EV-Eye

Rethinking High-frequency Eye Tracking through the Lenses of Event Cameras

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Background

Motivation

- The update frequency of conventional eye tracking systems is often bounded by a few hundred hertz , which stands in the way of enabling game-changing applications that often require over kilohertz tracking frequency , such as mental health diagnosis.

- To bridge the gap, the event cameras are introduced in high frequency eye tracking. It's asynchronous nature and cost-efficient readout enable sub-microsecond latency, achieve eye tracking in over tens of kilohertz.
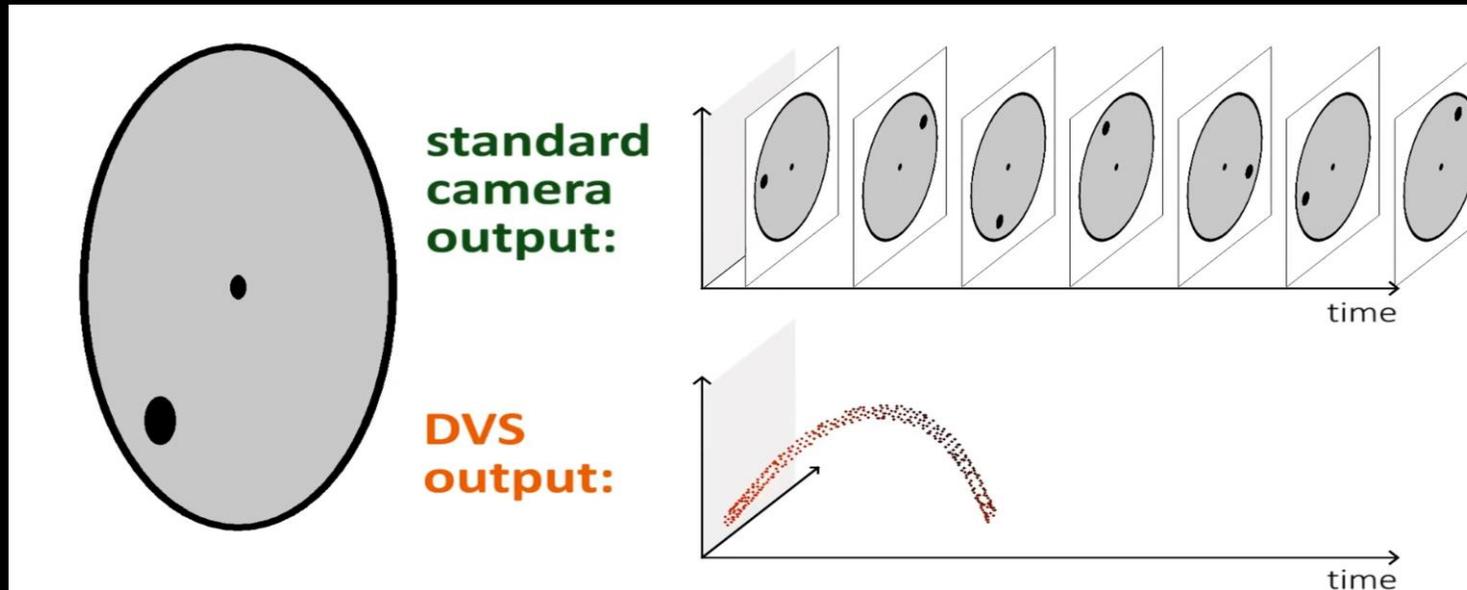
Contributions

- We introduce the largest and most diverse multi-modal frame-event dataset for high frequency eye tracking in the literature (totally over 170GB).

