POLITECNICO DI MILANO

PhD in ARCHITETTURA, INGEGNERIA DELLE COSTRUZIONI E AMBIENTE COSTRUITO / ARCHITECTURE, BUILT ENVIRONMENT AND CONSTRUCTION ENGINEERING - 38th cycle

THEMATIC Research Field: SEMANTIC PHOTOGRAMMETRY AND VISUAL MOBILE MAPPING FOR REAL-TIME 3D APPLICATIONS

Monthly net income of PhDscholarship (max 36 months)
€ 1275.0
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	**Motivation** There is a growing need to digitize information and track changes over time in today's world of construction and infrastructure monitoring. These changes can be manmade, such as those caused by site progress, and hence must be observed on a weekly basis. Natural changes, such as those related to degradation over time, must, on the other hand, be documented annually, if not monthly or weekly. Detecting these changes necessitates the employment of dynamic acquisition technologies that allow for the gathering of not just shapes and measurements, but also information valuable for explaining the processes under investigation. Nowadays, not only must the acquisition be quick, but the finished digital result must be available in real-time or near-real-time, and on its whole. Only in this way real-time change detection and easier data updating will be facilitated by allowing for automated or semi-automated data updates in a continuous information system. **Objectives** Real-time measurements and data collections are still an outstanding challenge, which this thesis program will assist in solving both the surveying and data retrieval and

	referencing aspects. The goal of the PhD research is to extend an innovative, portable, lightweight 3D surveying instrument developed in previous PhD activities at the Politecnico di Milano's ABC Department. The prototype uses a photogrammetric technique to acquire scenes of any shape, resulting in a scaled 3D point cloud of the surveyed environment. The system demonstrated its efficiency and reliability in a variety of applications. As a follow-up, the PhD's goal is to resolve two still open research problems: i) to speed up the digitalization process and ii) to aid data retrieval by using tools that automatically analyze data. In the first step of the research, the candidate will work on automatic real-time image orientation based on V-SLAM techniques. The second step will focus on the integration of machine/deep learning techniques to build a real-time image classification process to help with the automatic referencing of data and info on the 3D digital copy.
Methods and techniques that will be developed and used to carry out the research	The following are some of the approaches and procedures that will be created and used in the research 1.**V-Slam Techniques** for **Real-time images orientation** of a multi-camera system; 2.**photogrammetric techniques**, in particular dealing with the orientation of a huge number of images coming from a **dynamic multicamera system**; 3.**Artificial Intelligence** techniques **(machine learning and deep learning)** for real-time or near real-time image classification and transfer to the 3D data. The candidate will conduct the research with the 3DSurveyGroup of the Politecnico di Milano, ABC department, and with the 3DOM group of the Fondazione Bruno Kessler (FBK) in Trento, Italy. The Trento research group has demonstrated research experience in the topics covered, ranging from automatic navigation using image techniques to photogrammetric acquisition in dynamics to point cloud classification using AI techniques, and will thus be a key partner for the theoretical part of the project as well as the development of V-slam and classification

	methods. Within the 3DSurvey Group, the applicant will continue to develop the prototype of the multi-camera photogrammetric system that was developed as part of a previous PhD subject.As a first step, the candidate should approach the above concerns from a theoretical standpoint by designing code and methodologies for a multi-camera photogrammetric system in a generalized manner. Throughout the three-year PhD program, real-life examples and projects will be used to confirm the theoretical work. In the second part, the candidate will be required to interact with a real-world case from the construction and building industry, namely, monitoring the progress of a huge construction site. This is a representative case study that will highlight and validate scientific work. Filling up "work progress reports" on a major construction site is still a completely manual process that takes time. In this field, mobile lidar+image acquisition technologies have been tested with positive results in real-time 3D acquisition (albeit reliability may be improved!). As a result, while these technologies allow for continuous and recurring data collection throughout time, they do not allow for automatic data interpretation, rendering the entire process ineffective and requiring manual data interpretation. The PhD program's goal is to overcome the problem of mobile lidar systems' lack of repeatability and reliability by developing an image-based method and transitioning the measuring system into a data/information collection system.
Educational objectives	The educational objectives are focalized mainly in: 1.Mobile mapping systems, LIDAR and image-based techniques; 2.V-SLAM techniques for automatic image alignment 3.AI techniques (machine learning and deep learning)

	applied to image understanding; 4. Data referencing (GIS-BIM-Information Platform); and 5. 3D dense point clouds treatments: visualization and data referencing.
Job opportunities	Artificial Intelligence techniques such as Machine Learning end Deep Learning as well as V-Slam techniques are the more actual topic in the field of 3D Digitalization, autonomous navigation, and 3D visualization (MR-ER). The experiences done during this PhD can open the door to all these international job realities.
Composition of the research group	1 Full Professors 3 Associated Professors 0 Assistant Professors 7 PhD Students
Name of the research directors	Prof. Francesco Fassi, Dr. Fabio Remondino

Contacts
Prof. Francesco Fassi phone: 02 2399 6532 email: francesco.fassi@polimi.it

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	637.5 €
By number of months	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information
Scholarship co-funded by Politecnico di Milano, ABC Department, and Fondazione Bruno Kessler (FBK). **Additional information can be found in the Regulations for the 37th Cycle of ABC-PhD:** download is available at link: *https://beep.metid.polimi.it/web/abcphd/documenti-e-media*

Additional information about ABC department and ABC-PhD programme:
available at link:
https://www.dabc.polimi.it/

Additional support for the research activity:
a total amount of 5.197,62 Euros per student, available since the first year, to be spent according to the department rules.

Desk availability:
the ABC department provides non-permanent desks to be temporarily booked in common PhD rooms. In particular, the activity related to this scholarship will be partially developed at 3D Optical Metrology Unit (3DOM) of FBK in Trento (https://3dom.fbk.eu/).