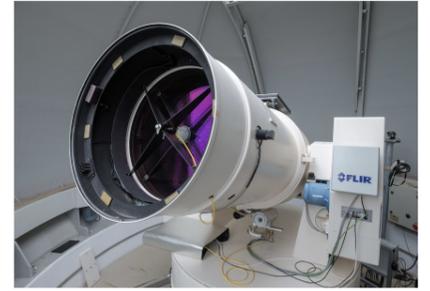


Advanced Visual Object Recognition for In-Sky-Laser Safety

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Introduction

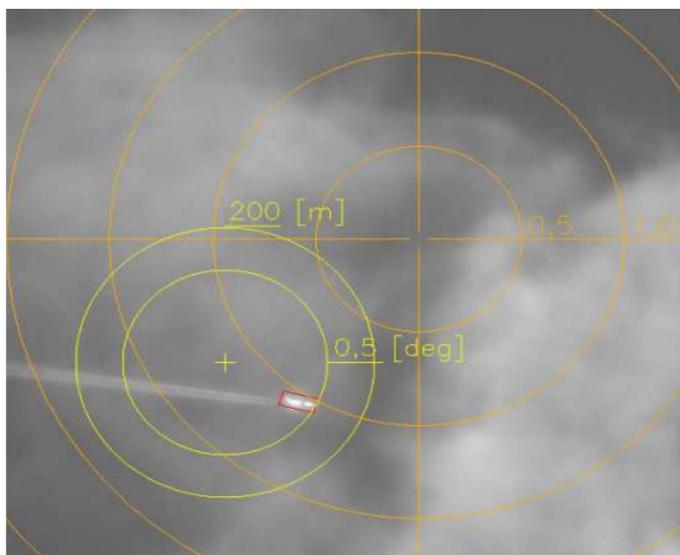
Safe SLR operation in a densely packed airspace provides a challenge both to user operated and automated ranging systems. Radar systems, slaved to the laser telescope, certainly provide important safety features. However at larger distances it is very desirable to have an extra level of safety, since the power level of the return signal of the radar system may drop to a level being too low for an unambiguous aircraft recognition. The desirable extra safety can be achieved by camera systems operating both in the visible and the infrared (IR) regime. We have designed and built an optical aircraft detection system, which is placed on the SLR transmit telescope. It operates autonomously and provides a laser inhibit when an aircraft is detected. At the same time a user alert is issued to the observer, indicating the laser shut-off state of the SLR system.

Daylight operation

The algorithm for the Smart-Cam-System developed at the Geodetic Observatory Wettzell is capable to detect flying objects (marked red) even in cloudy environment. A gradient based image segmentation algorithm separates flying objects and natural clouds. Artificial cloud condensation trails can be detected as well by shape.

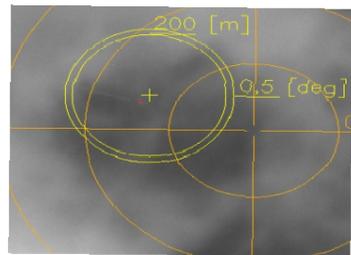
Distances of forty kilometers have been noticed so far.

Another useful feature is the verification of other sky-safety systems like ADS-B and ATC. The predicted aircraft positions provided are indicated as yellow markers in the figures below.

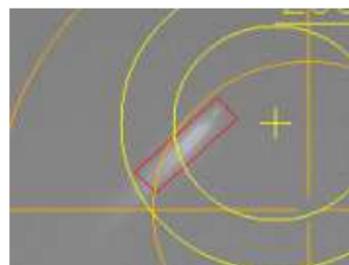


Medium-sized passenger aircraft Boeing 737 recognized by the Smart-Cam-System at a distance of 15 km.

Small business jet (Bombardier BD700, length 30 meters) detected between clouds at a distance of 24 km.



Boeing 777 (length 74 m) spotted at a distance of 40 km.



Airbus A320 (length 37 m) discovered at a distance of 34 km.

Night operation

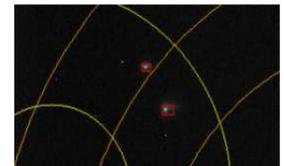
The Smart-Cam-System is also operable at night.

Any airplane flying between sunset and sunrise has to be equipped with position lights, anti-collision beacon lights and strobe lights. These aircraft position illuminations can be detected by a particular algorithm. Especially the frequently flashing anticollision strobe or beacon light is recognized over large distances. The image segmentation is based on a threshold method.

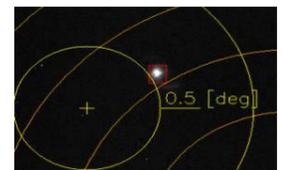
Large space objects like the moon can be identified by their well known radius.

The system switches automatically to the suitable operation mode, no user interaction is required.

Aircraft position lights detected at a distance of 10 km.



Anti-collision strobe light detected at a distance of 10 km.



Anticollision strobe light detected at a distance of 31 km.

Hardware

A weatherproof (IP65/67) high-quality camera with 2448 x 2048 pixel resolution optimized for computer vision is actually in use.

The cam operates in visible daylight as well as at night without any mechanical modifications like filters or apertures.

An eight core 3.2 GHz linux server processes the images.

The data stream from cam to server is transmitted by a TCP-IP GigE network.



Future plans

- Implementation of an infrared camera.
- Further support of an automated SLR operation by cloud detection.