- We propose a novel hybrid frame-event eye tracking benchmarking approach tailored to the collected dataset, capable of tracking the pupil at a frequency up to 38.4kHz. Our approach significantly outperforms the existing solution in both pupil and gaze estimation by a wide margin.
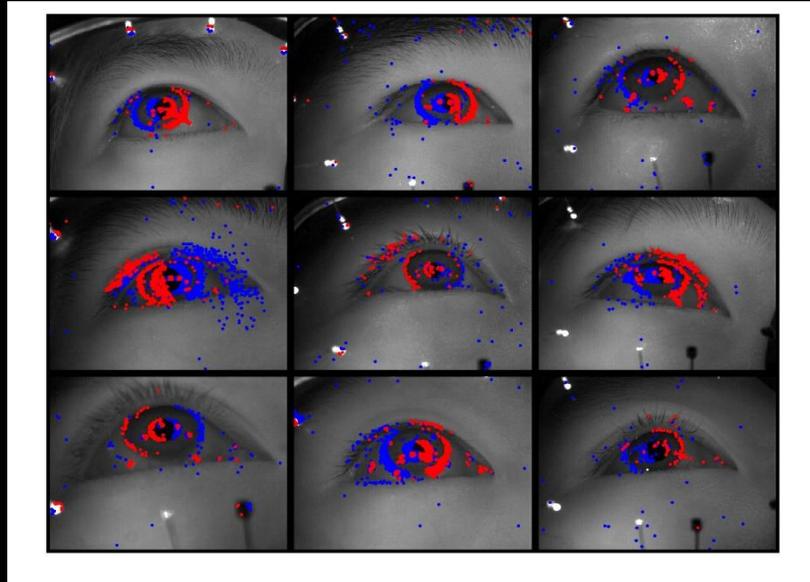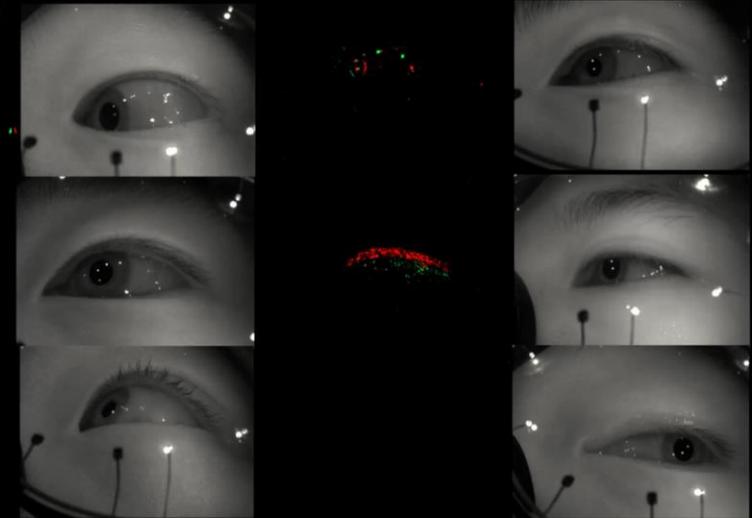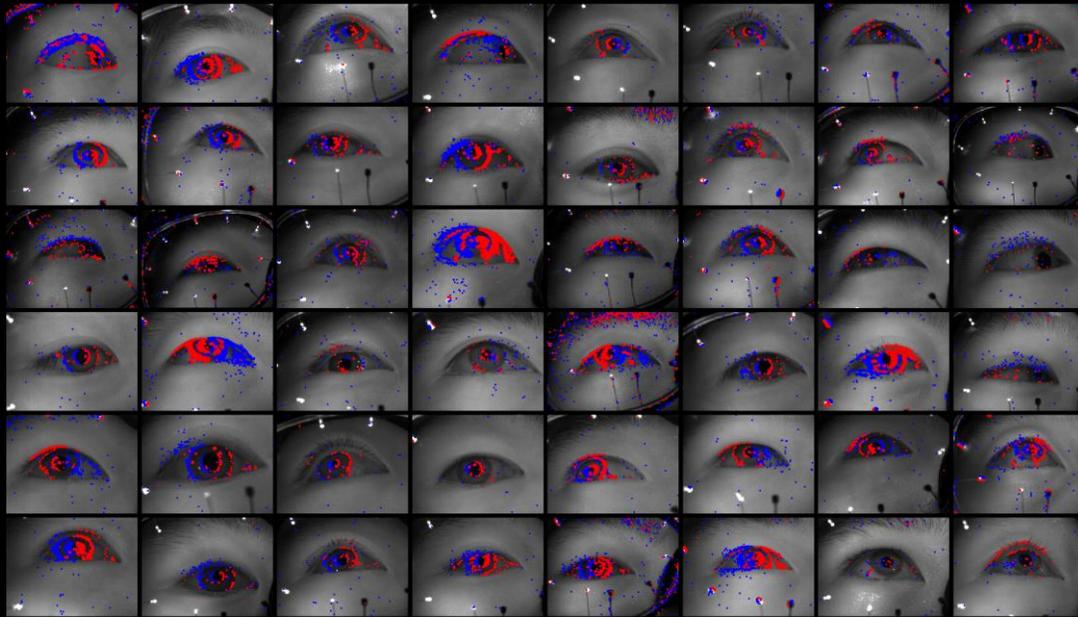
The EV-Eye Dataset

