Stereo-Vision Algorithm Based on Bio-Inspired Silicon Retinas for Implementation in Hardware

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Abstract. In this paper, we propose a silicon-retina-based stereo vision system, used for pre-crash warning or rather side-impact detection applications in vehicles. The bio-inspired silicon retina sensor is a new kind of sensor, which delivers data asynchronously and only if the intensity of the ambient light changes. Therefore, the amount of data that must be processed decreases significantly compared to standard CMOS or CCD imagers. The sensor uses an address-event representation (AER) protocol to transfer the event-triggered information. Concerning the special output characteristics of the imager, a novel approach regarding acquisition, storage, and matching of the data was implemented. The concept of the algorithm is specifically targeted and optimized for an implementation in hardware, e.g. on a Field Programmable Gate Array (FPGA).

Keywords: Stereo Vision, Silicon Retina, FPGA, Address-Event-Representation

1 Introduction

Nowadays, embedded systems have a variety of possible fields of application and ease everyday life in may areas, e.g. by operating in advanced driving assistance systems (ADAS). Our focus, as part of the EU-funded project ADOSE (http://www.adose-eu.org) is the development of a pre-crash detection and warning system for side impacts consisting of a stereo-vision system, which is based on silicon-retina sensors.

As imagers, bio-inspired silicon retina sensors, derived from the human vision system, are used. The sensors we use for this work have a resolution of 128x128 pixels and a temporal granularity of 1ms [2]. In comparison with standard frame-based CMOS or CCD imagers, the retina senor is an asynchronous, continuous-time, logarithmic photoreceptor, and every pixel independently delivers data only on changes of the luminance. Hence, the amount of data is significantly reduced, which would obviously lead to lower bandwidth requirements but certainly not to a simpler calculation process. Unfortunately, the data rate depends on the variance of the brightness in the observed scene and is, therefore, not constant over time.

2 Concept of the Algorithm

The silicon retina provides the data as an address-event (AE) stream, which contains the address of the firing pixel, the polarity of the change, and the time of occurrence. Similar to Kogler et. al. [1], the time is used as major matching condition for finding corresponding pixels in the left and right data stream. As a novelty, we uses only differences of the timestamps, yielding a very low memory consumption. In addition, for the matching process not only the current timestamps are considered, but also timestamps from the past, using a logarithmic weighting function to evaluate only events with equal timestamps together. Figure 1 shows a schematic of the event-based time correlation approach.

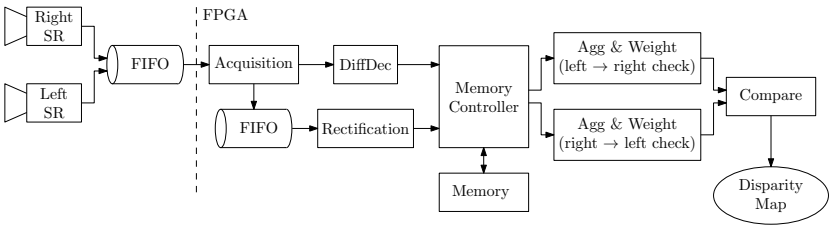

Fig. 1. Block diagram of the architecture of the stereo-vision-algorithm for an implementation in hardware.

3 Results

Considering only equal timestamps and using a logarithmic weighting function yields a rather dense disparity map, and additionally, noise has hardly any effect on the matching process. The presented approach was verified [3] and due to the efficient data representation and the simple matching process, the concept is very suitable for an implementation in hardware.

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