Event-based dataset with video augmentation for scene understanding

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Abstract

We have created an event-based dataset generation pipeline for visual scene understanding, with video augmentation:

- Datasets contain streams of events from one or more event cameras (x, y, time, polarity)
- Per-event semantic segmentation label for all cameras
- Translation and Rotation (pose) labels, relative to all cameras
- Event streams are augmented with spike-encoded 3D Fractal noise or video clips (from YouTube)
- Dense 3D noise or videos are converted into sequences of sparse event frames using a technique which 'assigns' events by thresholding the differences in pixel intensities between consecutive frames
- Events from these frames - identified by their location and timestamp - are 'injected' into the recorded event streams

Hardware Setup

- 8x 3D tracking (Vicon Vero 2.2) cameras
- 2x event/RGB (DVS DAVIS 346) cameras with NIR cut filters

Begin with prop STL mesh (used for 3D print) and known 3D tracking LED marker locations

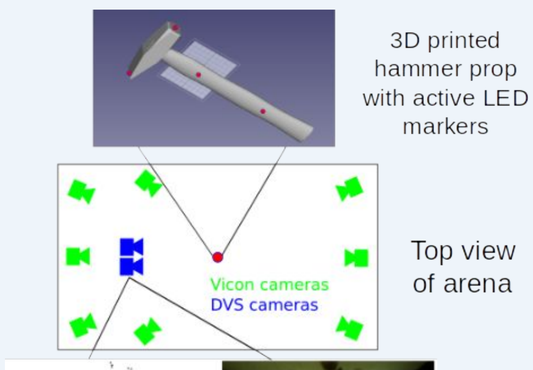
Learn optimal transformation $y = Ax + b$ from 3D Vicon space x to 3D camera space y, from known marker locations

$$\vec{y}^i = A\vec{x} + \vec{b}$$

$$\vec{z}^i = f \cdot \begin{pmatrix} y_1^i / y_3^i \cdot k \\ y_2^i / y_3^i \end{pmatrix} + \begin{pmatrix} s_x/2 \\ s_y/2 \end{pmatrix}$$

Project prop STL mesh to 2D camera image plane at coordinates z using standard pinhole camera model

A is a learnt rotation matrix, b is a learnt translation vector, f is focal length times pixel density, s_x and s_y are the horizontal and vertical camera resolution



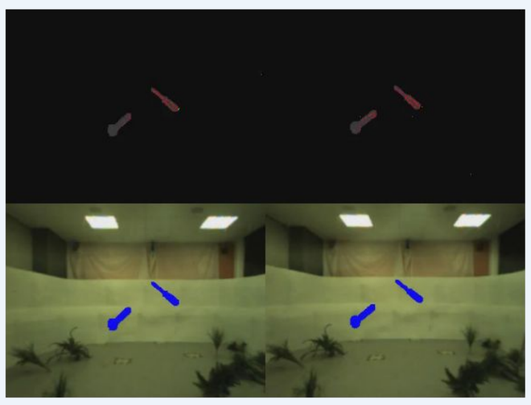
3D Tracker Props

Issue: 3D tracker system uses NIR light strobing to detect location of passive reflective markers, which introduces heavy noise to DVS cameras (even with filters)

Solution: disable NIR strobing on 3D tracking system, and use 'active' markers instead

- Custom 3D printed hollow props
- Use omnidirectional 780 nm NIR LED markers, rather than the standard passive reflectors
- Markers are wired into props at predetermined points (from STL mesh file)
- Any remaining noise from these lower-power non-strobing lights is easily filtered using 780 nm NIR cut filters

Raw Sample Dataset



Small sample dataset with 9 separate 30 second recordings of suspended moving props [1]

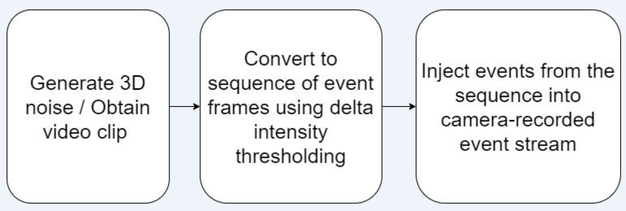
Camera-relative prop pose and per-event class labels for each of two cameras

Stored in HDF5 format online
https://doi.org/10.25377/sussex.17112080.v1

Processing code is available online
https://github.com/jamesturner246/vicon-dvs-projection

Video Augmentation

- 3D Fractal noise or custom videos can be used for augmentation
- The frames of the noise/video are converted to a sequence of events using a thresholding technique
- Between frames, If a pixel's intensity changes by an amount greater than a given threshold, an event is generated for that pixel



- Different event polarity, depending on direction of change of pixel value
- The raw dataset is then augmented by injecting events generated from the video/noise
- Code for augmenting event streams end-to-end is available at: https://github.com/NeelayS/event_aug

Augmented Dataset

- We augmented the camera-recorded event streams using both video clips downloaded from YouTube and generated 3D Fractal noise.
- The videos were selected such that they had object(s) performing relative motion with respect to their surroundings in them. This guaranteed the presence of a coherent stream of events after spike-encoding.
- The pictures below show an example of augmentation. On the left is one frame of a video containing dashcam footage of a car. The picture on the right depicts a still of an event recording of a screwdriver augmented with events from the video frame.

Summary and Discussion

- We have constructed a full pipeline for generating event-based datasets for semantic segmentation and pose estimation using custom 3D printable tracked props [1] [2]
- We have further implemented an event-based visual data augmenting process, which projects prop events from a raw dataset onto event-based fractal noise or video sources
- The prop-based data generation pipeline requires a 3D tracking system, such as Vicon, while the augmentation only requires standard video files or Youtube links
- We hope to contribute to further efforts for spiking neural network development, and ultimately neuromorphic computing in general by making training data more readily available

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References

[1] James Turner, Jens Pedersen, Jörg Conradt, and Thomas Nowotny. 2022. Event-based dataset for classification and pose estimation. In *Neuro-Inspired Computational Elements Conference (NICE 2022), March 28–April 1, 2022, Virtual Event, USA.* ACM, New York, NY, USA 3 Pages. https://doi.org/10.1145/3517343.3517378

[2] James Turner, Jens Pedersen, Jörg Conradt, Thomas Nowotny. 2022. Stereo event- and frame-based benchmark dataset for scene understanding. University of Sussex. Dataset. https://doi.org/10.25377/sussex.17112080.v1

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