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DETERMINING DRAMATIC INTENSIFICATION VIA FLASHING LIGHTS IN MOVIES

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ABSTRACT

Movie directors and producers worldwide, in their quest to narrate a good story that warrants repeated audience viewing, use many cinematic elements to intensify and clarify the viewing experience. One such element that directors manipulate is lighting. In this paper we examine one aspect of lighting, namely flashing lights, and its role as an intensifier of dramatic effects in film. We present an algorithm for robust extraction of flashing lights and a simple mechanism to group detected flashing lights into flashing light scenes and analyze the role of these segments in story narration. In addition, we demonstrate how flashing lights detection can improve the performance of shot-based video segmentation. Experiments on a number of video sequences extracted from real movies yields good results. Our technique detects 90.4% of flashing lights. The detected flashing lights correctly eliminates 92.7% of false cuts in these sequences. In addition, data support is compiled to demonstrate the association between flashing light scenes and certain dramatic intensification events such as supernatural power, crisis or excitement.

1. INTRODUCTION

Research in multimedia content processing and annotation has concentrated on analyzing visual and aural features to either segment a video stream into shots, sequences etc., or build descriptions of what the content depicts in terms of events and happenings in the video. The underlying approach directing this analysis is to find the syntactic properties of video data. Our work departs from this direction, and focuses on understanding the stylistic elements incorporated by directors and producers to manipulate form and to convey unvoiced meanings. We propose that a study of these elements allows us to annotate and analyze movies and videos in both a novel and meaningful way.

One important high level descriptive element of video and motion pictures is mood. Mood is a complex concept and is induced by manipulating colour, music, dialogue, lighting and so on. While these cinematic devices play a complex role in endowing a certain mood, there are some specific techniques that are used in film to intensify a mood. Lighting is one such device, and is often used to set a mood. Lighting adds to the atmosphere and helps build it up. For example, a mood can be set by using high or low key lighting. Shadows and harsh lighting create emotional responses related to horror, whilst romantic heroines are often back-lit. According to Sobchack and Sobchack [5], soft lighting elicits a feeling of warmth and harsh lighting makes images forbidding. However, in other cases, as pointed out by Zettl [9], lighting can be used as a "dramatic agent". Light can be used as an "element that operates as an important aesthetic intensifier" in a scene. This is often done by revealing the light source itself, which amplifies how a scene is perceived. Examples include flashing lights at concerts, on police cars, etc. These flashing lights are often used by directors to amplify a crisis situation, intensify excitement, increase a sense of foreboding or indicate the presence of a supernatural power.

The problem of flashing light detection has been addressed in [1], [2], [6] and [8]. The algorithm described in [1] is reported to be robust, but expensive since it is based on pixel tracking. However, we find the flashing light model discussed in these papers to be inadequate and accounting for only a small portion of flashing light in motion pictures. The algorithm presented in [8] detects flashing lights based on the presence of two close maxima in frame differences which differ greatly from the average of remaining difference within a sliding window. This will result in missed flashing lights if there is more than one flashing light present in the same sliding window or the flashing lights presented are gradual. Both [2] and [6] focus on computing the high correlation between frames before and after a flashing light, assuming that the length of a flashing light is less than 2 frames, which is often not the case. In addition, explosion detection using visual features is related to flashing light detection and is investigated in [3] [4].

In this paper, we focus our attention on the extraction of scenes with flashing lights, and examine the nature of this effect to intensify dramatic narratives. Our premise is that flashing lights that persist temporally must be inserted specifically to heighten the viewing experience. The layout of the paper is a follows: Section 2 outlines a computational model for flashing lights and the detection procedure based on this model. Section 3 shows the experimental results including the performance of the flashing light detection technique, the improvement of cut detection by incorporating this algorithm and the data support for the association between different types of dramatic intensification and flashing light scenes. The conclusions are presented in Section 5.

