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1 *3D-Camera in AVIGLE Flight Robot.*

AVIGLE CAMERA

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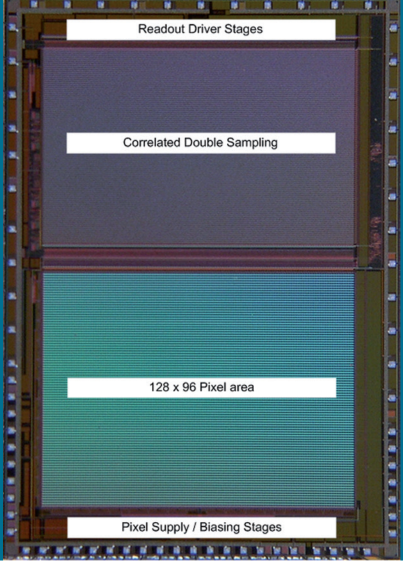
AVIGLE is aiming to provide means for faultless maneuvering in flight, requiring dedicated self-sustaining on board flight control systems. Here, new control approaches for a flight robot swarm consisting of a multitude of flight robots has been developed. In order to obtain an efficient and reliable collision avoidance scheme, a fast and robust near-field collision warning system had to be implemented in each flight robot. Radar systems using reflected radar echo measurement suffer from poor lateral resolution. The coarse data of a radar based measurement system would not be applicable for near-field manoevering of an autonomous flight robot system. Time of flight imaging shows significant advantages since the lateral resolution is much higher. Time of flight based vision sensors are able to resolve objects of at least 20 cm x 15 cm size at a distance of 7.5 meters.

Here, a special 3D Time of Flight Sensor of Fraunhofer provides near field (2 m up to 8 m) real time surveillance utilizing permanent distance control between the flight robots by emitting pulsed laser irradiation and calculating the distance from the back scattered laser light pulse.

The hardware of the camera consists of four fundamental components which all have been developed within the AVIGLE project:

- Customized 96 x 128 pixel 3D-CMOS chip with sensor electronics
- Imaging optics
- 4 x 75 W Laser modules for active infrared illumination
- Laser optics for the beam forming of the laser illumination
- Customised Ethernet IF
- Custom EIA485 IF to flight control



The mechanical assembly of these components into a common housing has been designed to be in line with the requirements of the mounting restrictions of the front nose of the flight robot. Figure 1 shows the Time of Flight camera mounted in the front part of the flight robot directly looking at the observed image scene.

Taking advantage of the accumulation capability of the floating diffusion node of the time of flight image sensor, a fixed number of back-scattered laser pulses is accumulated in each pixel. Future developments include the introduction of multiple pulse accumulation at various, but fixed accumulation numbers. Using a set of 1, 4, 8, 32 and 64 discrete accumulation steps, the signal-to-noise ratio will be further optimised for each pixel thus leading to a distance accuracy which is almost independent from the target distance, despite of the fact that the back-scattered light received by the sensor pixel decreases with the square of the distance.

In order to fulfill the reliability requirements of the outdoor time of flight operation within AVIGLE, the key specification criteria of the time of flight camera is summarized in the following table.

2 Chip Micrograph of the AVIGLE time of flight sensor.

3 AVIGLE Camera System.

Key specification date of the ToF sensor and AVIGLE camera

Distance range	0.7 m up to 7.5 m
Relative distance measurement error	< 5%
Reflectance range	5% up to 95% lambertian
Dynamic Range	75 dB (distance and reflectance range)
Frame rate	25 fps (up to 128 pulses / frame)
Minimum shutter	30 ns
NEP (30ns)	2,3 W/m^2
Background light suppression	> 40 dB
Laser wavelength	905 nm
Laser Power	4 x 75 W
Viewing angle	80 °h x 18 °v
Nominal Ocular Hasard Distance	Laser class 3R / N.O.H.D. = 120 mm
Pixel count	96 x 128
Pixel area	40 x 40 μm^2
Fill Factor	33%
Chip area	6.45 x 6.45 mm^2
Process	L035 CMOS OPTO