

FORCES PRO - An Easy to Use Tool for Rapid Design of High Performance Optimal Controllers

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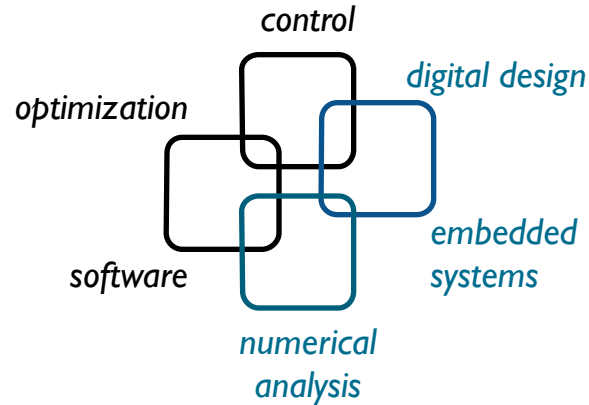
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embotech Team



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- ▶ PhD in Automatic Control, ETH Zürich
- ▶ Expertise: modeling, numerical linear algebra, optimization methods
- ▶ Tools: forces.ethz.ch, ecos.ethz.ch
- ▶ Applications: electrical drive control, autonomous vehicles

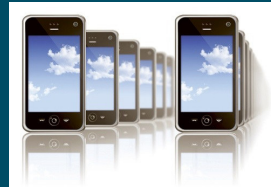
- ▶ PhD in Circuit Design for Real-time Optimization, Imperial College London
- ▶ Expertise: optimization methods, numerical analysis, digital circuits, fixed-point implementations
- ▶ Applications: aircraft control (HIL), atomic force microscopy

embotech's Vision

- ▶ In 2030, **optimization** problems are solved **on billions of devices**:

Communication & Computing

- Signal decoding
- Energy management
- Beamforming



Manufacturing

- High-performance tools and machinery
- Complex movements



Automotive

- Engine control
- Hybrid drive trains
- Autonomous driving



Power systems & buildings

- Smart grids
- Distributed generation
- Use of weather data



Why Is Optimization Not Everywhere?



Lack of computing power

- embedded platforms not powerful enough
- cost & power consumption limits



Lack of training

- most engineers not trained in optimization
- posing optimization problems and solving them require different expertise



Lack of tools

- implementation of algorithms time consuming & requires knowledge
- numerical challenges

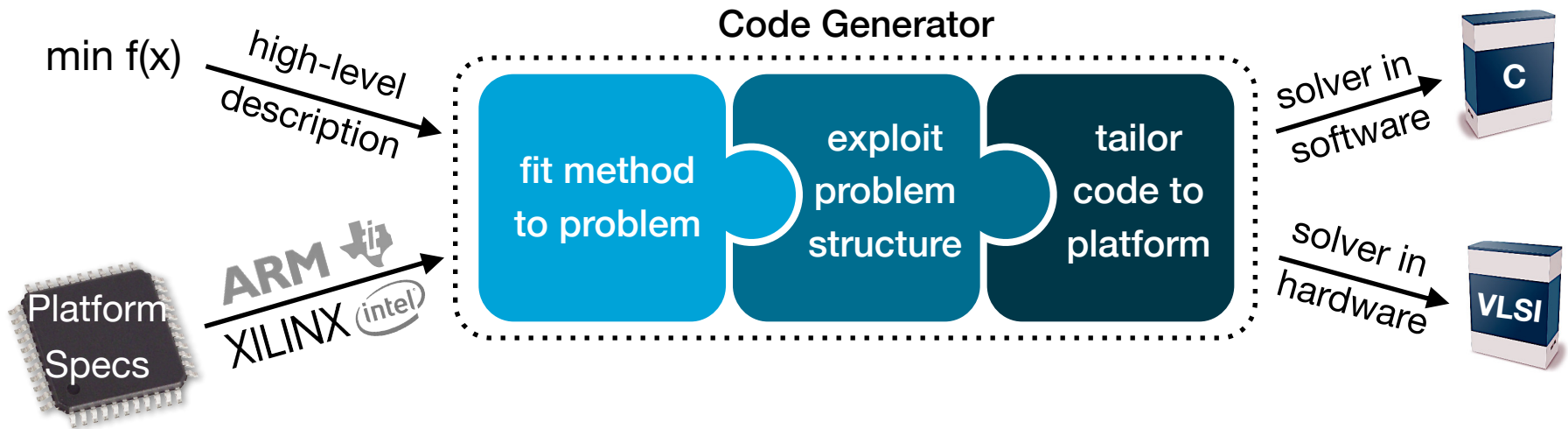
We make tools to address these problems

Solving the Optimization Problem

- ▶ The design space for an optimization solver for a particular optimal control implementation is very large
 - optimization re-formulation & scaling
 - algorithmic framework
 - particular algorithm variant
 - algorithm parameters
 - fixing the number of iterations
 - parallelization (platform dependent)
 - data types (platform dependent)
 - numerical linear algebra implementation (platform dependent)

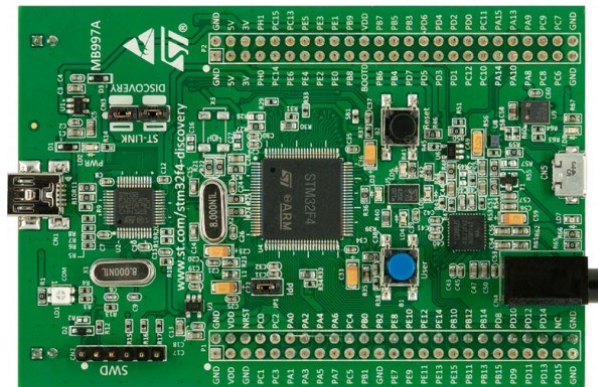
Exploring this design space is very time consuming and expensive

FORCES PRO



Case Study - Aircraft Demo

	Mathworks MPC Toolbox	IBM CPLEX	FORCES PRO
Desktop Platform (Intel 2.53 GHz)	200 ms	16 ms	0.5 ms
Embedded Platform (ARM 0.15 GHz) ~1\$	✗	✗	9 ms



Feature Roadmap