2. A COMPUTATIONAL MODEL FOR FLASHING LIGHT DETECTION

The mechanism to identify flashing lights is based on determining and measuring a substantial global change in the luminance of a frame. A flashing light starts with an increase in luminance, followed by a period of constant high luminance and ends with a decrease in luminance. Figure 1 depicts this model. A flash therefore can be identified by a triplet $\{\mathbf{s}, \mathbf{e}, \mathbf{p}\}$, with $\mathbf{s}$ and $\mathbf{e}$ being the first and last frame of that flashing light, and $\mathbf{p}$ the frame index

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where a maximum in the luminance occurs.

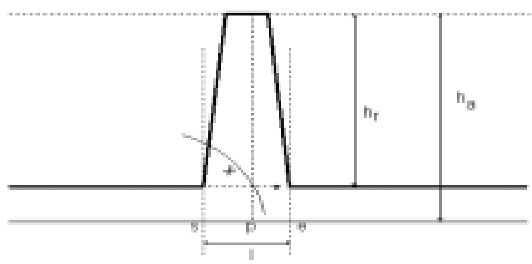

Figure 1: A flashing light model.

Different patterns of flashing light occurrences are depicted in Figure 2. These were extracted from 3 motion pictures: *Chameleon* [frames 0-120]; *12 Monkeys* [frames 130-220]; and *Matrix* [frames 230-300]. The first three flashing lights occurring at frames 27, 62, and 100 are gradual and weak, and rather dark, while the 4^{th} and 6^{th} flashing lights at frames 150 and 215 respectively are long, hard, strong and bright. The 5^{th} flashing light around frame 200 is short, strong, bright and hard, whilst the last 3 flashing lights at frames 271, 277 and 285 are short, weak, and very dark.

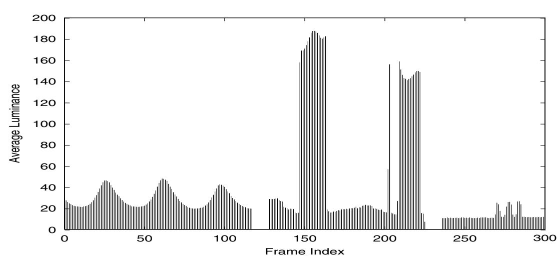

Figure 2: Average frame luminance in sample scenes with flashing lights.

Our model takes into account the following five attributes of a flashing light, not all of which are totally independent. All, except for the last attribute, can be computed from the average frame luminance:

Length The duration from the first increase in luminance to the last decrease in luminance, i.e., $l = \mathbf{e} - \mathbf{s} - 1$ in Figure 1. The shortest flash has a duration of 1 frame, and generally a flash is not very long. We therefore can set an upper-bound, $\mathcal{T}_L$ on the length of a flash. Higher values of $\mathcal{T}_L$ will allow the detection of long gradual flashing lights.

Strength The relative drop in luminance, h_r, from its peak to both ends of a flash, $h_r = min\{\mathcal{F}^\mu_{\mathbf{p}} - \mathcal{F}^\mu_{\mathbf{s}}, \mathcal{F}^\mu_{\mathbf{p}} - \mathcal{F}^\mu_{\mathbf{e}}\}$, where $\mathcal{F}^\mu_i$ is the average luminance of frame i. A strong flashing light features a significant increase/decrease in luminance while a weaker flashing light shows a subtle increase/decrease. A threshold for the lower bound on h_r, $\mathcal{T}_S$, will determine the inclusion of weaker flashes and also affect the number of false positives caused by motion.

Brightness The average luminance of the flashing light at its peak, h_a. A brighter flashing light is more noticeable than a darker one. We have, $h_a = \mathcal{F}^\mu_{\mathbf{p}}$. Often, a strong flashing light is bright. Higher values for h_a will reduce the false positive detection, but miss darker flashes. We denote the threshold for the lower-bound on the brightness of detected flashes as $\mathcal{T}_B$.

Velocity The rate of increase/decrease in average luminance of frames during the beginning and the end of a flash, x. This will determine whether a flash is gradual or instantaneous. x can be approximated as: $min\{\mathcal{F}^\mu_{\mathbf{s}+1} - \mathcal{F}^\mu_{\mathbf{s}}, \mathcal{F}^\mu_{\mathbf{e}} - \mathcal{F}^\mu_{\mathbf{e}-1}\}$.

