



PhD in INGEGNERIA DELL'INFORMAZIONE / INFORMATION TECHNOLOGY - 38th cycle

Research Area n. 4 - Telecommunications

PNRR_352 Research Field: CHANGE DETECTION AND PHASE ESTIMATION IN LARGE
INSAR DATASETS

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**

Over the last two decades, Synthetic Aperture Radar (SAR) data have been used successfully for the study of surface deformation phenomena (e.g. landslides, subsidence, sinkholes) and for monitoring various assets and infrastructures (e.g. pipelines, bridges, ...), by applying interferometric techniques (InSAR) to long temporal series of radar images acquired over the same area of interest.

These algorithms aim to identify a set of coherent points on ground exhibiting a stable radar return with time (the so-called Permanent or Persistent Scatterers, PS). These points usually correspond to rocks, outcrops, boulders or man-made objects like metallic poles, buildings, antenna, etc. Whenever the spatial density of PS is high enough, it is possible to estimate their relative motion and extract their range variations with an accuracy dependent on the frequency of the radar sensor, but usually better than 1 cm.

SAR data is also a key information source for change detection (CD). Coherent and incoherent change detection algorithms have been widely used for both civilian and military applications.

The main objective of this PhD program is to develop new SAR data processing algorithms where CD and InSAR become two outputs of a single processing chain.



	<p>In fact, the availability of very long temporal series of satellite SAR data makes it necessary to cope with changes in the location and the characteristics of the points where InSAR can work. The analysis of changes in the radar scenes, apart from being an information source per se, can help the estimation of the "optimum phase values" when multi-interferogram techniques are applied, which is sometimes compromised by reflectivity changes. The final target will be the detection of all major changes in a multi-temporal SAR data-stack and, for each image pixel, the identification of the different time periods where InSAR data can be used successfully.</p>
<p>Methods and techniques that will be developed and used to carry out the research</p>	<p>The analysis will start from the analysis of the algorithms already developed by TRE ALTAMIRA and POLIMI. First, the limitations of the current version of the SqueeSAR algorithm (patented by POLIMI and TRE in 2011) will be studied in detail, assessing the impact of reflectivity changes on InSAR measurements. Then the current procedures for the identification of changes in pointwise and distributed scatterers will be reviewed: the analysis will consider both CD algorithms based on conventional statistical signal processing as well Machine Learning (ML) algorithms based on neural networks. After the analysis of the techniques used by TRE ALTAMIRA/POLIMI and a thorough review of the scientific literature, the candidate is expected to propose, in agreement with the research group, a set of improvements which should allow the introduction of change detection algorithms in the processing chain and the identification of the so-called "Temporary Scatterers" (TS). In this context a "change" will be defined as a variation of the reflectivity values of a certain pixel (or set of pixels) that makes it impossible to retrieve a unique (continuous) time series of phase values. The target is then the estimation, on a pixel-by-pixel basis, of the number of different "objects" present in the resolution cell at different times, as well as the use of InSAR techniques for monitoring their displacements.</p>
<p>Educational objectives</p>	<p>The candidate is expected to learn: - SAR interferometry & InSAR techniques</p>



	<ul style="list-style-type: none"> - Multi-interferogram InSAR techniques (SqueeSAR, SBAS, PSI) - Change detection algorithms (for PS and DS) - Statistical signal processing - Machine Learning algorithms for change detection - Basic of Cloud computing & parallelization of signal processing algorithms
Job opportunities	<p>Provided that the results of the research will offer a concrete contribution to the improvement of the monitoring services offered today, at the end of the PhD program, TRE ALTAMIRA will offer to the candidate a permanent position.</p>
Composition of the research group	<p>1 Full Professors 0 Associated Professors 0 Assistant Professors 1 PhD Students</p>
Name of the research directors	Prof. Andrea Monti Guarnieri

Contacts	
<p>andrea.montiguarnieri@polimi.it, +393470022905, https://www.deib.polimi.it/ita/personale/dettagli/282280</p>	

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

National Operational Program for Research and Innovation	
Company where the candidate will attend the stage (name and brief description)	TRE ALTAMIRA Srl Settore di attività: servizi di telerilevamento satellitare https://tre-altamira.com
By number of months at the company	6
Institution or company where the candidate will spend the period abroad (name and brief description)	TRE ALTAMIRA, a Vancouver (BC)
By number of months abroad	6



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

Attinenza alle tematiche, alle missioni/componenti prescelte del bando PNRR v. D.M. 352, art.6

L'Italia vede nel settore Spazio un settore strategico per le sue politiche economiche e di Innovazione. Le attività di studi sono mirate a migliorare ed avanzare sistemi osservazione della Terra dallo spazio, e rientrano nella linea di investimento 4, in particolare la linea d'azione classificata dal PNRR come "Osservazione della Terra". Si tratta di osservazioni da sistemi Radar ad apertura sintetica, dove l'Italia ha già sviluppato un'eccellenza, si pensi alla costellazione nazionale COMSO-SKYMED, e si impegna nel PNRR "a potenziare i sistemi di osservazione della terra per il monitoraggio dei territori". Le attività del dottorato proposto sono finalizzate alle osservazioni di deformazioni millimetriche, su larga scala, spaziale e temporale. Si attendono pertanto dei risultati nel campo di stime e previsioni di frane, e di osservazioni di infrastrutture critiche (edifici, ponti autostradali e ferroviari, ecc), che rispondono alle missioni "M2C4: tutela del territorio e risorsa idrica" e "M3: rete ferroviaria ad alta velocità/sicurezza".

Impresa, presso cui si svolgerà l'attività esterna

TRE ALTAMIRA Srl

il dottorando potrà usufruire del Centro Elaborazione Dati di TRE ALTAMIRA, coordinarsi con il gruppo interno di ricerca e sviluppo e avere accesso all'archivio di dati radar satellitari, che ad oggi ha già superato le 250.000 immagini. La sinergia con l'impresa permetterà anche di indirizzare meglio gli sforzi verso soluzioni che possano trovare concreta applicazione nei servizi di monitoraggio satellitare offerti a clienti pubblici e privati.

Azienda presso cui si svolgerà il periodo di studio e ricerca all'estero

All'interno del triennio è previsto un periodo di 6 mesi presso la sede di Vancouver (BC) di TRE ALTAMIRA, che gestisce il maggior numero di progetti relativi a problematiche di Change Detection, periodo che permetterà al candidato di capire meglio i requisiti utente. Si stanno valutando ulteriori periodi di formazione all'estero, presso l'ALASKA SAR FACILITY, a Fairbanks (AK), per approfondire alcune tematiche relative al cloud computing, e presso il DLR (ente spaziale tedesco), con cui si sono già avuti in passato scambi e collaborazioni, che favorirebbe invece un approfondimento delle tematiche più teoriche del percorso di dottorato.

All information regarding educational activities, personal funding, regulations and obligations of Ph.D. candidates are available on the web site <https://dottoratoit.deib.polimi.it/>