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A VALIDATION APPROACH FOR A SILICON RETINA STEREO SENSOR

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Abstract: *In this paper we present a system validation approach for Silicon Retina based Stereo Sensors. These novel types of image sensors are derived from the human vision system. Due to the special characteristics of the sensor and the data representation, novel algorithms, verification and validation approaches are required. The developed validation system consists of a configuration tool and hardware for stimulating the sensors.*
Key words: *System Validation, Silicon Retina, Embedded Systems, Bio-inspired Vision*

1. INTRODUCTION

The EU-funded project ADOSE (reliable Application-specific Detection of road users with vehicle On-board SEnsors) is focused on the enhancement of safety functions through the development of high performance and low cost sensing technologies. Our aim is to develop a stereo sensor for side impact collision warning by computing the disparity of closer coming objects.

The Silicon Retina (SR) sensor technology is a novel sensor type with a high temporal resolution, a high dynamic range and an asynchronous event triggered data interface. (Lichtsteiner, et al. 2008). Due to the special characteristics of a novel imager technology, existing algorithmic approaches, system verification and validation techniques are improper.

An evaluation of existing stereo algorithm approaches shows that existing approaches cannot exploit the features of the sensor (Kogler et al., 2010). For field use, system verification and validation are of importance to give evidence of passed requirements. For algorithm verification a tool was developed for synthetic scene generation including ground truth information (Sulzbachner et al., 2010).

This paper presents the work on further developments of the verification tool including the development and integration of a displaying hardware for visualizing the scenes for system validation.

In a next step, we are interested in comparing the results of algorithm verification and system validation of the stereo system to find particular variations. We also need to compare the performance of the developed hardware for system validation to a real-world scene. Especially this performance comparison is difficult due to the temporal resolution of the sensor.

2. OVERVIEW SILICON RETINA

The SR is a novel type of image sensor derived from the human vision system. The sensor technology goes back to Fukushima et al. in 1970 (Fukushima et al., 1970) and Mead and Mahowald in 1988 (Mead & Mahowald, 1988). The specific type of information representation goes back to the 1991, where Sivilotti (Sivilotti, 1991) proposed a method for transferring the state of an array of neurons from one chip to another.

In contrast to conventional imagers that capture frames with a specific frame-rate, the SR technology is based on address event representation (AER).

The imager does not deliver static information of a scene; rather it delivers information of variations of intensity of pixels. Thus, unaltered parts of a scene need not be transmitted nor processed. A variation, a so-called event, each consists of a timestamp, coordinates and specific information of the variation, depending whether the pixels gets darker or lighter.

3. VERIFICTION TOOL

The verification tool consists of a simulator and an embedded interpreter, which are used for visualization of the address event data over the time and scene generation for verification and validation. The tool supports geometric primitives including ground truth generation of the stereo scene. For verification only, performance metrics allow to benchmark different algorithm approaches. Figure 1 shows the verification tool offline processing a recorded scene with a closer coming vehicle.

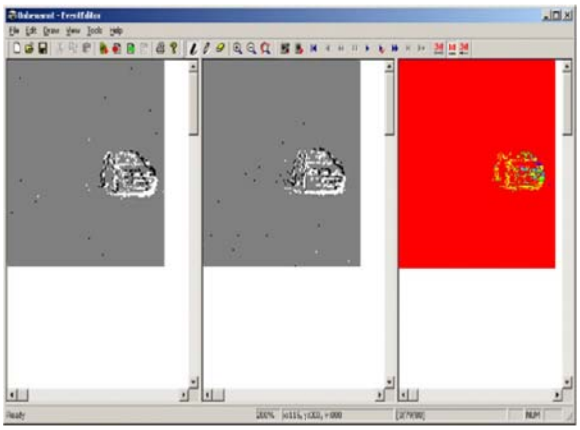

Fig. 1.Verification tool showing a scene with a closer coming vehicle; left, middle: stereo images; right: disparity map

3.3 Extensions

The main extension for the verification tool was the scene preparation for validation and the download to the hardware. Generally, the data transmission can be realized by sending an image per time or simply all available event information in AER format. Due to the high temporal resolution of the sensor, using frames for data transmission is quite inefficient given that a pattern has only few events per timestamp. The second technique is more variable and the amount of data to transmit depends on the number of events in a scene.

4. VALIDATION HARDWARE

The hardware consists of a microcontroller and a 42x30 light emitting diode (LED) matrix for visualizing generated scenes.

4.1. Requirements

The challenge of the displaying hardware is to reproduce a scene on the display such as the SR would capture it in a real-world environment. For meeting these requirements it was necessary to determine the characteristics of a real-world scene and evaluate the specifics of different stimulating mechanisms using different types of displays. Due to the scope of applications, we decided using pulsed LEDs.