Impact The area of the frame influenced by the flashing lights. The increase in luminance can take place in a large or small area of the frame. It is obvious that a large impact flash would have a higher **Velocity** than a small one. We compute this feature as follows. Let $\mathcal{D}^+_i$ be the proportion of pixels having luminance increased by more than $\mathcal{T}^*$ across frame i and $i+1$. Similarly, $\mathcal{D}^-_i$ is the proportion of pixels having luminance decreased by more than $\mathcal{T}^*$ across frame i and $i+1$. In our implementation, we set $T^* = 3$. The impact of a flash can be approximated as $min\{\mathcal{D}^+_s, \mathcal{D}^-_{e-1}\}$. Generally, a lower-bound threshold $\mathcal{T}_I$ can be set on **Impact** attribute for the whole luminance change durations of a flash. Thus, if i is a frame in the luminance increase duration, $\mathcal{D}^+_i > \mathcal{T}_I$. Additionally, we check $\mathcal{D}^-_i < \mathcal{T}_{I^*}$, with $\mathcal{T}_{I^*}$ being a pre-selected threshold, to eliminate motion effects.

From the model described above, we outline the algorithm for flashing light detection:

Step 1: Mark all frames where **Velocity** and **Impact** exceed thresholds. These frames can be classified as *start* or *end* depending on whether they belong to the duration of increase or decrease in frame average luminance.

Step 2: For all consecutive frames marked *start*, which would be caused by gradual flashing lights, we retain the rightmost one and consider it as the start of the flash. Similarly, we keep only the leftmost *end* frames for all consecutive *end* frames.

Step 3: Potential flashes are determined by pairs of *start* and *end* marks with no other marks in between. The frame with the highest average luminance between every pair of potential flashes is considered as the peak of that flash.

Step 4: All potential flashes not satisfying constraints on **Length**, **Strength** or **Brightness** are eliminated.

2.1. Experimental Results

The test data sequences are extracted from movies including *The Matrix*, *Sleepy Hollow*, *Chameleon*, *Titanic*, *12 Monkeys*, *Truman show*, *The Rock*, and *Tall Tales*. They have a total length of around 1 hour at 25 fps and contain 1656 flashing lights, which are manually labeled.

For our algorithm to be effective, the set of thresholds $\{ \mathcal{T}_L, \mathcal{T}_B, \mathcal{T}_S, \mathcal{T}_I, \mathcal{T}_V \}$ need to be chosen appropriately. A good set of values should facilitate high detection rate and low error rate. In addition, varying one of the parameters, keeping other parameters intact, the gain in detection starts to fall behind the increase in the error rate. We empirically work out that $\{\mathcal{T}_L = 17, \mathcal{T}_B = 28, \mathcal{T}_S = 10, \mathcal{T}_I = 0.3, \mathcal{T}_V = 2.0\}$ is a parameter set roughly satisfying such conditions. Figure 3 shows the rate of correct detection vs the error rate, when we alter each parameter over a certain

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range. In this figure, the performance for the selected parameter set is shown at the intersection of five parameter lines. Each of these lines are formed by varying one parameter while keeping the other four intact. Using this set, our algorithm detects 90.4% of flashing lights and has an error rate of 3.3%.

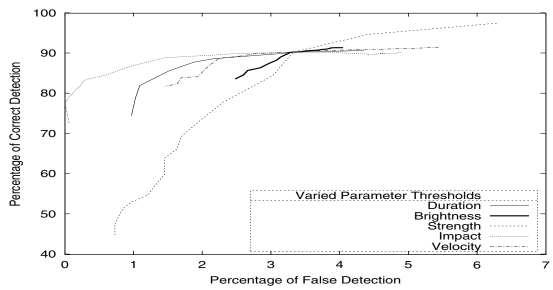

Figure 3: Performance of the flashing light detection technique with various parameter sets.

