UNIVERSITÀ
DEGLI STUDI
DI PADOVA

Real-time simulation and computational inverse problems

Dipartimento di Matematica "Tullio Levi Civita"

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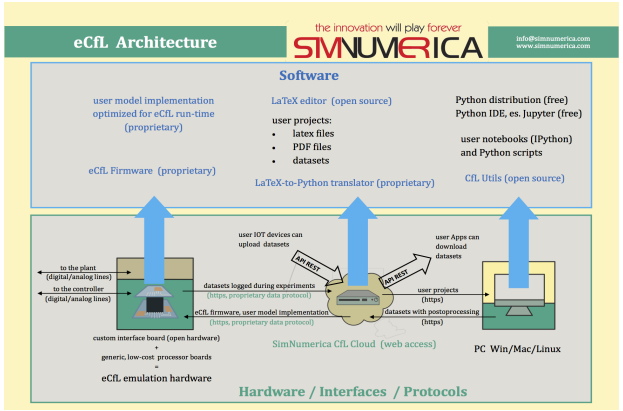
Real-time Simulation

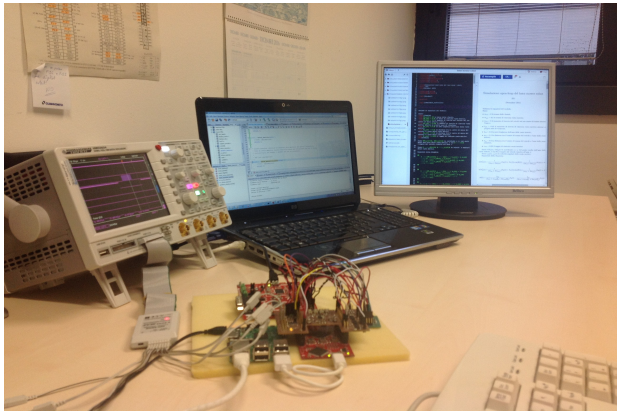
for virtual prototyping and fault-detection

Real-time Simulation
for virtual prototyping and fault-detection

Through the spin-off SimNumerica we have developed a real-time simulation platform for low-cost embedded applications, eCfL, which is:

- **a low-power HIL**
- **based on LaTeX and Python: free, state-of-the-art, high-level modelling and programming languages**
- **open hardware**
- **remote op: IoT, Cloud Computing**
- **synergetic with other platforms (Matlab/Simulink, LabVIEW)**





To see more about the eCfL platform ...

http://www.simnumerica.com/

The eCfL platform is designed for ...

System modelling and hardware prototyping

Mathematical equations: ODE/DAEs, PDEs, DLTI systems mixed with Python scripts

Control Firmware Development

Analyze the interactions between the running firmware and the controlled system in reproducible settings

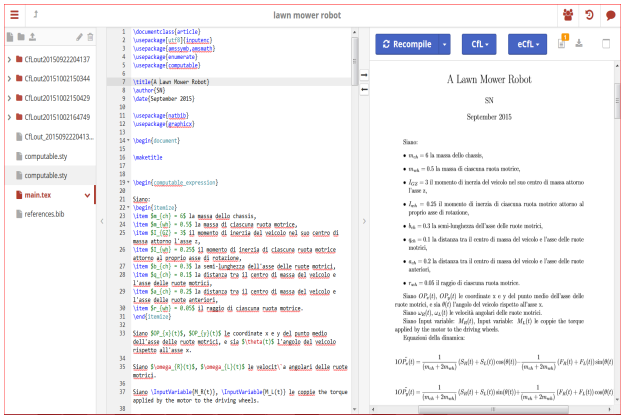
Do automatically and without physical reworking:

- sensitivity analysis
- FMEA
- regression analysis
- user-interface testing

Field Monitoring and Fault Detection

The same model developed during the design process can also be used to monitor the system on the field (labs, endusers)

eCfL systems support also real-time algorithms for fault-detection



Computational Inverse Problems

on embedded systems

Università degli Studi di Padova

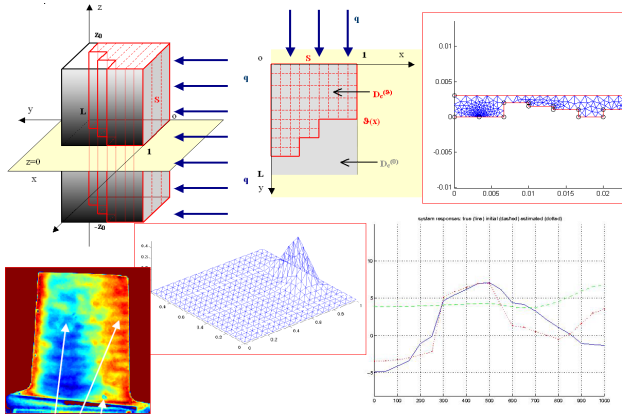
Computational Inverse Problems
on embedded systems

Research topics ...

Hidden Corrosion Detection

Model-based analysis of thermographic images

"Numerical Algorithms for an inverse problem of corrosion detection", Deolmi G., Marcuzzi F., Poles S., Marinetti S., Communications in Applied and Industrial Mathematics 1 (2011), n.2, 78-98



Acoustic camera

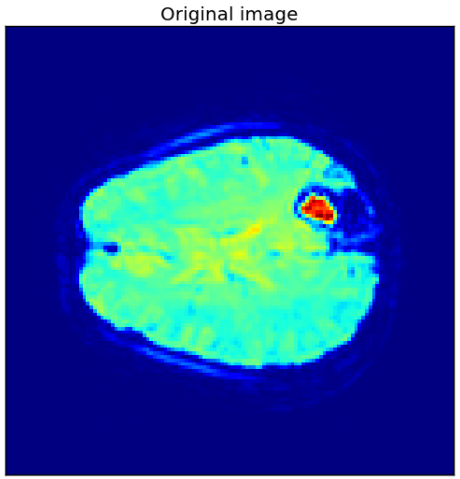
Analyze the material interior through vibration measurements

"Space and Time Localized PEM for the Estimation of Distributed Parameters in a Finite Element Model", Marcuzzi F., Comput. Methods Appl. Mech. Engrg. 198 (2009), Issues 37-40, pp. 3020-3025

DSC-MRI

A comparison with compressed sensing

M. Virgulin, M. Castellaro, F. Marcuzzi, E. Grisan (2014). Analytic heuristics for a fast DSC-MRI. In: Proc. SPIE 9034, Medical Imaging 2014: Image Processing, 903424 (March 21, 2014). ISBN: 9780819498274, San Diego, CA, FEB 16-18, 2014, doi: 10.1117/12.2042835



Pollutant transport in rivers

An inverse mass convection problem

"A parabolic inverse convection-diffusion-reaction problem solved using space-time localization and adaptivity", Deolmi G., Marcuzzi F., Applied Mathematics and Computation 219 (2013), n.16, pp. 8435-8454

Industrial topics ...

Indirect measurement of contact forces

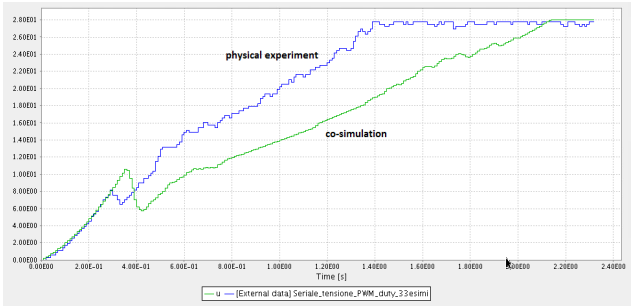
Deconvolution with a Kalman Filter

"Mobile Forces Reconstruction from Displacement Sensors", Marcuzzi F., Morandi Cecchi M., Resta F., Proceedings MASCOT03-IMACS/ISGG, IMACS Series in Computational and Applied Mathematics, 8, (2004) pp. 121-130, ISSN 1098-870X

