Project LightShield: Design of the Hybrid Sensor Chip

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The potential of the combination of 2D and 3D information is beyond controversy. However, the merging of sensors require an enormous amount of computation power and engineering. In this project, we propose a monolithic sensor where intensity pixels and distance sensors are combined in an joint array, resulting in a novel device to todays market. 1

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Introduction

Bi-dimensional (RGB) and tri-dimensional (Depth) imaging are perceived as fundamentally different (and somewhat incompatible) technologies. The vastest majority of computer vision algorithms in use today are designed to operate on 2D images, and most of them cannot easily be ported or adapted to a 3D point cloud. Conversely, processing algorithms for depth maps operate primarily on the geometry of the scene, as they make poor use of additional information carried by the reflectivity, or the color of the voxels. In reality, a correct mix of 2D and 3D techniques can greatly improve the efficiency and accuracy of computer vision devices and algorithms, and open the way to truly intelligent vision systems.

Method

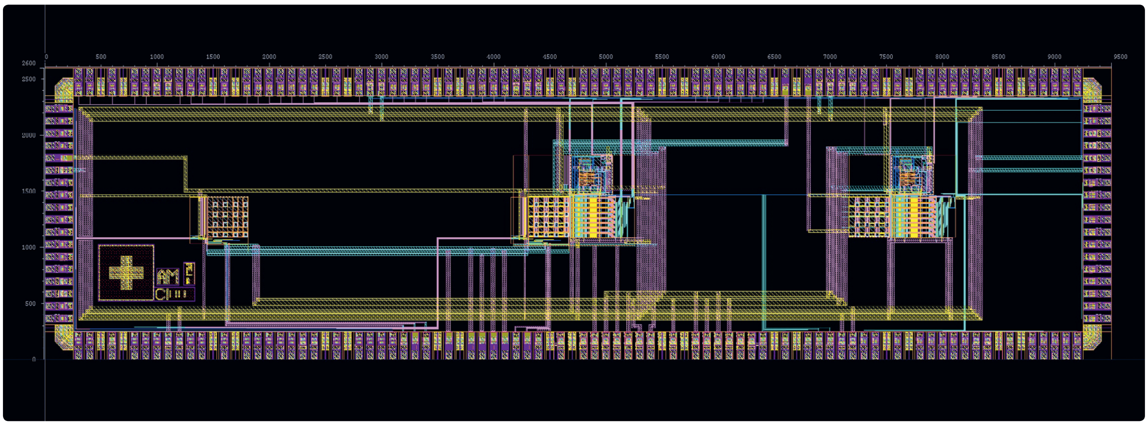
The proposed technology uses direct time of flight to measure the distance to a target.
From a proprietary laser source, a pulse is emitted onto the measuring object, reflected, and detected by time-correlated single photon counting (TCSPC) devices, so called SPAD's.
The detected laser pulse impact is measured in time, and the distance to the target can be computed.
On the other hand, common intensity pixels (RGB pixels) are used to detect the 2D-representation of the target.
Combining the SPAD and RGB pixels in a joint area removes parallax errors and provides a novel method to combine traditional 3D-point clouds with 2D-color pictures.

Result

In this project, a monolithic sensor chip was designed on a 180 nm CMOS image sensor process, where RGB pixels and TCSPC avalanche diodes are arranged in a joint array.
Additional circuitry to drive, control and readout the sensors required to achieve the experimental rate of 25 frames per second are realized.
To provide maximum flexibility and the ability to cross-check, the chip contains a TCSPC-only array, a RGB-only array and a combined array with corresponding control circuitry.

Conclusion

The desinged prototype device can be used to prove the usability of these two sensor types located next to each other, opening an entire new field for hybrid chip design.
Preliminary results showed that the achieved resolution in depth is below 8 mm.
Future work will focus on testing and verifying the circuitry, and on the design of a large-scale chip of the same character.



Layout of the monolithic sensor chip