CenturyArks Co., Ltd.

Low-Light Characteristics of Event-based Vision Sensors “IMX636/646”(Sony)

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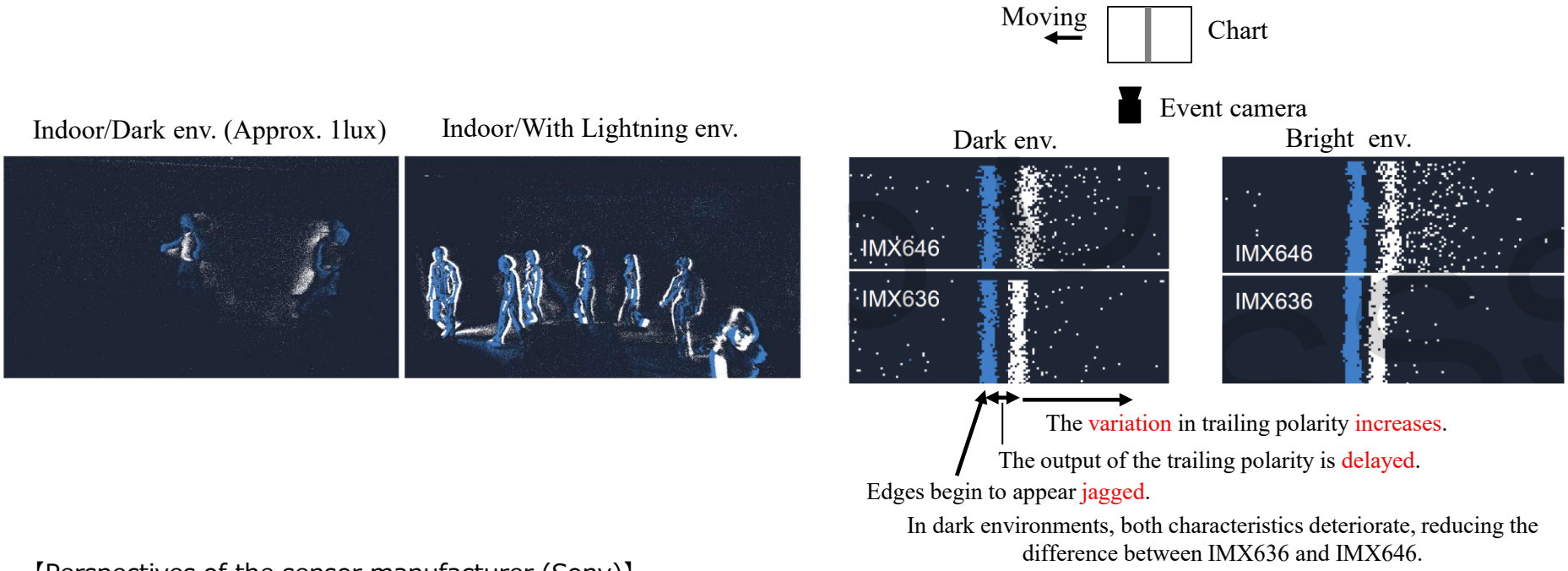
Appearance of Event in low-light environments

While event-based vision sensors (event sensors) features a wide dynamic range, Latency increases (becomes higher) in dark environments, causing trailing polarities to spread like blur.



In dark environments, both characteristics deteriorate, reducing the difference between IMX636 and IMX646.

【Perspectives of the sensor manufacturer (Sony)】

1. **About variation in trailing polarity, any prospects (plans) for improvement through future sensor enhancements?**
   - There is no immediate plans for an improved version, but we will provide feedback for future technical consideration.
2. **Any current Measures to mitigate the characteristics?**
   - Regarding afterimages, they can be removed using a trail filter/STC filter.
   - Improvement may also be achievable through HPF setting adjustments.
3. **As an idea, is it correct to understand that using only leading polarity (eliminating trailing polarity data output) would reduce edge variation?**
   - As mentioned above, using filters reduces the variation.
   - Since the sensor detects events analogically, this introduces some event output delay, but the impact is minor.

