Bachelor's Thesis

Temporal Artefact Mitigation in Rolling Shutter Videography

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1. Introduction

Rolling shutter cameras often suffer from distortions when capturing fast-moving objects or flashing light sources, such as LED or strobing IR-lights. These distortions occur due to the rolling shutter effect which is a result of the sensor reading the pixels in the image row by row. An issue was discovered that afflicted existing Axis cameras in the form of a band that move across the image due to strobing IR-lights. With the rise of global shutter cameras comes the use of strobing IR-illumination to increase image quality and reduce energy consumption.

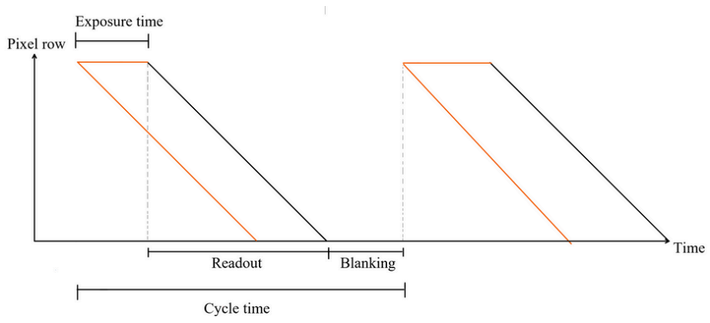

Figure 1: Exposure diagram of a rolling shutter camera.

Figure 2: An example of the strobe artefact.

2. Background

This issue was recognized by our supervisor and his department at Axis. A proof-of-concept solution was developed to verify the possibility of addressing the issue in software. They developed algorithms that detected the artefact, synchronized the camera's framerate to the strobe's frequency, and applied a delay to the exposure window.

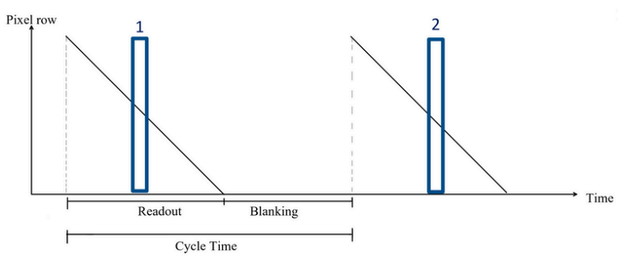

Figure 3: Exposure diagram of a rolling shutter camera with a stabilized artefact.

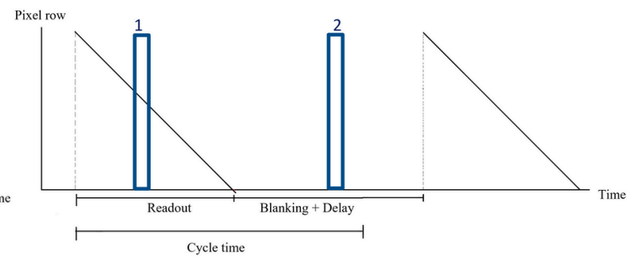

Figure 4: Exposure diagram of a rolling shutter camera with artefact eliminated.

3. Goals

- **Software Development:**
  - Improve the strobe artefact detection algorithm.
  - Develop a method to keep this artefact out of the frame after elimination.
- **Environmental Testing:**
  - Test the algorithms in both laboratory and real world environments to verify reliability and effectiveness.

4. Method

Our algorithm improved the existing solution in a number of ways. Firstly statistics was used to determine the background which to compare subsequent frames against. This led to a more reliable detection, with few false positives.

Secondly, we implemented adaptive thresholds based on the strobe artefact's peak intensity and the noise level in the image. This made our solution automatically adjust to lighting conditions without any manual input. In addition to these improvements, we've applied noise reducing filters to reduce the risk of detecting false positives even further.

Thirdly, the main improvement in our algorithm is a method called Maintain Delay. Here, the top and bottom row of the image is monitored for the reapperance of the artefact. When the artefact eventually reapperas due to a discretized framerate, a threshold is exceeded and the exposure is delayed again, resulting in a clear image.

Finally, to ensure reliability, we've implemented checks to detect changes in the background which update the appropriate values in order to adapt to environmental changes.

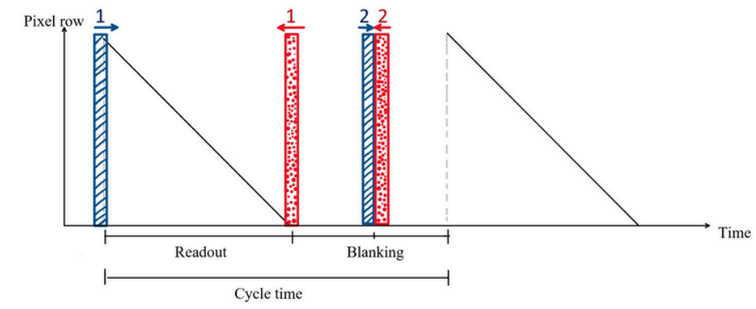

Figure 5: Exposure diagram visualizing how the Maintain Delay method keeps the artefact out of frame.

Figure 6: Flowchart visualizing our solution.

Figure 7: Strobe artefact present in the top of frame.

Figure 8: Delay applied.

5. Results

We have developed an algorithm that reliably detects a strobe artefact, even under challenging conditions. Our algorithm is sufficiently robust that any artefact intense enough to affect the forensic value of an image is detected. The second part of our software keeps the artefact out of frame at a success rate of 98% when used on an Axis P1385 camera.

6. Conclusion

A software solution has been produced that can be implemented on existing surveillance systems. This enables users of Axis cameras to keep employing their existing rolling shutter cameras while installing new global shutter cameras with their strobing IR-illumination. This will hopefully lead to reduced waste as existing systems can remain in service.