Evaluation and Characterization of a Logarithmic Image Sensor

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In digital video surveillance it is of great importance to be able to capture all information in a given surveillance situation regardless of how bright or dark different parts of the scene are. However, common integrating image sensors have a limited dynamic range and might either overexpose and burn out certain parts or underexpose and render certain parts completely dark. An alternative is to use an image sensor with a logarithmic response and a higher dynamic range

Background

The concept of a logarithmic image sensor is not new, and it has been studied for the better part of three decades. While providing an impressive dynamic range most designs have been plagued by a number of inherent problems. Mainly large amounts of noise, specifically what is known as fixed pattern noise. This type of noise appears as a stationary pattern on the image sensor and distorts the final image.

Recently a new type of logarithmic image sensor has been developed. This new type of sensor utilizes the logarithmic response of a photodiode in photovoltaic mode which allows for the incorporation of a reset signal. The reset signal is used to reset the photodiode to a known initial voltage that can be used to remove unwanted offsets that otherwise would lead to fixed pattern noise in the image.

The purpose of this thesis was to evaluate this type of logarithmic image sensor and to characterize the signal and noise.

Results and Conclusions

The measurements of the image sensor shows a logarithmic response that extends over more than six decades of illumination. However due to the design, at low illumination levels the response is linear rather than logarithmic.

The fixed pattern noise is quite small compared to other logarithmic image sensors. This validates the new design and the importance of the reset signal.

The temporal noise (i.e. noise that changes from frame to frame) is constant with respect to illumination. However due to low sensitivity at low illumination levels this still limits the sensor performance.

Additionally the temperature dependent behavior of the image sensor was also studied. Measurements showed unchanged levels of temporal noise but a small increase in fixed pattern noise.
However, the black level of the sensor (the signal in complete darkness) varied a lot with temperature, which is problematic for a stable implementation, especially in cameras that should operate in both cold and warm climate.

To conclude, this new design of a logarithmic image sensor remedies several of the issues with earlier logaritmic image sensors. However the current design is still limited by low sensitivity and practical issues that needs further study.