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Main technical features and performance evaluation of a miniaturized test system for star trackers

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Introduction

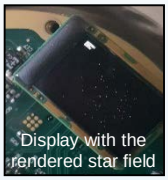
Star trackers are electro-optical devices fundamental for determining the attitude of satellite platforms. Being a critical element for every satellite mission, usually a redundant number of star trackers is mounted onboard of a platform. The test of star trackers is usually carried out by means of Optical Ground Support Equipment (OGSE), used to test both the optical characteristics of the star trackers and their internal algorithm for star recognition. Usually OGSE are designed for testing star trackers in laboratory, but their validation after onboard installation requires both the simulation of dynamic star fields and device miniaturization. The availability of such devices on the market is still very limited. Here we present MINISTAR, an OGSE prototype recently developed by a consortium of Italian enterprises and the Applied Physics Institute of the National Research Council. MINISTAR can test simultaneously up to 3 star trackers by means of the dynamic simulation of the observed star field. MINISTAR simulates the observed scene in relative motion due to the real-time simulated changes in attitude. Besides its main technical features, we present the results of a set of tests for its performance evaluation.

MINISTAR - description

MAIN REQUIREMENTS FOR THE MINISTAR DESIGN:

Fast computation, System miniaturization, System compatibility with most star tracker models available on the market


MINISTAR prototype


Display with the rendered star field

MINISTAR's main blocks:

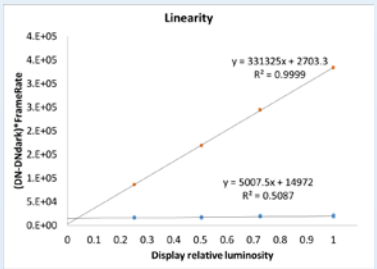
- ✓ **Star field simulation SW** provides as output the star position and corresponding magnitudes for the real-time rendering of the simulation on the display.
- ✓ **Opto-mechanical system**, includes a collimating optical system and a mechanical assembly for coupling between MINISTAR and the star tracker.
- ✓ **Processing unit and electronics**, generates the synthetic star field scene and renders it on the display allowing open and closed loop validation configurations.

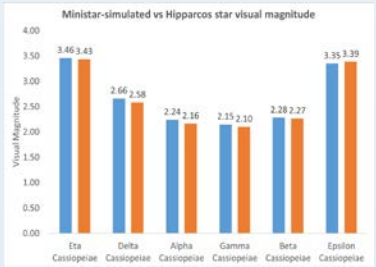
Stimulation	Functional testing of Star Tracker
Display dimensions	1920x1200 pixels
FOV	20° (± 10°)
Frame rate for dynamic scene	85 Hz
Pupil diameter	35 mm
Device dimensions	86 mm (⌀) x 150 mm (175 mm ⌀ x 150 mm with baffle flange)
Weight	< 1Kg
Alignment error	0.001°
Single Star Accuracy	0.005°
Star Catalogue	Hipparcos
Star magnitude range	4.5 ± 0.2 mag

MINISTAR - performance evaluation

Radiometric test set up

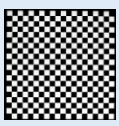
MINISTAR radiometric response was determined by comparison with a calibrated source, assuming the display emission spectral shape from datasheet.

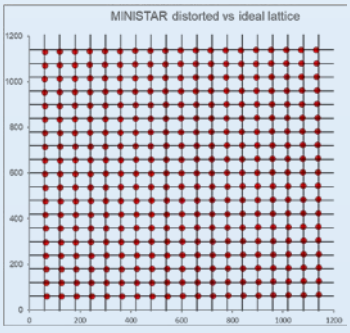




Geometric distortion test set up

A chessboard pattern projected by MINISTAR display and acquired with corrected camera was used for the geometric distortion characterization of MINISTAR





Optics-induced geometric distortion is measured by fit on a 2D polynomial transformation. The inverse transformation is real-time applied at the star coordinates, producing a distortion-corrected dynamic simulation of the moving scene.

Ideal star position map

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Inverted distortion model

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Corrected star position on display