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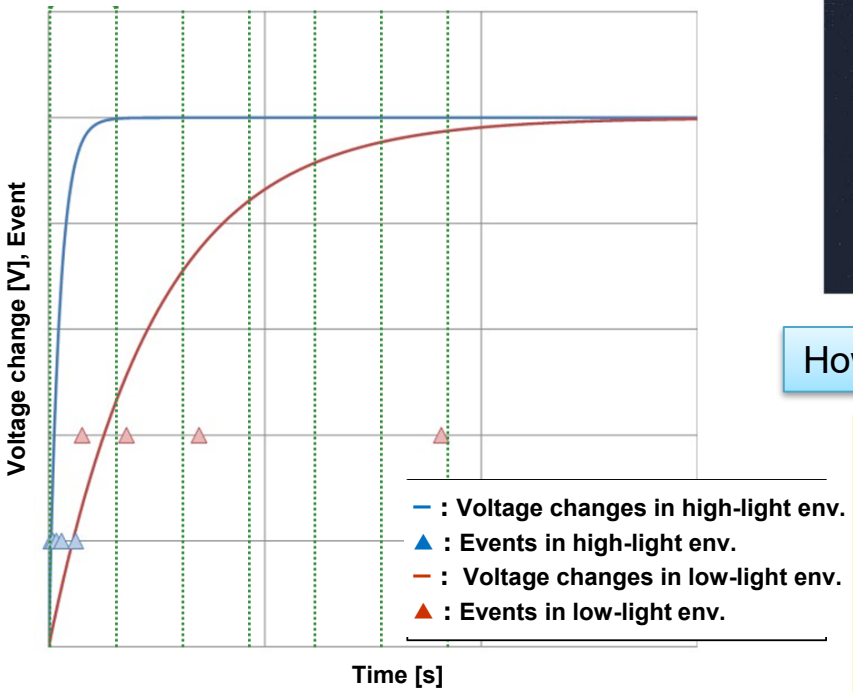
Afterimage events in low-illumination region

One frame on processing (Accumulation time @Metavision studio)



This example show a "dark ⇒ bright" change, reverse scenario is similarly applicable.

Indoor/Dark env. (Approx. 1lux)

Indoor/With Lightning env.

How trailing event appear due to illumination differences

In the high-illumination region, latency is low, so multiple events may be output. However, voltage at the PD (Photo Diode) node changes rapidly, and considering Accumulation Time, the impact is minor. Events within the same frame are OR-processed, so only one event is output.
Conversely, at the low-illuminance region, voltage changes slowly and latency is high, causing events to occur across multiple frames. This results in events appearing like afterimages, thickening the edges of moving objects.

Effectiveness of the event filters

The afterimage event component can be filtered using a trail filter that outputs only the first event.

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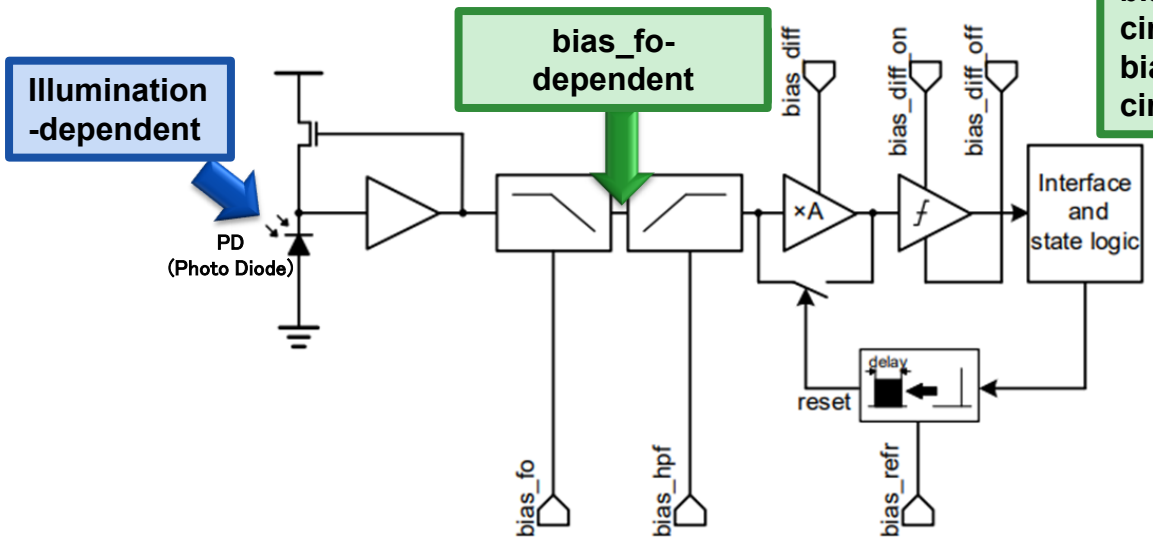
Latency Bottleneck Points



Event-based pixel block diagram

bias_fo (Low) : Voltage changes slowly in the circuit : Latency is high
bias_fo (High) : Voltage changes rapidly in the circuit : Latency is low

The latency is dictated by the higher of the two.
For reference, It is dictated by the illuminance on the sensor surface as below.
~100lx (less than or equal to) ⇒ PD part
~100lx (more then or equal to) ⇒ bias_fo part

Low light level : Few electrons are generated on PD = Current is low = Voltage changes slowly = Latency is high
High light level : Many electrons are generated on PD = Current is high = Voltage changes rapidly = Latency is low

In low-light area, the key point is how effectively the PD can convert light into electrons (=quantum efficiency).
The PD structure is the same in Both IMX636 and IMX646.

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