Optical Flow Estimation Based on Spatiotemporal Plane Fitting of Event Point Clouds

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***Abstract*—Event data is the asynchronous acquisition of the increase or decrease in luminance of each pixel. Events are mainly generated near the edges along the motion of the subject and camera, and the event point clouds form a plane in the spatiotemporal 3D domain. Therefore, the surface formed by the event point clouds in the spatiotemporal domain can be regarded as the trajectory of motion (optical flow). In this paper, we propose a method for optical flow estimation using parameters of planes estimated from event point clouds in a segmented spatiotemporal subregion.**

***Index Terms*—Event camera, optical flow, plane fitting**

I. Introduction

Event camera has the advantages of high dynamic range, microsecond-order temporal resolution, low power consumption, and all of which are effective in environments that are difficult to capture with frame cameras. However, the output event data $\boldsymbol{e}$ is stream data consisting of coordinates x, y, timestamp t, and polarity p in the direction of luminance change, making it difficult to apply conventional computer vision algorithms as is. One such algorithm is optical flow estimation, which estimates the motion of a subject. Therefore, in order to apply the existing variational optical flow estimation method to event data, we propose a method that divides event data into small regions and utilizes RANSAC-based planar estimation in each region.

II. Optical Flow Estimation Method [1]

Optical flow estimation using the frame-based variational method finds the flow $\boldsymbol{u}(\boldsymbol{x}) = (u(\boldsymbol{x}), v(\boldsymbol{x}))^\top$ that satisfies the luminance invariance condition in the following equation.

$$u\frac{\partial f}{\partial x} + v\frac{\partial f}{\partial y} + \frac{\partial f}{\partial t} = 0 \tag{1}$$

III. Proposed Method

First, the 3D event data in the x, y, t axis is divided into small regions, and RANSAC planar estimation is performed for each region. Figure 1 shows an enlarged image of one of the divided regions and a schematic representation of the planar in which events are concentrated in the region, as shown in the green planar. We propose a method to estimate the optical flow from the intersection l_0, l_1 of the green planar and the orange planar at time t_0, t_1, which is estimated from events in a small segmented region. As shown in Figure 2, the constraint equation for luminance invariance at the corresponding pixel of the optical flow represents the straight line of its solution (u, v). Since the equation of the intersection between the plane of the event estimated by RANSAC and the plane at time t_0, t_1 is known, we are currently in the process of examining whether it is possible to replace the coefficients a, b, c in the equation $ax+by+c = 0$ for the line by the partial derivative of each term in the above-mentioned constraint (1) for the optical flow.

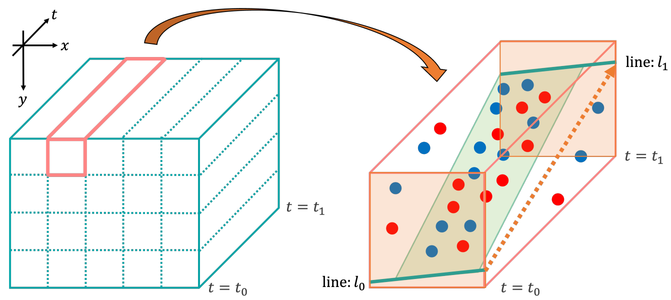

Fig. 1. Region Segmentation and planar Estimation

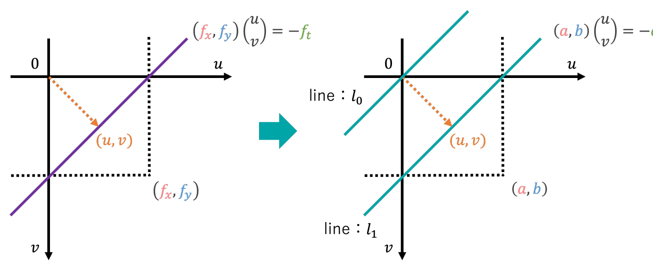

Fig. 2. Optical flow Constraint Equation and Linear Equation

IV. Conclusion

In this paper, we propose a method for estimating the motion of an event by estimating the plane for a segmented region and replacing the partial derivatives of each term in the constraint equation with the coefficients of a linear equation based on the information in the plane. In the future, we intend to evaluate the estimated motion, continue investigating the characteristics of events, and move from plane-by-plane estimation to more detailed event-by-event estimation.

References

[1] Yusuke Kameda et al. "Numerically stable multi-channel depth scene flow with adaptive weighting of regularization terms." EUSIPCO220, pp.605–609, 2020.