Master in Telecommunication Engineering: Specialization (Orientamento)

Remote Sensing and Radar

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Introduction

Rete di Telecom Commerciale

Ka Crosslink

Ka Crosslink

Sensore multispettrale

Sensore multispettrale

Gateway

Comm Gateway

Stazione di Ricezione Utente

Sito di Fusione Dati, Elaborazione e Archiviazione

Elaborazione Locale

Rete di Telecom Commerciale
Skills and Know-How

- Design of advanced remote sensing systems (active and passive systems; satellite, airborne, UAV, and terrestrial systems).

- Design advanced active systems (radar, lidar, sonar) for different applications (air traffic control, environmental monitoring, meteo nowcast and forecast, sea monitoring, biomedical, etc.).

- Design of integrated communication systems (remote sensing, radar, GIS, radiolocalization, etc.) for surveillance, detection and environmental monitoring.

- Design of satellites systems and their use in Earth observation, telecommunication and planetary exploration.

- Design of multiplatform systems (satellites UAV, airplanes, sensor networks) for telecommunications.
Skills and Know-How

- Detailed knowledge of technologies related to satellite radiolocalization (e.g., GPS).
- Basic knowledge of the GIS (Geographic Information Systems) technology.
- Design of advanced environmental monitoring systems that integrate different technologies of telecommunications.
- Design of multidimensional signal processing, image processing and pattern recognition methods and algorithms.
- Systems and methodologies for the analysis of Big Data.
- Techniques for 3D modeling and multidimensional visualization.
- Design of multisensor data analysis systems and of data fusion methodologies.
Application Domains

- Environmental Monitoring
- Climate change
- Urban planning
- Big Data
- Water reservoir
- Resource Exploration
- Civil protection
- Automotive
- Air Traffic Control
- Snow and Ice
- Image Time Series
- Smart cities
- Stratigraphy
- Damage Assessment
- Biomedical
- Monitoring Urban Areas
- Emergency Response
- Risk Assessment
- Detection and Estimation
- Forest management
- Meteorology
- Imaging
- Planetary Exploration
- Precision Farming
- Food
- Earth Observation
- Surveillance and Infrastructure monitoring
- Agriculture
- Heat fluxes
- Planetary Exploration
- Climate change
- Urban planning
- Big Data
- Water reservoir
- Resource Exploration
- Civil protection
- Automotive
- Air Traffic Control
- Snow and Ice
- Image Time Series
- Smart cities
- Stratigraphy
- Damage Assessment
- Biomedical
- Monitoring Urban Areas
- Emergency Response
- Risk Assessment
- Detection and Estimation
- Forest management
- Meteorology
- Food
- Earth Observation
- Surveillance and Infrastructure monitoring
- Agriculture
- Heat fluxes
Courses

The specialization take specific advantage from the background given by the mandatory courses on “Digital Signal Processing” and “Recognition Systems”. The full path of the specialization includes the following optional courses:

- Sistemi di Telerilevamento (Remote Sensing Systems) (6 cdt, II semester, every year);
- Advanced Remote Sensing Systems for Environment (6 cdt, I semester A.A. 2015-2016);

More information on the optional courses is provided in the next slides with the purpose to allow the students to make a proper choice.
Sistemi di Telerilevamento (6 cdt)

General Concepts
- Introduction to remote sensing systems
- Radiation theory
- Sun and Earth emission properties
- Atmospheric windows
- Spectral regions used in remote sensing
- Spectral signature
- Architecture of remote sensing systems
Acquisition Process

- Remote sensing platforms;
- Satellites for telecommunication and remote sensing;
- Ground segment and space segment;
- Passive and active sensors for remote sensing;
- Multispectral and hyperspectral sensors;
- Radar imaging sensors;
- Geometrical and spectral resolution;
- Acquisition architectures;
- Main satellite missions for remote sensing.
Remote Sensing Image Analysis

- Basics on multidimensional image processing;
- Radiometric and geometric distortions and corrections;
- Image registration;
- Image filtering;
- Segmentation and texture extraction;
- Multispectral and hyperspectral image processing;
- Radar image processing.
Automatic data recognition
✓ Architecture of automatic recognition systems;
✓ Pre-processing and feature extraction;
✓ Discriminant functions and machine learning;
✓ Automatic classification techniques:
  • Statistical approaches;
  • Artificial neural networks;
  • Support vector machines;
✓ Change detection techniques.
Sistemi di Telerilevamento (6 cdt)

Remote sensing applications

- Environmental monitoring
- Risk assessment and civil protection
- Resource monitoring
- Agriculture (shift of cultivation, production estimation, etc.)
- Meteorology (atmosphere dynamic, weather forecast, estimation of precipitations intensity, etc.)
- Thematic map production
- Planetary exploration
Advanced Remote Sensing Systems for Environment (6 cdt)

✓ Remote sensing and situ sensing;
✓ UAV remote sensing systems;
✓ Payloads for UAV systems;
✓ Planning of acquisitions with UAV systems;
✓ Integrated Earth observation;
✓ Data fusion and data assimilation.
Advanced Remote Sensing Systems for Environment (6 cdt)

✓ Advanced approaches for the design of satellite missions:
  • Basics of space environment;
  • Analysis of mission constraints;
  • Architecture of a satellite system;
  • Risk analysis.
Orbital mechanics;
Power, structural and thermal design;
Propulsion;
Case study (example of real missions studied in detail).
✓ GPS and Differential GPS.
✓ Basics of geographical information systems.
✓ Basics of data representation and 3-dimensional visualization.
Advanced Remote Sensing Systems for Environment (6 cdt)

- Analysis of multitemporal optical and SAR images;
- Analysis of time series of data;
- Multiscale image processing;
- Multisensor architectures.

