Shape optimization on FEMLAB 3.1 platform

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Outlines

- Shape Optimization of Fast Microfluidic Protein Folding Device
  - Problem Modelling
  - Global optimization method
  - Numerical methods comparison
  - Experimental implementation
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- Shape Optimization of coastal structures
  - Problem Modelling
  - Numerical results

Conclusion and perspectives
PART II: Shape Optimization of Fast Microfluidic Protein Folding Device

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Modelling

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Modelling
- Global Optimization method
- Simplified Gradient
- Shape optimization results
- Experimental implementation

PART III: Shape Optimization of coastal structures minimizing water waves impact

Conclusion and perspectives
Modelling
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Modelling

Steady equations:

Navier–Stokes

Convective–Diffusion
Global Optimization method

Idea: Improve any optimization method (Here steepest descent method (SD2A) and genetic algorithm (HSGA)) by searching adequate initial conditions.


Simplified Gradient

Coarse meshes: 20 secs / Fine meshes: 2 mins
Computational difference: Difference of 50% !!! △ !!!
Gradient difference: 10%
Shape optimization results

- GA: Evaluations: 5400 / Time: 7 days
- HSGA: Evaluations: 2500 / Time: 3 days
- SD2A: Evaluations: 3400 (90% coarse mesh) / Time: 18 hours
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Both cases: mixing time $8 \mu s \rightarrow 1.15 \mu s$

Initial mixer

Optimized mixer
Experimental implementation

'Exp' optimized mixer  \quad 'Num' optimized mixer

Average gain of $\sim 4\mu s$
PART III: Shape Optimization of coastal structures minimizing water waves impact
Coastal structure modelling
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- on $\Gamma_0$: Reflection condition
- on $\Gamma_1$: Radiation condition
- on $\Gamma_{2,a}$ and $\Gamma_{2,b}$: Periodic Boundary Condition
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- on $\Gamma_0$: Reflection condition
- on $\Gamma_1$: Radiation condition
- on $\Gamma_{2,a}$ and $\Gamma_{2,b}$: Periodic Boundary Condition
- incident monochromatic linear small-amplitude water wave:
  \[ \xi^i(x) = ae^{i(k \cdot x)} \]
- reflected water wave: solution of $\Delta \xi^r + k^2 \xi^r = 0$ in $\Omega$
Objective: To find the best shape for structure which permit to reduce uniformly the free surface elevation along the coastline (for unidirectional and multidirectional incident water wave).
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![Parameterization Diagram](image-url)

**Figure 1**: The parameterization ($n_i = 2$ and $n_{i+1} = 1$).
Results: with feasibility constraints
Results: with feasibility constraints
Results: free optimization

Coastline between two successive structures
Results: free optimization

Coastline between two successive structures

Coastline between two successive structures
Conclusion and perspectives
Other Industrial applications

- Temperature and pollution control in a bunsen flame/ Engine
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- Optical filters design
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- Shape optimization of under aerodynamic and acoustic constraints for internal and external flows
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- Optimization of drift spraying
Conclusions and perspectives

- SD is applicable and improve various optimization methods (GA, Steepest descent ...)

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Conclusions and perspectives

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- SD has been efficient on various industrial problems
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!!! Thank You !!!