Data Collection

Stimulus to guide the subject eye movements, we record grayscale images,event streams and gaze references
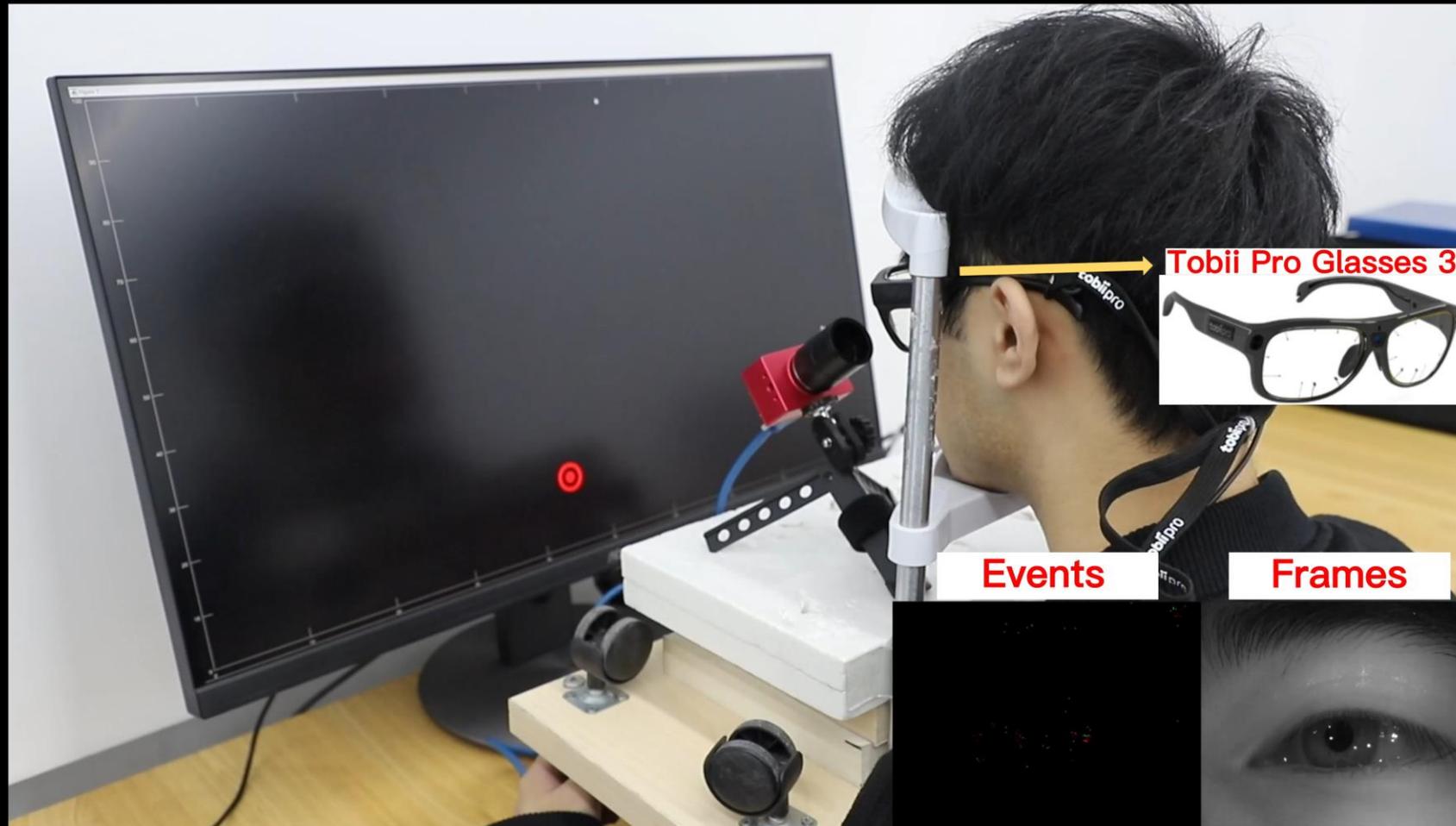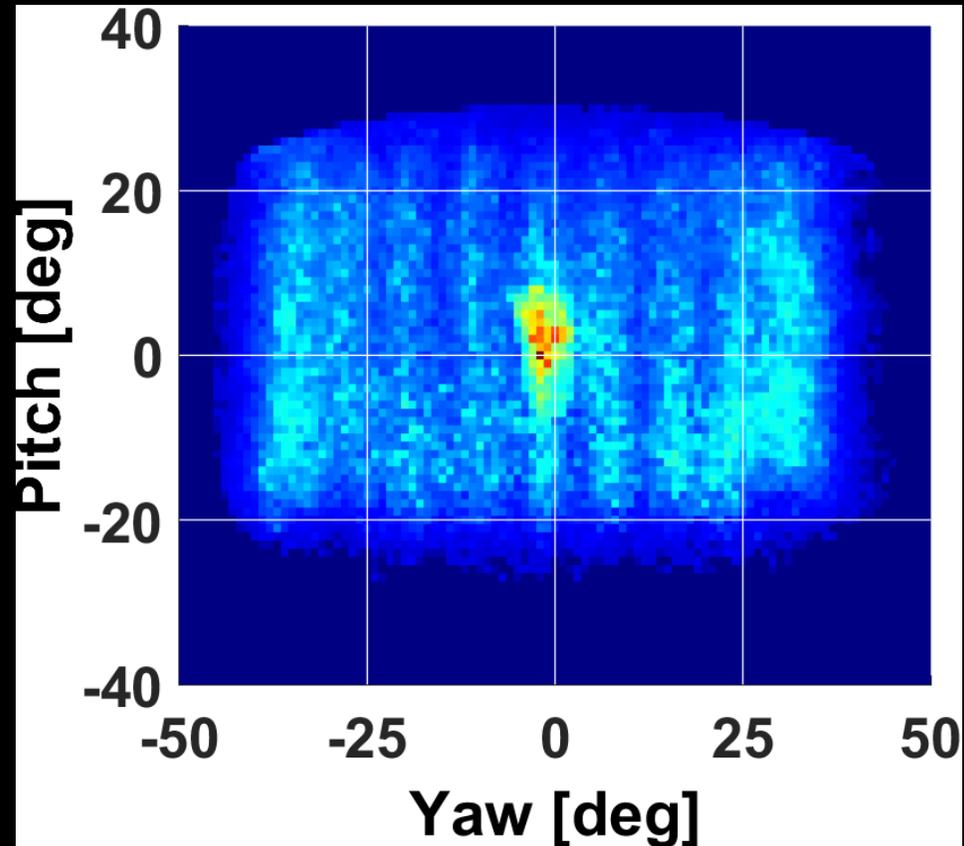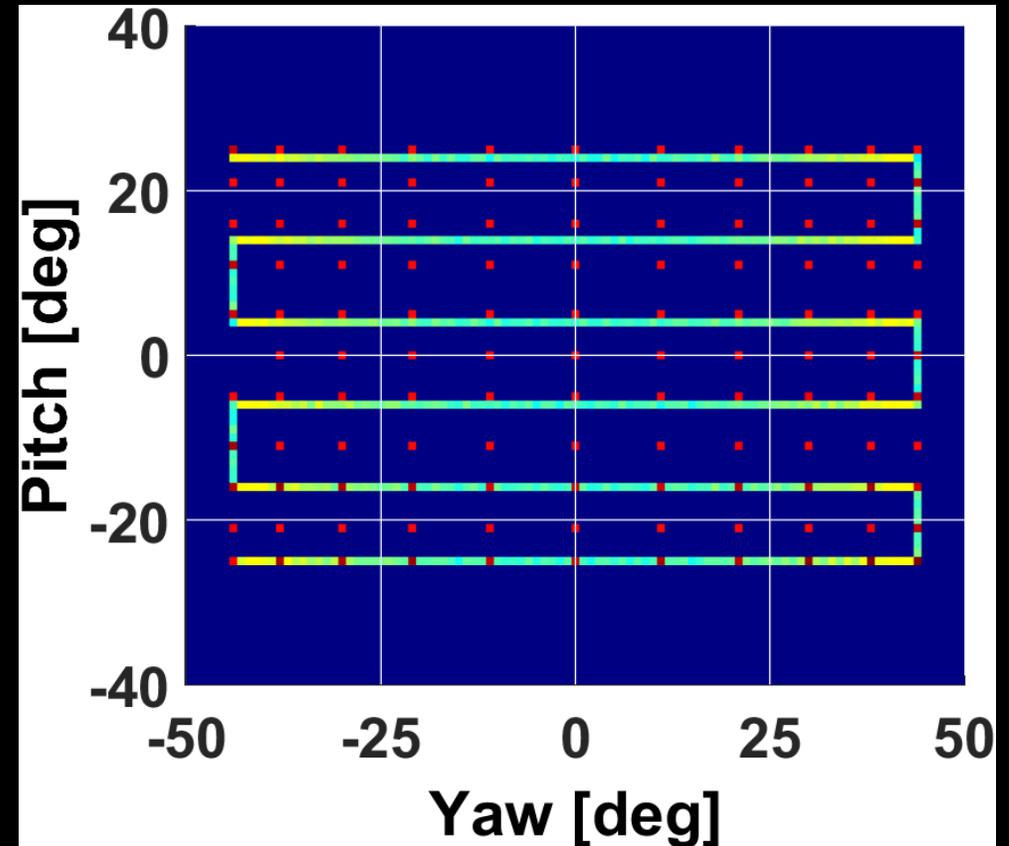
Dataset Characteristics