Physical parameters estimation and autotuning of an electric sliding gate

Real-time physical modelling and co-simulation

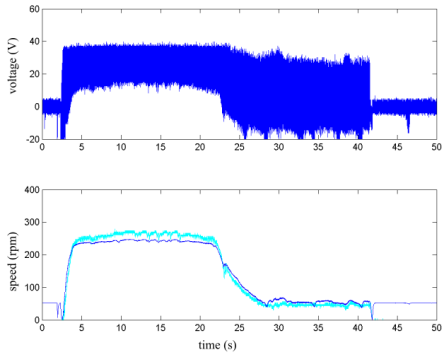
"Virtual prototyping of embedded control software in mechatronic systems: A case study", Beghi A., Fabio Marcuzzi F., Martin P., Tinazzi F., Zigliotto M., Mechatronics, to appear



Real-time simulation of a CO2 refrigeration plant

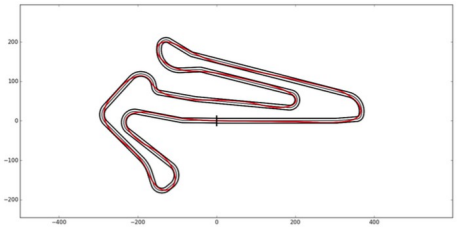
Complex real-time modelling using eCfL

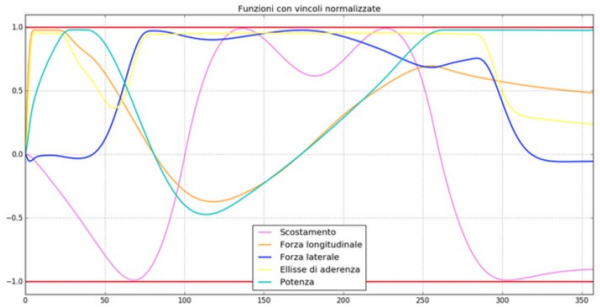
"MONUFRIGO: Sviluppo di modelli numerici real-time per le applicazioni di controllo automatico nel settore refrigerazione"
Cod progetto: 2105-91-2121-2015; Regione Veneto, fondi FSE.



High Performance Computing

GPU computing

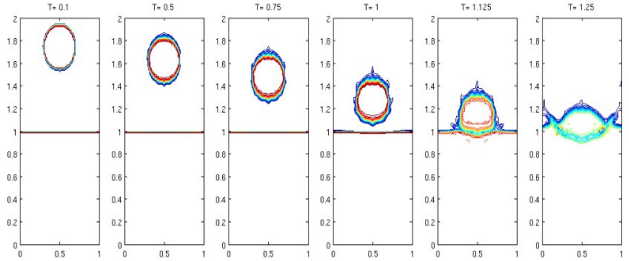




Lap-time simulator

Optimal control problem solver parallelization

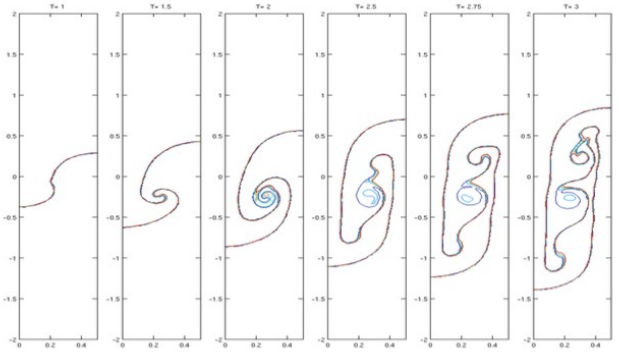
laurea thesis, Francesco Giaretta (2017)



Variable density fluids simulation

Hybrid Finite-Element, Finite Volumes solver parallelization

laurea thesis, Monica Dessole (2017), Mauro Vanzetto (2015), Lornzo Barasti (2014)



Model Predictive Control Algorithms

Optimal control algorithms parallelization

"OPTIMECH: Metodi di calcolo ad alte prestazioni per il controllo real-time di sistemi meccanici su elettronica integrata", project proposal, Regione Veneto, fondi FSE

Open-source Scientific Computing

with Python

Computing from LaTeX

Mathematical modelling

"Computing from LaTeX: automated numerical computing from LaTeX expressions", Crafa S., Marcuzzi F., Virgulin M., 2014