POLITECNICO DI MILANO

PhD in INGEGNERIA AEROSPAZIALE / AEROSPACE ENGINEERING - 39th cycle

THEMATIC Research Field: VISION-BASED AUTONOMOUS NAVIGATION FOR PROXIMITY OPERATION ON GEOSTATIONARY TRANSFER ORBITS

Monthly net income of PhDscholarship (max 36 months)
€ 1400.0 In case of a change of the welfare rates during the three-year period, the amount could be modified.

Context of the research activity	
Motivation and objectives of the research in this field	GEO Satellite operators have traditionally chosen to opt for a GTO deployment, raising their orbit using an onboard propulsion system. This orbit-raising system is generally heavy (20 % of the mass) and used only once in the lifetime of the satellite despite representing 10 % of its costs. Recent market trends have shifted towards smaller GEO satellite platforms driven by several technological and commercial advantages. This small segment of GEO platforms offers greater flexibility in terms of development and deployment, improved time to market, and significantly lower capital expenditures compared to traditional GEO platforms. However, many of the small GEO platforms presently under development lack the capability to hold enough fuel to raise their orbit, and even if they could, it would take more than eight months to achieve orbit raising using electric propulsion. This exposes the satellite platform to an extended period in the Van Allen belts, known for high radiation levels that can potentially damage the satellite. As a result, access to the GEO orbit through Reusable and Refuellable Orbit Transfer Vehicles is becoming increasingly crucial. Orbit Transfer Vehicles (OTVs) will enable more efficient use of satellites by allowing operators to adjust their orbit to match their mission requirements. By eliminating the need for dedicated launch vehicles for each satellite, OTVs can enable faster and more cost-effective transfer of assets between GTO and GEO, increasing the overall efficiency and sustainability of space operations. OTVs on GTO will

	need to be able to perform proximity operations for rendezvous, docking and refuelling, on high elliptical orbits (like GTO), which require the use of vision-based autonomous navigation toward other satellites. In order to enable recurring missions with a new customer target, or refuelling the vehicle, thus performing several logistics lifecycles, innovative vision-based navigation algorithms should be considered when dealing with targets of general shape with variable illumination conditions, and in fully non-linear relative dynamics (high eccentricity).
Methods and techniques that will be developed and used to carry out the research	The activity will start with a review of the current approaches to the solution of the vision-based navigation problem for proximity operation around cooperative targets. In parallel, a review of the technological solution currently adopted for sensors will be conducted, focusing also on the dynamics modelling framework most suitable for the navigation problem. The activity will proceed with the study of the navigation problem, in which optical sensors will be exploited to derive the relative pose measurements, eventually considering variable baseline stereo cameras and IR cameras. The absolute position sensor suite onboard can be used to identify the position of the sun and hence the expected illumination conditions of the target. The information will be included in the navigation loop, to make the image processing and feature extraction more robust. To provide additional depth information, a second sensor can be included in the system. If another monocular camera is considered, the relative navigation sensor will constitute a variable baseline stereo camera. To reduce the dependence of standard monocular sensors on the relative position between target/chaser/sun, the inclusion of a second IR sensor can be considered. To use an infrared sensor, it will be necessary to devise an innovative data fusion module. In fact, this sensor typically provides low-resolution images that will need to be suitably processed to extract the largest number of information possible: depth if both sensors can acquire data, and angles only in case of an eclipse.
Educational objectives	The main educational objectives are: - the acquisition of a

	solid background on cutting-edge methodologies for navigation of satellites in the proximity of cooperative targets; - the development of skills in advanced numerical methods, software engineering and data-analytics techniques; - the development of key capabilities in the fervent area of GNC for proximity operations (docking, refuelling, inspection, active debris removal, on-orbit service, etc.).
Job opportunities	The research will be developed in the framework of a Horizon Europe Research Project: GEORyder: Giving Back Access to the GEO Orbit Through a Reusable Kickstage Vehicle Allowing Transfer from GTO to GEO. The project sees the participation of partners involved both in the design of OTVs and in small GEO platforms. This will offer networking opportunities for the candidate in the industrial sector which may better exploit the research results and that will need the long-term support of experienced professionals in the field.
Composition of the research group	0 Full Professors 2 Associated Professors 2 Assistant Professors 12 PhD Students
Name of the research directors	Prof. Mauro Massari

Contacts
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Additional support - Financial aid per PhD student per year (gross amount)	
Housing - Foreign Students	--
Housing - Out-of-town residents (more than 80Km out of Milano)	--

Scholarship Increase for a period abroad	
Amount monthly	700.0 €
By number of months	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information

The PhD candidate will receive a desk, possibly through a hot-desking procedure, and a personal computer, if needed. Apart from the compulsory ones, the PhD candidate will have the opportunity to follow additional courses and receive economic support to attend summer schools and participate in conferences. There will be the possibility of paid teaching assistantship.