Depth resolved sensor for accurate space object motion tracking

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Foreground

- The new proposed OSSS is able to obtain at once observable space object ranges and coordinates (3D data) data for further calculation of their orbital parameters in different space applications

- low earth orbit flying object observation, incl. small satellites and space debris from one observation site, no need to have very expensive observation site network.

Application

New Transportable Optical Space Surveilance Sensor (OSSS) designed for Detection and Tracking of Small size satellites, airplanes or rockets and Space debris, by the way of high energy and short laser pulse sequence, for:

- space objects finding,
- space objects tracking,
- measuring the observable space object range and coordinates (3D data in the sensor's instrumental system).

Current observation situation

Low Earth Orbit and space debris in manned space stations flight zone are controlled by diferent space surveillance systems, for example, ILRS, NORAD, but the tasks of these systems does not include not threatening (for example, known micro and nano satellites) and very small (less then some cm in diameter) object tracking

Current Satellite Laser Ranging (SLR) technologies deal with embarrassing, expenssive and time consuming distance measurements and these satellites orbits are calculated (improved) from the number of SLR stations, and result is not available immediatelly

Depth resolved Sensor development objectives

The main project objective: design and fabricate transportable Optical Space Surveilance Sensor (OSSS) for illuminating and ranging space objects with high energy and short laser pulse seguence for:

- Space object finding
- Accurate space object visible motion tracking
- Measuring the observable space object range and coordinates (3D data) at the same time in the sensor's instrumental coordinate system

Ranging ***long-range low flying platforms*** as small airplanes or rockets

As distant satellite ***free*** s***pace communication*** data link

OSSS technical performance objectives

The proposed development OSSS:

- Is fully equipped with Laser Ranging/illuminating system and Image sensor – ***switch on and work***
- The sensor's instrumental coordinate system is ***tied to Earth-fixed coordinate system*** on observation spot in real-time
- OSSS system is made ***modular*** with the possibility of interchangeability
- OSSS telescope is placed in a rotating ***astronomical pavilion***
- OSSS system measuring system is placed in climate stabilized ***operator room*** in the container
- OSSS system is simply and reliably constructed, easy dismantle and assemble, adjust and align, ***easy to move***
- Standard container is equipped with ***fixed transport boxes*** for packaging OSSS telescopes dismantled assemblies and measuring equipment and special sockets for dismantled astronomical pavilion components, assemlies and telescope support components in transport mode
- Container with a OSSS in transport mode secure system can be ***transported by sea, land and air*** vehicles

OSSS design ideology

- To be used in ***various*** space objects ***surveillance applications*** (universality)
- The sensor's instrumental coordinate system is ***tied to Earth-fixed coordinate system*** on observation spot in real-time
- OSSS system is made ***modular*** with the possibility of interchangeability of system nodes for each application
- The telescope mount configuration and the main optical system ***are unchanged*** in all applications

Telescope mount axes actuators

- Azimuthal axis turning angle: +/- 270°, speed range: from 0.1 arcsec/sec till 5°/sec, axis rotation speed in setting mode: till 10 °/sec
- Altitude axis turning angle: - 5°/+ 95°speed range: from 0.1 arcsec/sec till 3°/sec, axis rotation speed in setting mode: till 5 °/sec
- The telescope's axes are coupled with gear reducers and operated clutches to their servomotors
- Servo systems servomotors with their encoders coupled directly to servomotors axes rotate the telescope's axes; servomotors encoders produces no less then 4 encoder ticks for each arc second of telescope motion
- Servo systems data exchange rate: no less then 1,000 times per second
- The telescope axes are coupled directly to their axes rotation angle encoders (with resolution no less then 0.25 arcsec) coupled directly to the telescope's axes rotation angle measuring devices

Optical channel set-up and adjustment

- Laser Collimator optical system and Video information acquisition optical system set-up and adjustment are made with the multiaxes motorized stages (four-axis and five-axis aligners) with mounted diagonal mirrors
- The optical channels adjustment control are made regularily with permanently build in the channels auto colimating systems with video sensors
- Telescope coordinate system is related to Earth gravitation vector (in sensor location place) and so are controled its optical channels

Laser transmitter

Laser transmitter:

- The new generation laser (currently in the development stage):
- up to 10J per pulse at 1064 nm at least 10 Hz repetition rate
- < 200 ps pulse duration

SLR measurement system includes:

- high-speed light photon receiver:
- - new generation (fast) SPAD (Single Photon Avalanche Diode) detector,
- - new generation (ultra fast) PMT (PhotoMultiplier Tube),
- the new generation High-speed Event Timer (HSET) - a PC-based instrument (currently in the development stage) – for close group space object measurments: single-shot RMS resolution - better then 50 ps, measurement rate - up to 200 MHz

The Laser operation is synchronized with Video sensor and Event Timer device processing the 3D data in real time scale

OSSS system location

OSSS is placed in the single unit to facilitate and simplify the operation, maintenance and transportation locating it in the rebuilt standard shipping container

OSSS system placement include:

- rebuilt standard 20' shipping container
- mounted on the container roof folded rotating astronomical pavilion with its control system
- telescope and laser head support systems, positioned on a separate fundations
- operator room with measuring equipment is separated from the telescope
- operator room is equipped with the climate system

OSSS container with build in telescope and laser head is placed on a pre-prepared concrete foundations on the observation site

Estimated OSSS system and shelter total weight: less then 4,000 kg

The container and its contents in transport performance allows it to transport with sea, land and air vehicle

OSSS Telescope

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