3. IMPROVING SHOT SEGMENTATION WITH FLASHING LIGHT DETECTION

The performance of cut detection techniques often suffers from the presence of flashing lighting effects, since they result in sharp peaks in the frame difference curve, which tends to be the basis for most cut detection algorithms. We consider a detected cut transition as a false positive due to flashing light presence, if there is a flashing light determined by our algorithm whose temporal window overlaps with that of the cut. Unfortunately, this may lead to eliminating some true cuts, owing to any false positives in the flash light detection, or due to the detection of the flash lights offset by a few frames. If the peak of a flashing light happens immediately after the cut (rather common in *Sleepy Hollow*) the last frame of the previous shot would be mistaken as the start of the flash. There are also false cuts that do not interfere with any flashing lights, due to misses in flashing light detection or motion effects.

Using our cut detection algorithm described in [7], without any post processing or verification of results, we manually identified 740 falsely determined cuts. Figure 4 shows the results of correct elimination of false cuts against their incorrect elimination for various parameter sets as discussed above. The pattern is rather similar to the performance of flashing light detection. For the default parameter set (i.e., at the intersection of plotted lines), 92.7% of false cuts was correctly eliminated. The technique has an error rate of 6.1%. Overall the default parameter set performs well, since it lies on the rather horizontal slope of all five parameter lines shown in figure 4, which suggests again that correct elimination is giving way to an increase in error.

4. FLASHING LIGHT SCENES AND DRAMA INTENSIFICATION

While the detection of flashing lights can be used to improve the accuracy of shot segmentation, a more important aspect of their detection is to enable a study of their roles as expressive elements in motion pictures. In an analysis of 21 movies, we found 15 movies

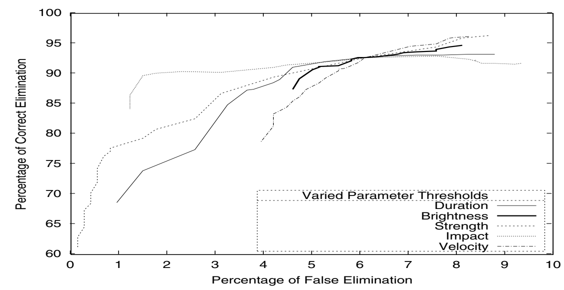

Figure 4: Performance of false cut elimination technique with various parameter sets.

where flashing lights were used to enhance the emotional experience by the viewer.

We identify the following dramatic effects that are intensified with the use of flashing lights:

A Supernatural power and influence (e.g. Headless Horseman killing scenes in *Sleepy Hollow*).

B Crisis in situation (e.g. Sinking ship scene in *Titanic*)

C Terror, fear and unsettled atmosphere(e.g. The train station scenes in *Mimic*).

D Excitement and joy (e.g. The night club scene in *Armageddon*)

E The importance of an event, especially media photographers related (e.g. the court scene in *Hacker*).

However, it should be noted that more than one of these effects could be present in the same scene. For example, the sense of terror and fear could result from a crisis or supernatural power.

Generally, flashing lights do not occur in isolation but as a burst over a whole scene or part of the scene where certain meanings are conveyed. These segments are called flashing light scenes, and comprised of consecutive shots where flashing lights occurs. In order to determine drama intensification using flashing lights, it is more useful to work on flashing light scenes as a whole rather than individual flashing lights. A simple mechanism can be used to determine these flashing light scenes: We define the *flashing light level* of a shot as the number of flashing lights overlapping with the shot normalized by the length of the shot. Thus for shots with no flashing light, their flashing light level is zero. In addition, the flashing light levels of shots with false flashing lights is still low comparing to those with real flashing lights, due to the "burst" nature of flashing light effects. A shot is considered as the start of a flashing light scene if its flashing light level is greater than a value $\mathcal{T}_1$ and it is the first shot satisfying that condition or the flashing light levels of the next $\mathcal{T}_2$ shots are below $\mathcal{T}_1$. Similarly, a shot is identified as the end of a flashing light scenes, if it has flashing light level greater than $\mathcal{T}_1$ and it is the last such shot or the next $\mathcal{T}_2$ shots have flashing light levels less than $\mathcal{T}_1$. Moreover, we eliminate all short flashing light scenes containing less than 3 shots. In our implementation, we set $\mathcal{T}_1 = 0.05$ and $\mathcal{T}_2 = 20$.