Loss of vegetation

Re-vegetation

NDVI

1989 1997

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Advanced Remote Sensing Systems for Environment (6 cdt)

- 3D acquisition with Synthetic Aperture Radar (SAR);
- SAR Interferometry;
- Differential interferometry;
- Persistent scatters;
- SAR tomography.
Interferogramma co-sismico del terremoto de l’Aquila, 6 aprile 2009
L’immagine mostra l’interferogramma co-sismico tra due acquisizioni SAR (febbraio 2009 la prima, aprile 2009 la seconda), raffigurante le deformazioni superficiali indotte dal sisma. Lo spostamento è rappresentato su scala circolare, ad ogni trancha intera corrisponde uno spostamento di 28mm.
L’interferogramma è stato sovrapposto ad una immagine ottica solo per comodità di visualizzazione.
Dati satellitari Envisat (Febbraio 2009 - Aprile 2009), Immagine di sfondo: Google Earth.
Image 3 of 6.
Nell'immagine è rappresentata la velocità media di deformazione dei bersagli radar (PS) individuati nella zona in esame. I dati si riferiscono all'arco temporale 1995-2000. Le velocità dei PS sono saturate tra -5 (rosso) e +5 (blu) mm/anno.
Design of systems for:

- **Environmental Monitoring** (i.e. forestry, agriculture, glaciers, climate change, etc.);
- **Civil protection** (risk monitoring and damage assessment for landslides, subsidence, forest fires, floods, earthquake, etc.);
- **Infrastructure monitoring** (e.g. buildings, bridges, man-made structures, etc.);
- **Surveillance at detailed scale** (e.g. industrial areas, ports, airports, etc.).
Integrated multisensor and multisource civil protection system (forest fires).
Example: Images acquired before (5th April 2009) and after (12th September 2009) the earthquake of L’Aquila (Italy, 6th April 2009).

- 1m×1m resolution
- X-band
- 1-look
- Amplitude
- HH-polarization
- 57-58 degree incidence angle
- Ascending orbit
- Right look
- CSKS1
- Calibrated
- Co-registered
- Geo-referred

Backscattering decrease  Backscattering increase  Unchanged areas

Advanced Remote Sensing Systems for Environment (6 cdt)

Pre-Crisis Reference Image

Post-Crisis Reference Image

- Destroyed Building
- Change (no destroyed building)
Introduction to active systems; Basic concepts; Illumination sources, signals, applications; Taxonomy of active systems; Examples of active systems.

Basics of microwave active systems; Surveillance radar systems; Radar tracking; Doppler radar; Radar signal processing.
Radar Systems for Civil Air Traffic Control
- Architecture of a system for civil air traffic control;
- Interaction between primary and secondary radar;
- Transponders;
- Communication via secondary radars;
- Radar standards.
Meteorological Radar

- Meteorological radar;
- Reflectivity targets;
- Equation of meteo radar;
- Polarimetric radar;
- Meteorological signals;
- Analysis of meteorological signals.
Ground Penetrating Radar and Radar Sounder
✓ Architecture of the system;
✓ Georadar;
✓ Low frequency radar sounders;
✓ Applications (geology and ice monitoring, planetary exploration, pipeline detection, etc.).
Ultra-Wide Band (UWB) Radar

- Radar UWB technology;
- Radar UWB anticollision (e.g. automotive);
Lidar systems
✓ Basics on optical active systems;
✓ Basic concepts;
✓ Equations and architecture;
✓ Lidar for atmosphere monitoring;
✓ Lidar for land monitoring;
✓ Lidar for speed control (e.g. autovelox).
Radar and Radiolocalization (6 cdt)

15 July 2001

15 September 2001
Sonar and Sidescan Sonar
✓ Basics of acoustic active systems;
✓ Array and beam pattern;
✓ Sonar signals;
✓ Noise in sonar systems and sonar equation;
✓ Sidescan sonar;
✓ Application of sonar.
Ecographic and Eco-Doppler systems

- Basics on ultrasonic systems;
- Equations and architecture;
- Acoustic propagation in tissues;
- Ultrasound signal processing;
- Applications.
Remote Sensing Laboratory

Staff
✓ Prof. Lorenzo Bruzzone (Director)
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✓ Dr. Claudio Persello
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More Information @.....

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