Sponsoring GDR Mascot Num

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UNIVERSITÉ DE LYON

ÉCOLE CENTRALELYON

Formalisation of some industrial issues

Ciroquo in this context

Numerical simulation

Computer codes

- They represent complex physical phenomena : car crash, damage in floating wind turbines in operation, multi-phase draining in porous media regions, a loss of coolant in a nuclear accident, ...
- They are based on CFD (Computational Fluid Dynamics) or FEA (Finite Element Analysis) or Monte Carlo
- They are often time consuming (several hours or several days)

Numerical simulation

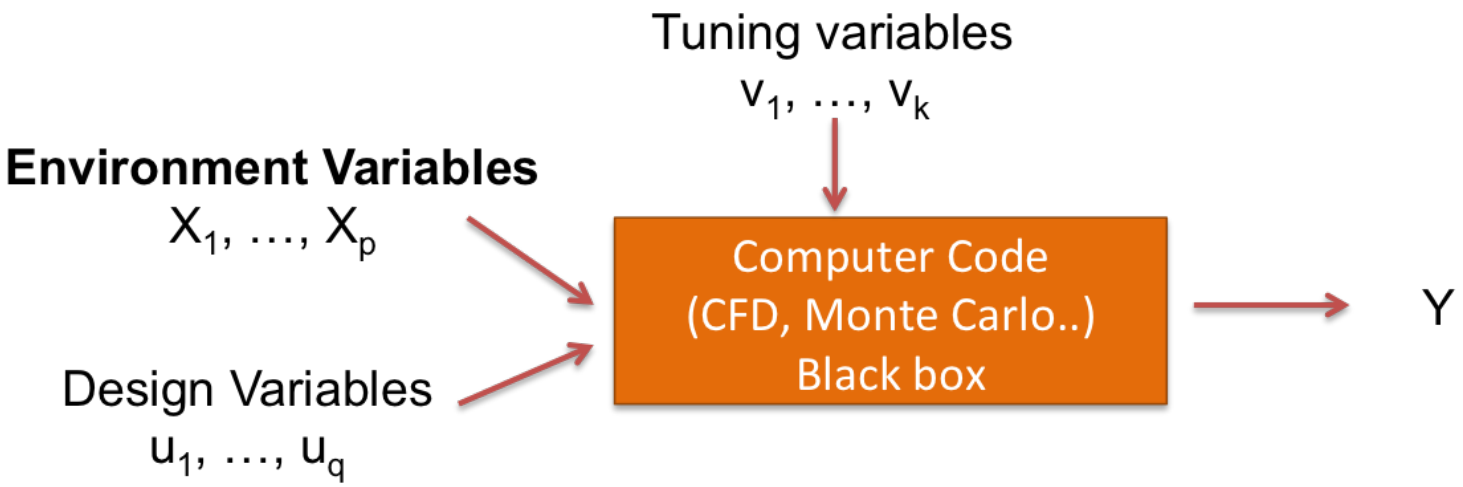
Inputs

- Design variables - Environment variables - Tuning variables
- Scalar - Vectorial - Functional (temporal, spatial, spatio-temporal)

Outputs

- Scalar - Vectorial - Functional (temporal, spatial, spatio-temporal)