We recruit 48 participants, resulting in 1.5 million near-eye grayscale images and 2.7 billion event samples and 2.7 million gaze reference

Gaze references of EV-Eye are more dense and involve all states, i.e., fixation,saccade and smooth pursuit
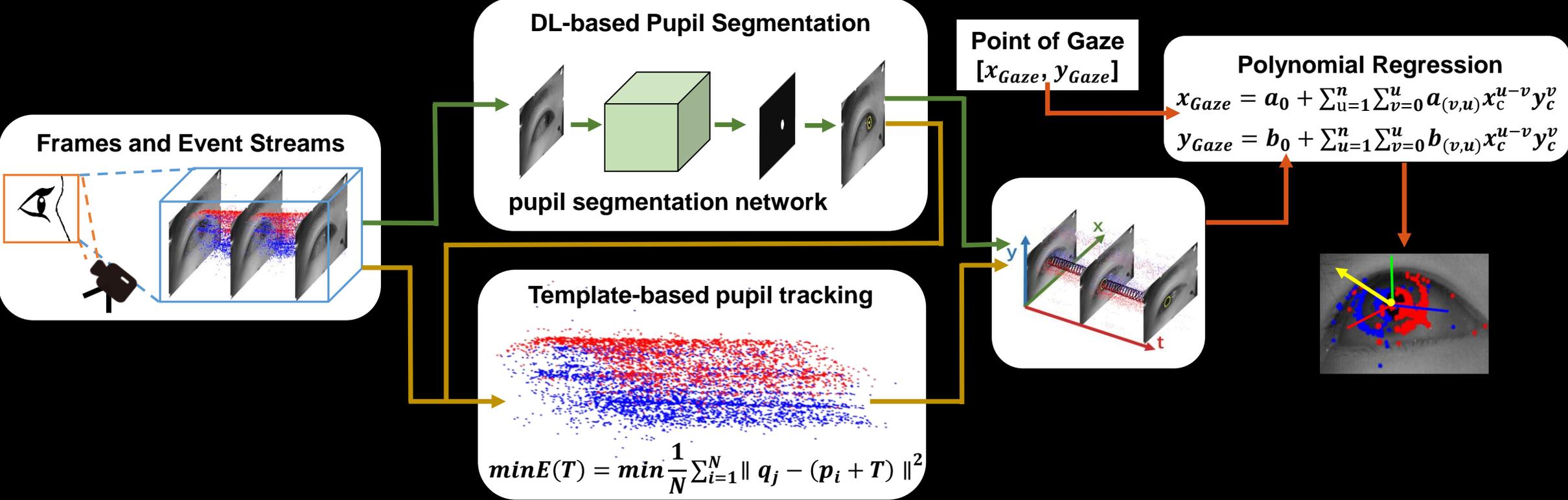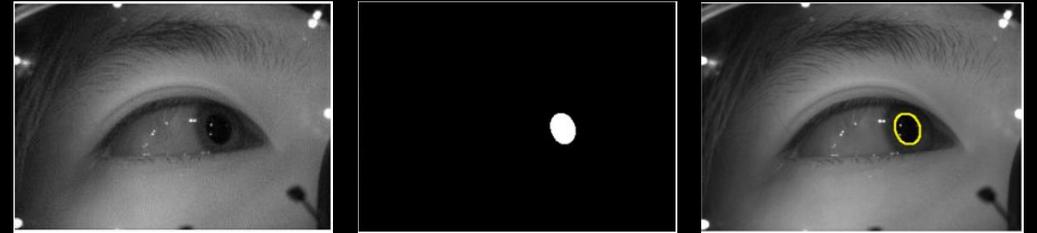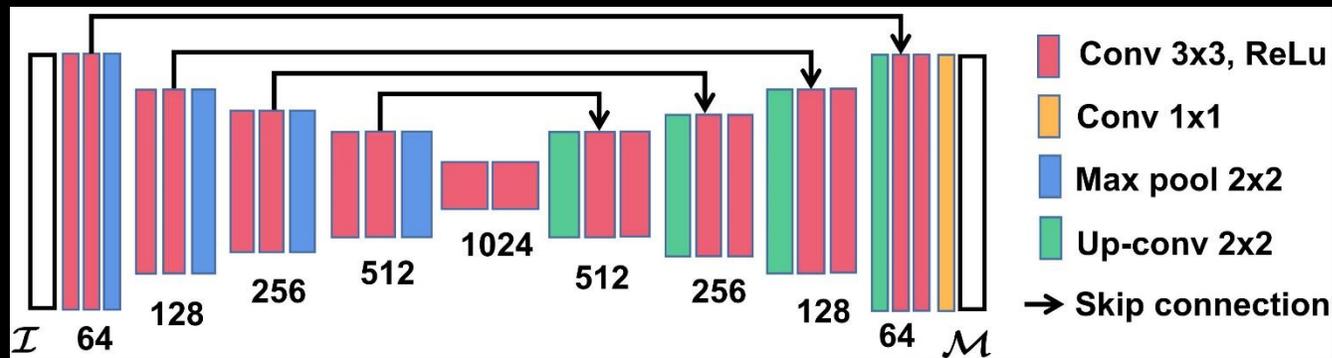