4.1. Experimental Results

Figure 5 shows the flashing light levels for the first half of *Sleepy Hollow* movie together with flashing light scene boundaries. The

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manual annotations of the story unfolding in flashing light scenes are presented in Table 1.

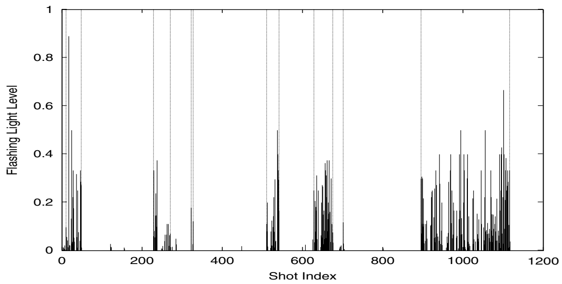

Figure 5: Flashing light based segmentation of Sleepy Hollow.

Table 1: Annotation of flashing light scenes in Sleepy Hollow.

Start	End	Effects	Description
11	49	**A**, **B**, **D**	Headless horseman murders Peter Van Garrett and his son.
229	271	**B**,**D**	The horseman in battle.
323	328	**A**, **B**, **D**	Headless horseman murders Jonathan Masbath.
511	542	**A**,**D**	Crane's first dream.
626	649	**A**,**B**,**D**	Headless horseman murders Magistrate Samuel Philipse.
700	702	**A**,**D**	Crane's second dream.
896	1117	**A**, **B**, **D**	Headless horseman murders Killian family.

Table 2 shows the results of flashing light scene segmentation for 21 different movies belonging to various genres such as action, horror, sci-fi, drama, comedy, and film-noir. We also manually label the type of drama intensification, possibly multiple labels sometimes, in all flashing light scenes. A large portion of flashing light scenes convey the sense of fear and unsettled (**C**), while the number of flashing light scenes to enhance the media attention aspect of an event or to indicate the atmosphere of joy and excitement (**D**, **E**) are few. In addition, two flashing light scenes are missed. One is due to the fact that flashing lights occur in only one single shot, while the other is caused by merging of two consecutive, but semantically unrelated scenes, both containing flashing lights, into one single flashing light scene. On the other hand, high motion sequences cause 9 false flashing light scenes.

Table 2: Accuracy of detection of flashing light sequences in movies.

Categories	**A**	**B**	**C**	**D**	**E**	Total
Correct	26	46	69	8	4	86
False	-	-	-	-	-	9
Miss	0	0	0	2	0	2

4.2. Discussion

We alsoobserve that the colour of a flashing light influences the type and level of emotion it enhances. Bright, hard flashing lights with blue as main color component would effectively convey the sense of supernatural power as well as the terror felt by characters. Red and orange, and sometime soft and gradual, flashing lights are often associated with signs of danger and warnings of fire and explosions.

With the sound track, the environmental sound at a high volume normally accompanies flashing lights to enhance the perception of a situational crisis and the demonstration of supernatural power. A crisis related to the emotions of characters without any immediate crisis in the situation would be effectively enhanced by using instrumental music. The joy and excitement of flashing lights, e.g., night clubs, can be further enhanced by fast-beat music, while the enhancement of media-significant events due to camera flashes would be accompanied by sounds of camera shooting.

5. CONCLUSION

In this paper, we investigate a lighting technique used by directors to intensify the drama of certain scenes in a movie. We propose a robust algorithm for detecting flashing lights and also examine how flashing light detection could help improve cut detection. In order to allow high-level access to media content, flashing lights are grouped into flashing light scenes. Experiments on a number of movies yields good results with our technique. We present data supports for the association between flashing light scenes and five aspects of dramatic identification including supernatural power, crisis, terror, excitement and the media importance of an event.

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