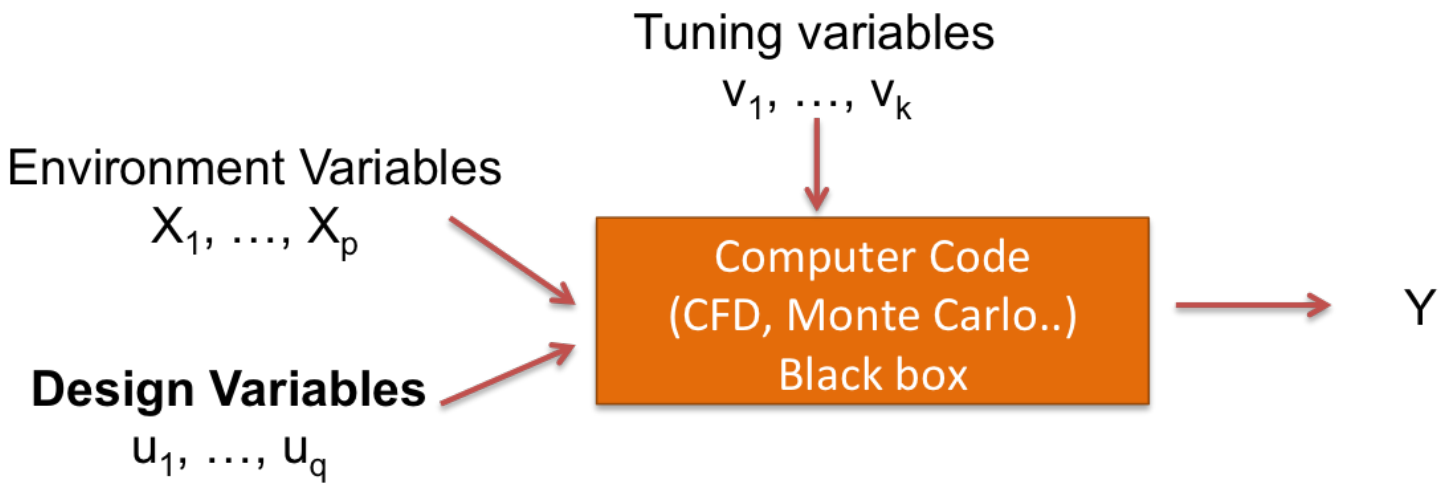
Main objectives



Uncertainty quantification

- Propagation (ex : probability of exceeding a threshold)
  - Find the pdf of $Y = \mathcal{M}(X, u, v)$
  - Evaluate $\mathbb{P}(Y > \textit{threshold})$(reliability)
- Sensitivity Analysis (ex : screening, Sobol' indices)
  Find the most influential variables on Y, and quantify their impact.

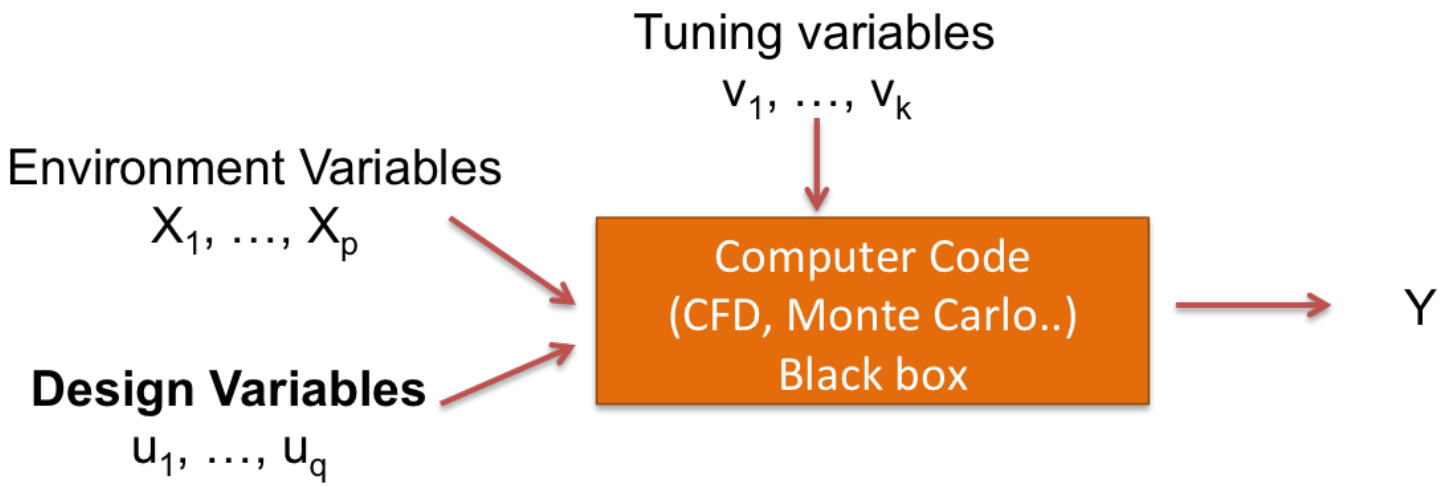
Main objectives



Optimization

- Find $u^* = (u_1^*, ..., u_q^*)$ such that $\mathcal{M}(x, u*, v)$ is maximum, where x and v are fixed
- Robust optimization : Find $u^* = (u_1^*, ..., u_q^*)$ such that $\mathcal{M}(X, u*, .)$ is maximal
- Muti-objective optimization or constrained optimization.

