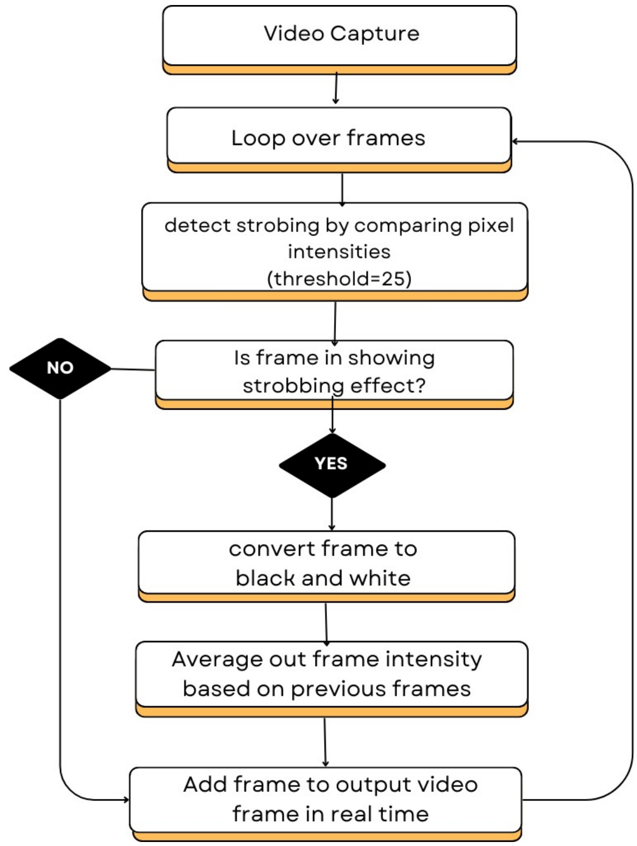

Figure 1. Algorithm Flow

5) Handling Consecutive Strobing Intervals: Consecutive frames that trigger the threshold are grouped into intervals representing continuous strobing effects. These intervals are further processed to merge close successive intervals into a single, prolonged strobing period. This merging is controlled by a 'gap threshold', which allows small fluctuations in intensity that briefly fall below the set threshold but do not significantly interrupt the overall strobing pattern.

6) Final Strobing Detection: The result of this process is a list of time intervals during which strobing effects are detected. Each interval is defined by its start and end times, calculated based on the video's frame rate. These intervals can then be used to apply corrective measures or analysis within the video.

D.2. Mitigation Strategy

Once the strobing effects are detected in the video content, our mitigation strategy is implemented through a series of steps designed to minimize the impact of these effects on viewers.

1) Conversion to Black and White: For frames that fall within the detected strobing intervals, we convert the color frames to black and white. This conversion significantly reduces the visual impact of strobing by eliminating the rapid changes in color, which are often more disturbing or disorienting than changes in brightness alone. This method is effective because it reduces the complexity of the visual content, focusing only on luminance and not chrominance.

2) Frame Averaging for Flash Reduction: In instances where a sudden flash (a significant, rapid increase in brightness) is detected, we apply a frame averaging technique. This technique involves blending the current frame with the previous frame using a weighted average, where each frame contributes equally to the output. This smoothing effect reduces the peak brightness of the flash, thereby mitigating its potential discomfort.

3) Video Frame Adjustment in Real-Time: The adjustments — converting to black and white and reducing flash intensity — are applied in real-time as the video is processed. Each frame is examined, and if it falls within a strobing interval or exhibits a sudden flash, the mitigation strategies are immediately applied.

4) Flexible Adjustment to Video Parameters: Our solution is designed to be flexible, allowing adjustments to the sensitivity of strobing detection and the strength of mitigation techniques. Parameters such as the threshold for detecting intensity changes and the gap threshold for interval merging can be fine-tuned based on the specific requirements or viewer sensitivities.

5) Outputting the Processed Video: After applying the necessary adjustments, the processed frames are compiled back into a video stream. This modified video stream is then saved to a file, ensuring that all mitigated frames are seamlessly integrated, maintaining the continuity and flow of the video content.

Additionally, the system has been designed to operate in real-time, which is crucial for environments where immediate video processing is necessary to ensure viewer safety. This real-time functionality allows the system to analyze and adjust video content dynamically as it is being viewed.

D.3. Integration with Slack Bot

In order to ensure the accessibility of our algorithm to the general public, we recognized the need for a user-friendly interface. To address this, we integrated our algorithm with Slack, a widely used communication platform, by developing a Slack bot named Photosensitive Bot.

The Photosensitive Bot serves as a pivotal tool within Slack channels, providing real-time detection and mitigation of photosensitive content in videos shared by users. Upon integration, the bot is seamlessly added to any Slack channel where it actively monitors incoming media content. When a user uploads a video, the bot promptly processes the content, scanning for potentially harmful photosensitive elements. If such content is detected, the bot automatically applies mitigation measures to ensure the safety of viewers. Subsequently, the modified video is reuploaded to the channel, accompanied by an alert notifying users of the content alteration.

