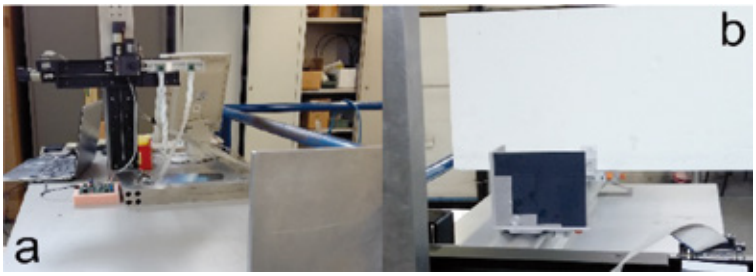
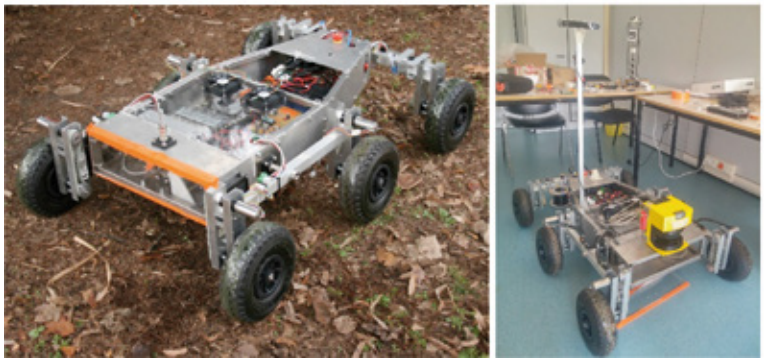
Vision based and hybrid navigation systems for vehicles, drones and satellites

In planetary exploration, the position and orientation measurement of a wheeled rover or a flying drone is a critical task, which can be performed by a stereo vision system using Visual Odometry (VO) or a Simultaneous Localization And Mapping (SLAM) algorithm. The employment of a monocular vision system, instead of a stereo rig, could be very interesting, since it is lighter and far more compact. However, monocular vision systems have the drawback that they are not able to properly evaluate the scale of the measured trajectory. For this reason, a sensor fusion (or hybrid) approach employing a monocular RGB camera plus an auxiliary sensor for scale evaluation seems particularly promising. In our laboratory, different hybrid systems comprising an RGB camera and depth sensors, such as a Time of Flight (ToF) camera or 2D/1D Light Detection And Ranging (LiDAR) systems, are investigated. Before the hybrid system can be used for navigation, each camera or sensor has to be individually calibrated, i.e. intrinsic parameter evaluation, and then also the extrinsic parameters have to be determined, i.e. the relative position and orientation between the ToF and RGB cameras. The figure below depicts an experimental set-up for the joint calibration of a stereo RGB camera and a ToF camera.



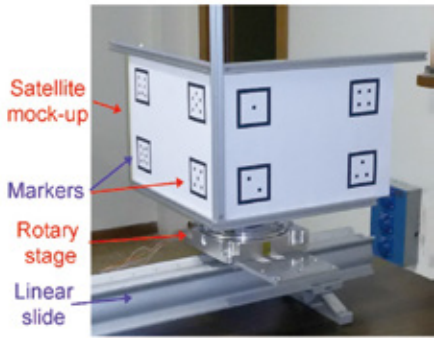
Several instrument calibrations have been carried out for hybrid systems.

Visual and depth instruments for navigation have been applied to a wheeled rover, developed together with engineering students and employed also in the PANGEA project of the European Space Agency.



In space, there are several scenarios that require an accurate measurement of the relative position and orientation (pose) between two spacecrafts, as the autonomous rendezvous and docking for on-orbit servicing, or between a spacecraft and a target, as position evaluation of a tip-mass during the deployment of an electro-dynamical tether. A vision based instrument able to measure the position and orientation of a spacecraft has been.

Calibrated from a metrological point of view. The instrument comprises a simple camera which observes the external surface of the satellite provided with fiducial markers and a software procedure which combines together a closed-form and direct solution of the Perspective from three Points problem, a non-linear optimization and bundle adjustment.



Misure per lo spazio
Measurements for space

DII research group

Mechanical and Thermal Measurement

Marco Pertile
marco.pertile@unipd.it
Phone: +39 049 8276798

www.dii.unipd.it

The research activities are carried out with the Mechanical and Thermal Measurement research group, at the Department of Industrial Engineering - Padova University, which is led by Prof. Stefano Debei and Prof. Enrico Lorenzini and comprises Dr. Sebastiano Chiodini, Dr. Riccardo Giubilato, Dr. Mattia Mazzucato, Dr. Andrea Valmorbida. Some research activities about position and attitude measurement are performed in collaboration with ALTEC s.p.a. - Torino.

Main research topics:

- Measurement of position and attitude of a vehicle or drone with hybrid measurement systems comprising cameras and other instruments such as ToF cameras, LiDARs, Inertial sensors, GNSS instruments.
- Metrological calibration of hybrid measurement systems.
- Analysis and development of algorithms for vehicle or drone navigation in GPS-denied environments, such as mono or stereo VO, and SLAM with vision systems or depth measuring instruments (e.g. ToF cameras, LiDARs).
- Measurement of relative position and attitude between two spacecrafts or between a spacecraft and a target using visual systems.