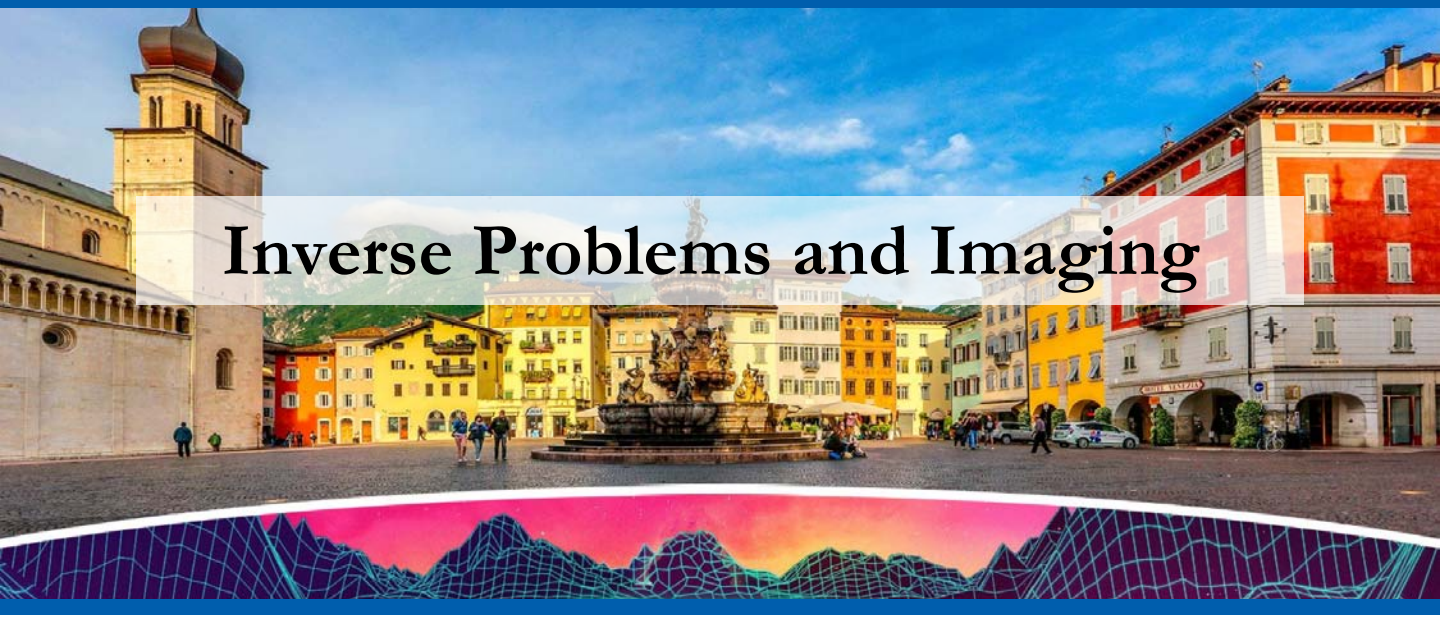
2024 ELEDIA@ICAM PhD Summer Schools



Inverse Problems and Imaging

Inverse problems (IPs) have been traditionally considered as mathematically challenging because they are intrinsically ill-posed. Imaging problems are a class of IPs with many practical applications in a variety of engineering disciplines, ranging from biomedical diagnostics to industrial non-destructive testing, up to geophysics and security screening, just to mention a few. Such IPs require suitable mathematical tools for their robust/stable solution in order to recover the well-posedness typical of forward/direct problems through suitable regularization and information-acquisition/exploitation techniques.

The course will review fundamentals and main issues of IPs, then focusing on classical/ state-of-the-art and recently introduced inverse solution procedures and algorithms, with main emphasis on the techniques for imaging and localization. Applicative examples including exercises will corroborate the theoretical concepts.

Course Topics
- Introduction and basics: motivations (methodological, applicative), imaging problems in engineering as IPs;
- Formulation of IPs and numerical techniques for dealing with their resolution;
- Non-linearity and ill-posedness: on the role of information in IPs;
- Non-linearity: physical meaning, degree of non linearity, the role of a-priori/available information;
- Ill-posedness and the need for regularization;
- Solution of IPs as minimization/maximization of a cost-function/functional;
- Multi-resolution and information-acquisition strategies as an effective recipe to counteract ill-posedness and non-linearity;
- Numerical techniques for imaging problem solving in biomedical and industrial contexts;
- Applicative examples including exercises regarding specific engineering applications.

Teaching Activities
- Theoretical Lessons
- e-Xam Self Assessment (each teaching class or periodically)
- MATLAB Hands-On
- e-Xam Final Assessment

Lecturers
- Dr. ANSELMI Nicola (https://www.eledia.org/eledia-unitn/people/anselmi-nicola)
- Prof. MASSA Andrea (https://www.eledia.org/eledia-unitn/people/massa-andrea)
- Dr. SALUCCI Marco (https://www.eledia.org/eledia-unitn/people/salucci-marco)

References

[1] M. Bertero and P. Boccacci, "Introduction to Inverse Problems in Imaging". IoP Press, 1998.
[2] F. D. Moura Neto, A. J. da Silva Neto, "An Introduction to Inverse Problems with Applications". Springer, 2013.
[3] M. Pastorino and A. Randazzo, "Microwave Imaging – Methods and Applications". Artech House, 2018.

Dates: July 22-26, 2024

Location
- *In presence*: Polo di Mesiano, Via Mesiano 77, 38123 Trento, Italy
- *Online*: Zoom Platform (video registrations will be available for 2 weeks after the event)

Lessons
- 32 h total (including exam – not mandatory)
- 12 h hands-on (in Matlab)

Prerequisites: Basics of maths

ECTS: 4

Registration Fees (*)
- Free for UniTN Students
- 200 Euro - online attendance
- 400 Euro - in presence attendance

Registration is mandatory

Course Coordination
- Prof. MASSA Andrea

Further Information
- summer-schools@eledia.org

(*) The fees include the course teaching and the slides/material

Register at: https://edu.eledia.org/courses/phd-school-2024-inverse-problems

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