Additionally, we recognized that people have different preferences and requirements, so we added extra features to make our algorithm more flexible. Users can set parameters like threshold levels and frames to skip when sharing videos. This personalized control allows people to tailor the mitigation process according to their individual needs and preferences, ultimately improving the overall user experience.

To make the Slack bot work, we used Slack's Software Development Kit (SDK), which integrates smoothly with Slack's functions. We developed an event trigger mechanism based on Slack's API, so the bot can efficiently process incoming messages and respond in real-time. Furthermore, to connect the Slack API with our local server, we used ngrok to create a forwarding gateway. This allowed message details to smoothly transfer from Slack channels to our server, ensuring the bot worked without interruption.

E. Result

E.1. Input and Output Video Analysis

Input Video: The input video (an example frame shown in Figure 2) provided for processing, serves as the raw footage upon which the strobing effect detection and mitigation strategies are applied. This video contains sequences that include rapid changes in brightness and color, which are identified as strobing effects. These effects can be disruptive or harmful to viewers, particularly those with photosensitive conditions. The original video captures various scenes that will be analyzed to detect any such effects.

Output Video: The output video (the processed example frame of the input frame in Figure 2 is shown in Figure 3)is the result of applying the strobing mitigation strategies described in the project. Using the code, this video has been processed to reduce the impact of detected strobing through two primary interventions:

1) Black and White Conversion: Frames identified within the strobing intervals are converted to black and white to minimize the intense color fluctuations that contribute to the strobing effect.

2) Flash Reduction via Frame Averaging: Frames that exhibit sudden, significant increases in brightness are adjusted by averaging them with previous frames to soften the brightness peaks and reduce the sharpness of the flash effects.

The output video thus represents a safer version of the original, with reduced strobing effects, making it more suit-

Figure 2. Input Video (Source: Pokémon Episode [Dennō Senshi Porygon] (used for informational purposes))

Figure 3. Output Video

able for all audiences, including those who are sensitive to such visual triggers. This processed video ensures that the viewer's experience is less likely to cause discomfort or adverse reactions, maintaining the integrity of the visual content while enhancing viewer safety.

E.2. Comparative Analysis of Pre and Post-Processed Videos

Input Video Graph Analysis: The graph associated with the input video illustrates the intensity fluctuations over time, where the X-axis represents the timeframe of the video, and the Y-axis indicates the intensity levels of the frames. Sharp spikes in the graph as shown in Figure 4 suggest rapid changes in intensity, characteristic of strobing effects. These peaks and valleys correlate with the potential strobing moments where the brightness of the video increases or decreases significantly, which can be problematic for viewers with photosensitive epilepsy or similar conditions.

Output Video Graph Analysis: The graph for the output video as shown in Figure 5 displays a noticeably smoother intensity profile over the same timeframe, indicative of successful mitigation. The sharp peaks seen in the input video graph have been leveled out, reflecting the application of the black and white filter and the frame averaging tech-

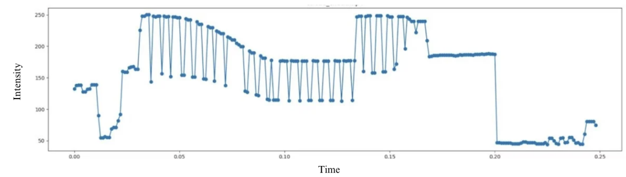

Figure 4. Input Video - Time vs Pixel Intensity Graph

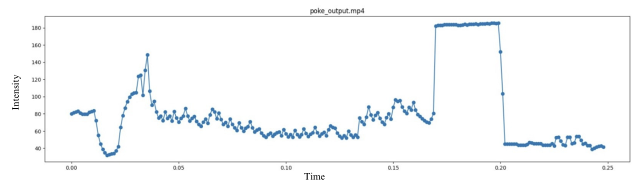

Figure 5. Output Video - Time vs Pixel Intensity Graph

nique used to reduce flash intensity. The absence of intense fluctuations demonstrates the effectiveness of the processing in stabilizing the intensity throughout the video, thereby reducing the risk of adverse reactions from strobing content. This graph visually confirms that the applied techniques have moderated the intensity variations to create a safer viewing experience.

E.3. Metrics

To evaluate the efficacy of our system in detecting strobing effects, we conducted a comprehensive analysis using a dataset of 20 different videos. Each video was processed through our system, which identified and timestamped sequences where strobing effects were detected.

To ensure the accuracy of our system, these automatically detected timestamps were then meticulously compared against a set of control timestamps, which were established through manual observation and recording of each video. This comparative analysis revealed that our system achieved an impressive detection accuracy of approximately 96%.