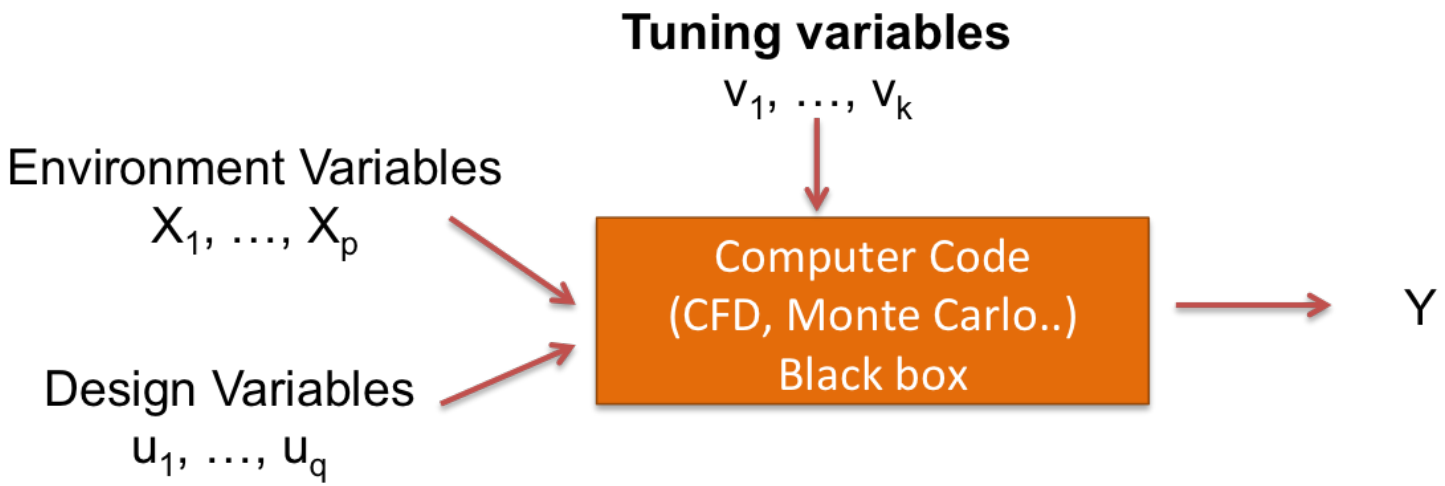
Main objectives



Inversion

- Find $\Gamma_{x,v} = \{u \in D \subset \mathbb{R}^q, M(x,u,v) < threshold\}$
- Robust inversion

Main objectives



Calibration

- Find $v^* = (v_1^*, ..., v_q^*)$ such that $\mathcal{M}(x_i, u_i, v^*) \approx y_{i,exp}$

Usual process followed

Issue

- No matter what the objectives, thousand of simulations are required.
- But each simulation costs a lot !

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Idea : statistical approach

- Design of experiments (only few well-chosen simulations are run)
- Metamodel (a statistical model of outputs as a function of inputs)

=> which metamodel ? which data to fit the metamodel ? how to use the metamodel as efficiently as possible ? etc.

=> how to build an efficient enrichment ?

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Ciroquo in this context

CIROQUO

Consortium Industrie Recherche pour l'Optimisation et la QUantification d'incertitude pour les données Onéreuses

- CIROQUO follows DICE, ReDICE and OQUAIDO
- Coodination : Ecole Centrale de Lyon & IFPEN
- Academic partners

- Technological research partners

Consortium Industrie Recherche pour l'Optimisation et la QUantification d'incertitude pour les données Onéreuses

- Total budget : 1 M€ over 4 years 2021 - 2024. It finances research activities, meetings, training days, software developments, researcher invitations.
- 5 PhD and 3 post-doctoral students
- Experts : Mathilde Mougeot (machine learning), Pascal Havé & Yves Deville (softwares).

Main research issues

- Axis 1 : Calibration, validation and transposition of codes (In situ measurements and numerical simulations are not done at the same scale)
- Axis 2 : Metamodeling of codes in complex environments (the output belongs to a non euclidian space).
- Axis 3 : Optimization and inversion in the presence of uncertainties, in particular for outputs being probability distributions.
- Axis 4 : Numerical simulation in high dimension (metamodeling, optimization etc.)
- Develop the link with machine learning approaches,
- Develop code prototypes (R/Python/Matlab, libKriging)

Thank you for your attention

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