Contour Detection and Characterization for Asynchronous Event Sensors

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Abstract

The bio-inspired, asynchronous event-based Dynamic Vision Sensor (DVS) records temporal changes in the luminance of the scene at high temporal resolution. Since events are only triggered at significant luminance changes, most events occur at the boundary of objects. The detection of these contours is an essential step for further interpretation of the scene. This work presents an approach to learn the location of contours and their border ownership using Structured Random Forests (SRFs) on event-based features that encode motion, timing, texture, and spatial orientations. The classifier integrates information over time by utilizing the classification results previously computed. Experimental results demonstrate good performance in boundary detection, border ownership and segmentation.

Border ownership assignment via SRF

The SRF is trained for border ownership assignment using event-based features from random (16x16) patches. (A) Given the training data D, we learn an optimal splitting threshold \( \Theta \), associated with a binary split function \( h \) at every split node. (B) The leaves at each tree \( \mathcal{T} \) encode a distribution of the most events occur at the boundary of objects. The detection of these ownership orientation which we use during inference. Averaging the responses over all \( k \) trees produces the final boundary and ownership prediction: \( \mathcal{E}_k = (\mathcal{E}_k, \mathcal{E}_k, \mathcal{E}_k) \). We then obtain \( \mathcal{E}_k \) by applying a watershed transformation over \( \mathcal{E}_k \) to construct an initial segmentation \( S_{\text{init}}(x) \).

Experiments

1) Indoor sequences of 15 common objects, over varying backgrounds, distances, shape, and sizes with a maximum of 3 depth layers.
2) Outdoor sequences with moving and static cars.

Extraction of event-based features

We augment in (E-F) the event-based features with the predictions computed for the previous time interval. The original, non-sequential SRF \( R_{\text{seq}} \) creates predictions \( \mathcal{E}_{n+1} \) which are used with the features for the next time \((n+1)\) as input to the sequential SRF \( R_{\text{seq}} \).

Refinement and event-based segmentation

We refine the segmentation of the SRF using an event-based segmentation algorithm. First approach for locating border contours and assigning border ownership for event-based data. The method will be used in future work to develop a complete motion segmentation using as input DVS streams together with classical images (provided by new experimental cameras).

Motivations:

- Event-based motion encodes relative depth information and allows us to detect occlusion boundaries.
- Temporal data is extensively used in boundary detection and ownership[1].
- Time texture helps mainly separating foreground and background textures from contours.

Temporal data provides information for tracking contours. Orientation is extensively used in boundary detection and ownership[2]. Time texture helps mainly separating foreground and background textures from contours.

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Refined segmentation

1) Initial segmentation \( S_{\text{init}} \) estimated from the predictions \( \mathcal{E}_n \) of the SRF.
2) Segments are refined by enforcing motion coherence between them.

Future work: select features according to the predominant global motion and use specific SRF classifiers tuned for the predicted motion.

Conclusions

- First approach for locating border contours and assigning border ownership for event-based data.
- The method will be used in future work to develop a complete motion segmentation using as input DVS streams together with classical images (provided by new experimental cameras).

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