Subpixel Localization of Active Markers with Event Cameras

Graduate Candidates

Milena Squindo

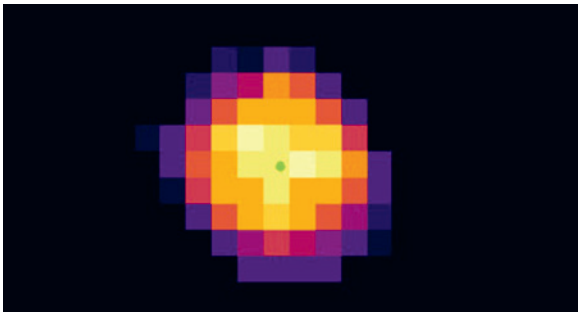
Markus Halef

Introduction: Event cameras are a specific type of imaging sensors that differ from traditional frame-based cameras. Unlike conventional cameras, event cameras operate based on the principle of asynchronous event-driven sensing. Rather than capturing entire frames at fixed intervals, event cameras only report changes in pixel intensity, known as events, with extremely high temporal resolution. Furthermore, the amount of data is reduced significantly in comparison, which therefore reduces the computing power required to handle events. Many applications can benefit from these traits, one of them is active marker tracking, where accuracy is just as important. Different subpixel processing methods were already developed to enhance the precision of tracking algorithms. However, the unique data structure of events does not allow for direct application of most known image-processing algorithms.

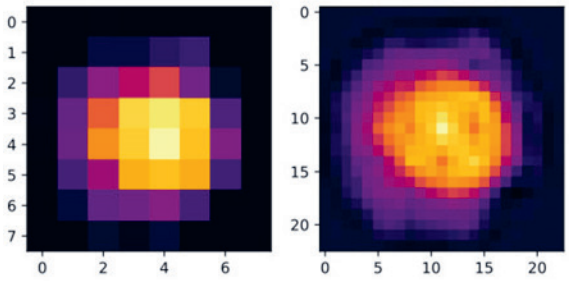
Objective: The objectives of this thesis were focused on the development and evaluation of new algorithms for active marker tracking using event cameras. The primary goal was to enhance the precision of object localization by finding ways to apply subpixel-processing methods to event camera-generated data. Furthermore, exploration of the event formation process and the choice of an appropriate active marker were essential steps to find a proper solution.

Result: An algorithm that could accurately estimate the center of an active marker was successfully designed. By exploiting the information captured by the event camera, the marker could be localized with the standard deviation up to a precision of 0.27 pixels. This can easily be extended to achieve subpixel-precise tracking. Additionally, a second algorithm that uses super-resolution imaging techniques to enhance the precision of object tracking in low-resolution images was developed. The limitations imposed by the camera's resolution were surpassed and resolution enhancements up to a factor of nine were generated.

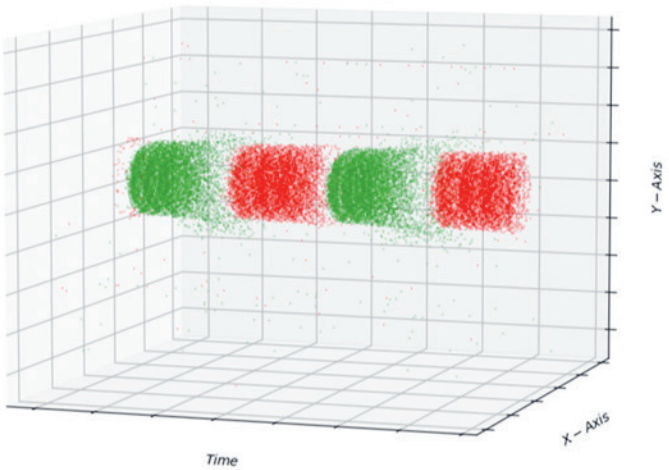
First algorithm: Calculated subpixel center position (green dot) on an intensity image of an active marker.
Own presentment

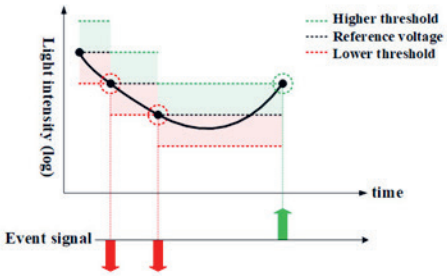


Second Algorithm: Calculated super-resolution image with resolution enhancement of factor 9.
Own presentment



Point cloud of events generated from a flashing LED and visualization of event generation on the sensor.
Own presentment





Advisor
Prof. Dr. Martin Weisenhorn

Co-Examiner
Jonas Schmid, Stettbacher Signal Processing, Dübendorf, ZH

Subject Area
Image Processing and Computer Vision

Project Partner
AlpsenTek GmbH, Zürich