EV-Eye

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Benchmarking Methodologies

The benchmarking approach of EV-Eye is a hybrid frame and event-based method for accurate and high-frequency eye tracking

DL-based Pupil Segmentation.

We adopt a pupil segmentation network to localize the pupil. The output of the network is a mask serving as a template for event based eye tracking in high frequency.
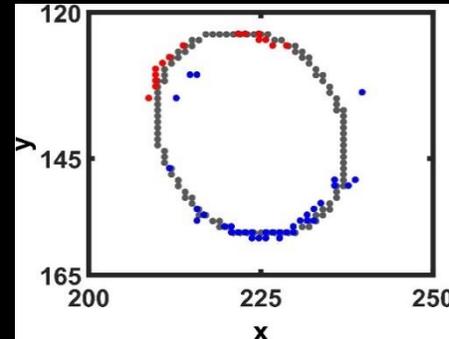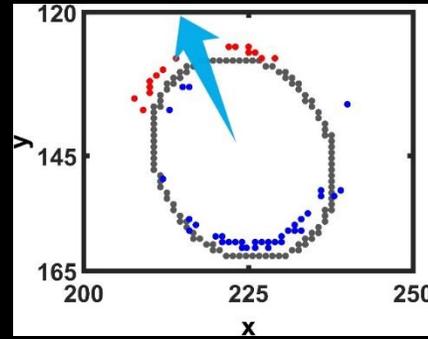
High-Frequency Event-based Pupil Tracking

