Live Demonstration: SCAMP-7

Laurie Bose Piotr Dudek Stephen J. Carey Jianing Chen

University of Manchester, Manchester, England

Abstract

We propose to demonstrate the next generation of the SCAMP vision sensor, SCAMP-7, whose architecture embeds programmable processing cores into each pixel. This IC allows various computer vision tasks to be performed "on-sensor" at high speeds while avoiding the slow and power hungry transfer of image data off the device. Through in-pixel computations over the image array, visual information is reduced to small amount of highly-informative 'event' data (e.g. detection results, coordinates of objects of interest, motion vectors, etc.). This methodology reduces power consumption associated with data movements and shortens the pipeline between visual event and image information output, resulting in typical latency of a single frame time, while processing thousands frames per second.

1. SCAMP-7

Our new SCAMP-7 vision system builds upon its predecessor SCAMP-5 [2], with revised silicon chip implementation providing increased light sensitivity, greater digital memory per processing element PE, and various other improvements such as more accurate global analog summation. The system as shown in Figure 1 has also a smaller footprint than the older SCAMP-5 camera system, due to integration of a larger amount of peripheral circuitry on-chip. If possible we would bring demonstrations for a number of applications performed entirely with "in-pixel" processing. Programming techniques for processor arrays are different from that for serial processors - in all these examples, we show how the IC can output data regarding an image, without necessarily outputting the image itself (the image is only output to aid understanding of the demonstration). The program development environment will be demonstrated alongside discussion of specific programming techniques for pixel parallel processor arrays and the new features of the SCAMP-7 device.

Figure 1. SCAMP-5 system vs SCAMP-7 system.

2. Target Tracking

This demonstration performs position extraction of a moving target located upon a spinning disc. The disc spins at around 5000rpm producing fast motion that requires high-speed processing to perform tracking. Target discrimination can be performed based on object shape, size, or other properties. The primary output of the sensor is two bytes describing the location of the target sought, this is captured at over 10,000 Hz; additionally a single frame (from a long sequence) is output for verification purposes.

3. Gaze Tracking

Given a clear image of a user eye pupil extraction and extraction of LED reflections employed by many gaze tracking systems can be performed on SCAMP-7 as illustrated in Figure 2. This process is very efficient and can be performed in excess of $10,000$Hz given sufficient illumination. We can demonstrate a basic setup for such tracking, by projecting a user's estimated gaze vector onto a screen display while their head is placed upon a rest to ensure the SCAMP system is provided a clear image of their eye. Further details of this implementation can be found at [1].

4. Face Tracking

We will demonstrate the detection and tracking of a user's face, along with eye blink detection. Detection is per-

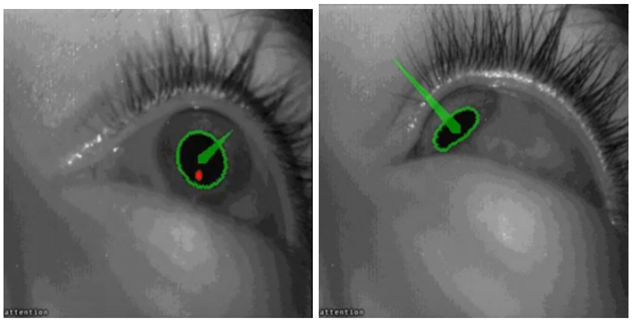

Figure 2. Pupil extraction performed on SCAMP, along with extraction of LED reflections shown in red. Estimated gaze direction is shown in green.

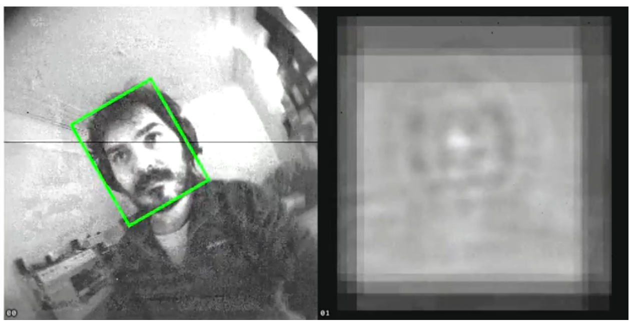

Figure 3. Detection and tracking of a specific user's face performed entirely upon the processor array. Left: input image overlaid with bounding box of detected face. Right: heat-map of detection strength within processed image.

formed using a Haar feature based approach. SIMD Analog compute is used to evaluate Haar features at every possible location within the image, simultaneously in parallel. Once detected the scale and rotation of the face within the image are tracked, allowing the inverse scale and rotation to be applied to the input image. This provides a degree of robustness to changes of scale and rotation. This process is performed entirely upon the SCAMP system's PE array ”in-pixel”, image output is only being shown for illustrative purposes. In the future such an approach could allow applications such as detection of operator fatigue, a driver monitoring system, or in building automation scenarios where complete on-chip processing, without transfer of images off-sensor, ensures user privacy.

5. Visitor Experience

Visitors will be able to view and interact with the various live demonstrations along with discussion of the system and its capabilities. These demonstrations will have SCAMP-7 systems connected to a standard laptop for visualizing their output. Due to the limited number of systems not all possible demonstrations can be shown at once, but visitors are welcome to request a specific demo or examine other capability of the system. The development environment and programming of the SCAMP-7 device can also be demonstrated.

References

[1] Laurie Bose, Jianing Chen, Stephen J Carey, and Piotr Dudek. Pixel processor arrays for low latency gaze estimation. In *2022 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW)*, pages 970–971. IEEE, 2022. 1

[2] Jianing Chen, Stephen J Carey, and Piotr Dudek. Scamp5d vision system and development framework. In *Proceedings of the 12th International Conference on Distributed Smart Cameras*, page 23. ACM, 2018. 1