Additionally, we observed exceptional performance in terms of speed and responsiveness, processing an average of 88.2 frames per second in real-time with less than a millisecond in latency. This high level of precision and efficiency underscores the reliability of our algorithm in identifying strobing effects across a diverse range of video content, ensuring minimal disruption to the viewing experience.

E.4. Slack Bot

Upon integration of the Photosensitive Bot with Slack, we conducted a series of tests to evaluate the effectiveness and responsiveness of the system. To assess the real-time capabilities of the Photosensitive Bot, we shared a variety of media content, including both normal and photosensitive

Figure 6. Input message containing harmful video content

Figure 7. Slack Bot which processed the harmful content in real time and outputs the processed content for safe viewing

videos, within Slack channels. Upon detection of photosensitive content, the bot promptly responded with alerts, notifying users of the potential risks associated with the shared videos. Subsequently, the bot successfully applied mitigation measures to rectify the problematic content, ensuring the safety of viewers.

In order to accommodate users' preferences for custom threshold values, we implemented a basic functionality allowing users to specify parameters such as threshold levels and frames to skip when sharing videos. To streamline the process, we opted to utilize JSON format for passing custom parameters, avoiding the complexity associated with Natural Language Processing (NLP) techniques since our main focus is on Video and not parsing the message. By the provided parameters we were able to run our algorithm based on it and return the processed video. As we can see in Figure 6 where a user shares a video in one of the channels and the Photosensitive Bot promptly responds with an alert and rectified version of the video(Figure 7).

F. Discussion

Our project addresses photosensitive epilepsy triggered by strobing effects in digital media content, offering a comprehensive system for detection and mitigation. Using Python and OpenCV, our algorithm identifies rapid changes in video brightness and color, implementing real-time processing and integration into communication platforms like Slack.

The methodology involves frame acquisition, intensity change computation, and strobing interval marking. Mitigation strategies include black and white conversion and frame averaging. Evaluation on a dataset of 20 videos showed a detection accuracy of approximately 96%, with real-time processing speed averaging 88.2 frames per second. Integration with Slack Bot enhances online accessibility.

While the system shows promise in enhancing viewer safety, limitations may include sensitivity to parameter tuning and the need for broader platform integration for widespread impact. The system may struggle to detect and mitigate strobing effects that involve novel patterns or unconventional visual stimuli not covered by the existing algorithms. Continuous updates and refinements to the detection and mitigation techniques may be necessary to address emerging challenges.

G. Conclusion

This project represents a significant advancement in the field of digital media processing, focusing on the detection and mitigation of strobing effects in video content. Through the innovative use of Python and OpenCV, we have developed a system capable of identifying rapid changes in video brightness and color, which are indicative of potentially harmful strobing effects. The subsequent mitigation strategies, which convert affected frames to black and white and apply frame averaging to reduce flash intensity, effectively minimize the risks associated with these strobing effects.

Currently, there is a notable absence of widely available tools that address the detection and mitigation of strobing effects, which poses a risk to individuals sensitive to such visual stimuli. The integration of our project into a Slack bot is pioneering in this area, as no similar mitigation process is publicly available, especially in a form that could be easily accessed by the general public or integrated into existing video platforms.

Additionally, our system is designed to run in real-time, processing input content immediately and allowing users to view the mitigated video without any delay. This real-time capability significantly enhances the user experience by providing instant results, making it practical for live streaming and real-time video modification.

The potential impact of this project is expansive, spanning across diverse industries and reshaping the landscape of video content consumption. By offering safer viewing options, our technology holds the potential to profoundly benefit individuals with photosensitive epilepsy or similar conditions in the medical field, while also bolstering player safety in the gaming industry by mitigating the risk of seizures or adverse reactions to rapid visual effects.

Furthermore, with the integration of our project's techniques into video streaming platforms, digital cinemas, and television broadcasts, there lies the opportunity to establish a universally safer environment for video content consumption. This integration not only fosters inclusivity but also transcends industry boundaries, contributing to a more accessible digital media landscape. As our technology becomes embedded in these platforms, continuous research and development will drive the refinement of advanced computer vision techniques, ensuring the ongoing enhancement of strobing detection and mitigation. This adaptability positions our project to tackle emerging challenges as video content and display technologies evolve over time. Ultimately, the widespread application and continual advancement of our project promise to significantly enhance the production, consumption, and enjoyment of videos, guaranteeing a safer viewing experience for global audiences.

Looking to the future, there are several avenues for continued development and expansion of this project. One immediate goal is to transform our strobing effect mitigation system into a Chrome extension, making it readily accessible to the general public. This would allow users to automatically process and adjust videos directly within their web browsers, greatly expanding the tool's usability and reach.

In conclusion, our project not only fills a critical gap in digital media safety but also sets a foundation for future innovations that could protect and enhance the visual experience of users worldwide.

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