Figure 2a shows the number of AE per time resolution detected in the field of view by the SR using a pulsed LED at a multiplexing frequency ranging from 0.1 Hz to 4 kHz. With increasing frequency, the number of AEs is decreasing. At a frequency of 3 kHz, the SR is not able to detect events any longer. Thus, this is the minimum frequency for multiplexing a LED array.

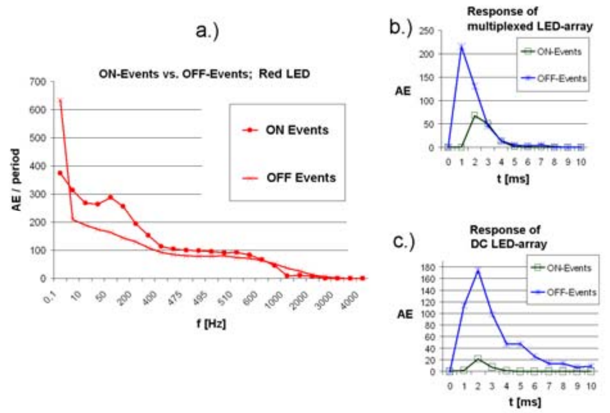

Fig. 2. Characteristics of pulsed LED; (a) SR event response for pulsed LED in a frequency range; (b) turn-off characteristics of a multiplexed LED array; (c) turn-off characteristics of DC powered LED array

For accurate scene reproduction it is necessary that the turn on and turn off characteristics are the same. Figure 2b shows the turn off characteristics of a LED array using multiplexed LED array at a frequency of 3060 Hz and figure 2c shows the same scene using a DC powered LED array. The consistency of both methods is adequate and the usability of multiplexed LEDs is verified.

4.2 Hardware and Software Design

The hardware is based on an 8-bit microcontroller that controls the 42x30 LED array. For data transmission from the host to the embedded system a USB interface is used.

For storing the scene, the hardware was equipped with a SD card interface that is connected via the SPI interface of the controller. A 2GiB SD card is able to store about one day of data using 10fps and a protocol of 2Byte for event and time representation. For fully describing a frame, one timestamp and 1260 events are required. Due to pin and timing restrictions, the LEDs are multiplexed in three stages independently using latches for each stage. Each stage is independently multiplexed with a frequency of 3060 Hz. For multiplexing the stages, the controller modifies one stage while the others are driven by the latches. Thus, flickering can be suppressed and a high frame-rate can be achieved.

The SR stereo system requires a stereo scene; therefore one embedded system is required for each imager. Both systems have to assure to synchronously visualize the frames. Therefore the systems have been synchronized using a common signal for identifying a new frame using a master slave system. The master uses a timer and the slave uses a general purpose I/O interrupt. Figure 3a and 3b show a generated scene using a moving circle in the direction of the red arrow generated with the verification tool and displayed with the embedded system.

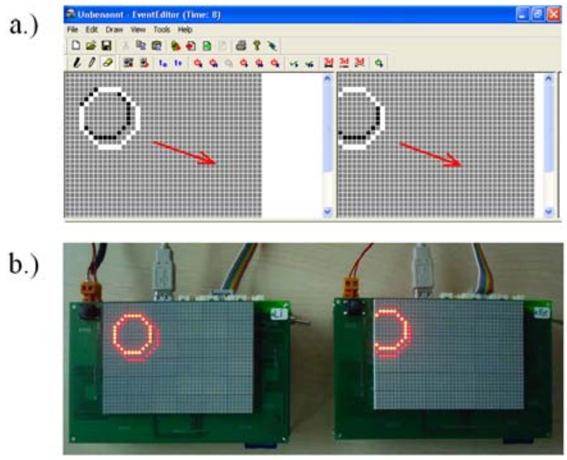

Fig. 3. System validation; (a) scene visualized on the verification tool; (b) scene reproduced with embedded system

5. CONCLUSION

This paper presented a validation approach for Silicon Retina based stereo sensors. An existing verification tool used for scene generation and verification was extended for scene preparation for validation and download. We also showed characteristics of the sensor and derived the hardware requirements.

The embedded system is connected to the host using an USB interface with a data-rate of 921600Baud. For displaying a scene a 42x30 LED array is used controlled by an 8-bit microcontroller at a multiplexing frequency of 3060 Hz to get a simultaneous behavior of the Silicon Retina such as in a real-world environment. The embedded system has a maximum frame-rate of 45fps.

6. ACKNOWLEDGEMENTS

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