With the template obtained from the previous step, the events around the template are chosen to update the location of pupil region by a point-to-edge matching algorithm, through the event stream.
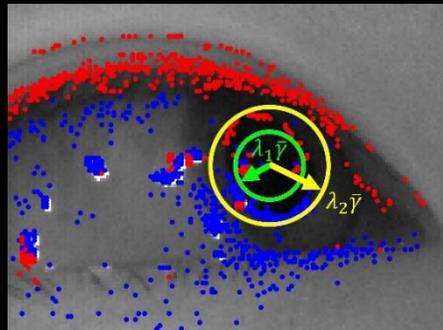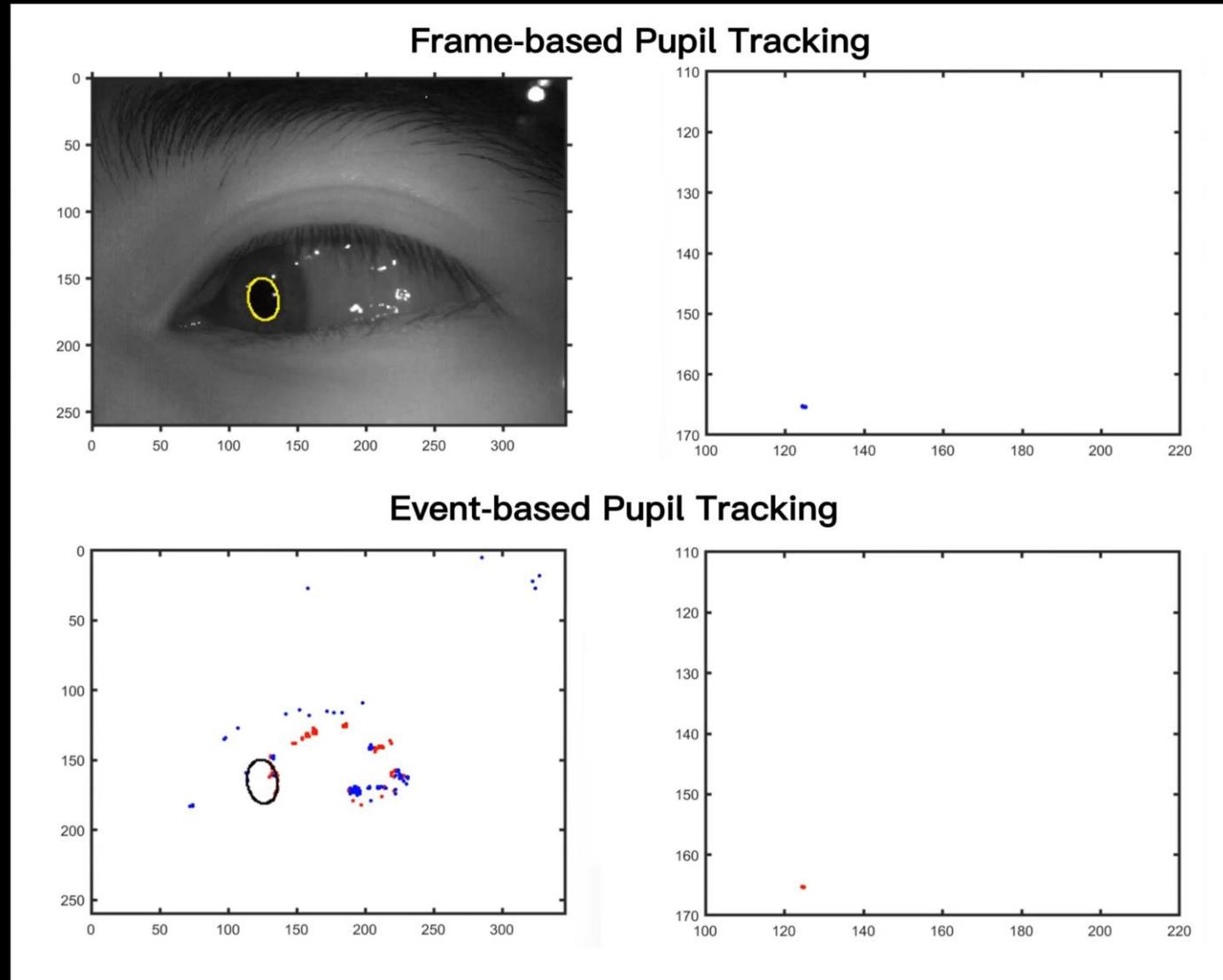

(a)   (b)

Eye Tracking Demonstration

The event based approach provides much denser tracking outputs than the frame based one, our dataset can provide tracking frequency up to 38.4khz if the pupil location is updated for every 20 events.

- The EV-Eye dataset and the implementation of our benchmarking methodologies are available at: https://github.com/Ningreka/EV-Eye.

- If you have question or comments on our dataset, please drop an email to guangrong.zhao@sdu.edu.cn.