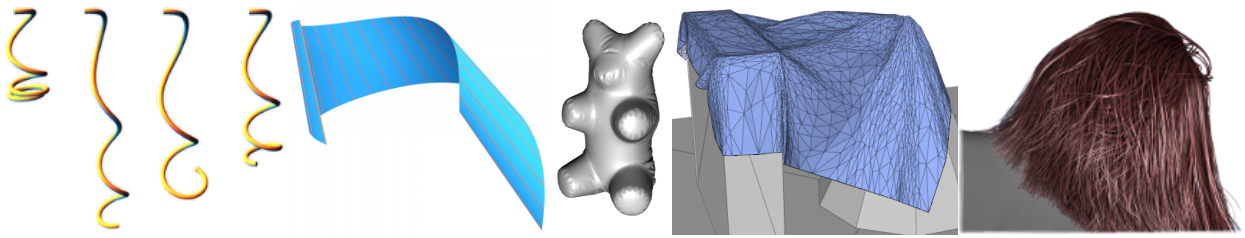
Class on numerical mechanics:

From Lagrangian mechanics to simulation tools for computer graphics



Florence Bertails-Descoubes [1], Mélina Skouras [2], Mickaël Ly [3]

2019, September 12 - ENS Lyon

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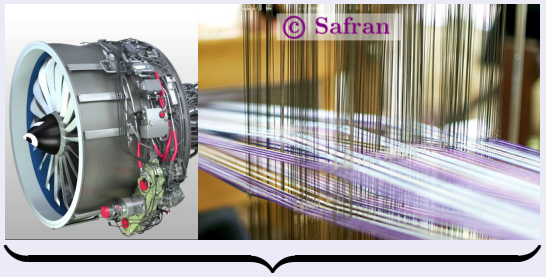
[2] melina.skouras@inria.fr
[3] mickael.ly@inria.fr

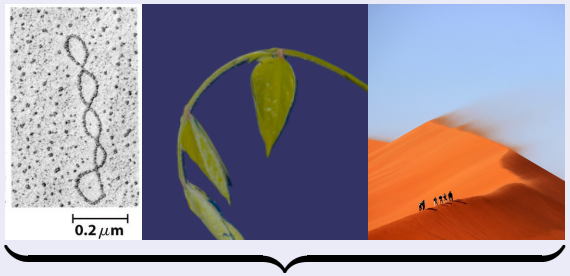
Motivation

Increasing need for effective mechanical simulators

Movie industry



Virtual prototyping



Natural sciences

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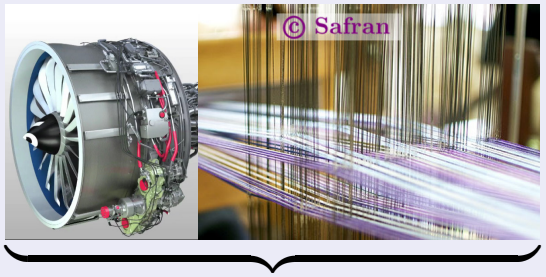

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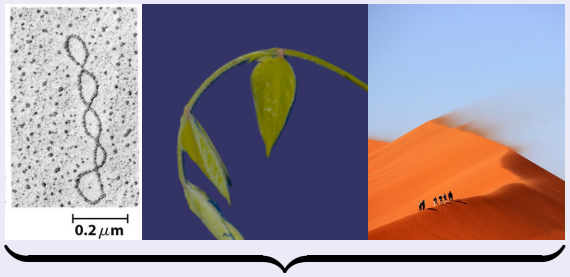
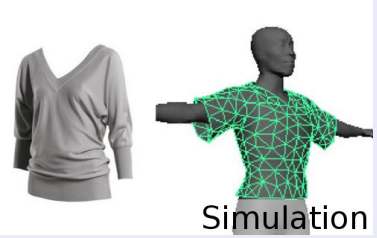
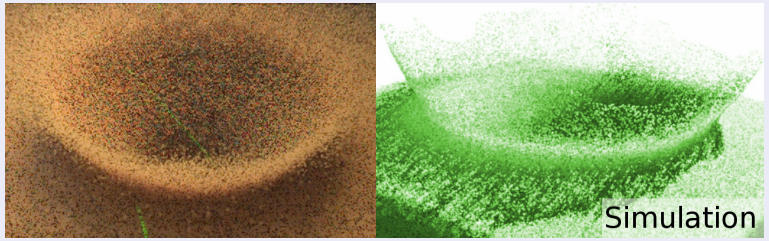


Natural sciences

Requires the numerical modeling of objects with complex shapes and motion





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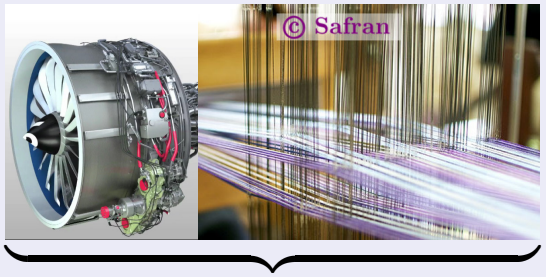

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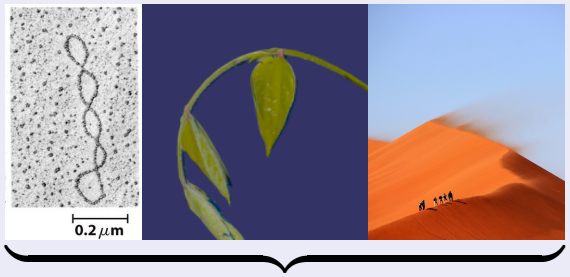

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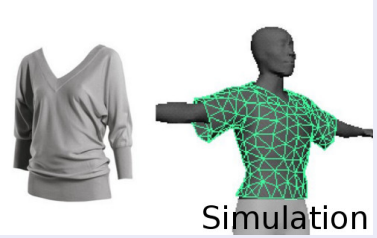

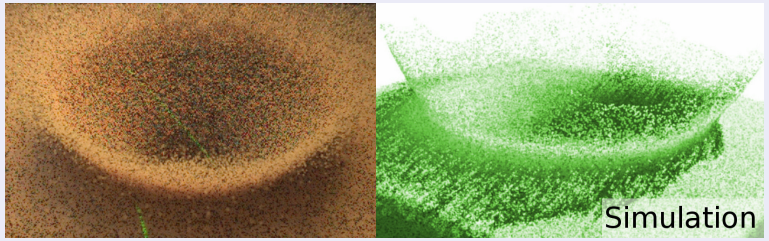

→ Challenges: nonlinear and even nonsmooth regimes

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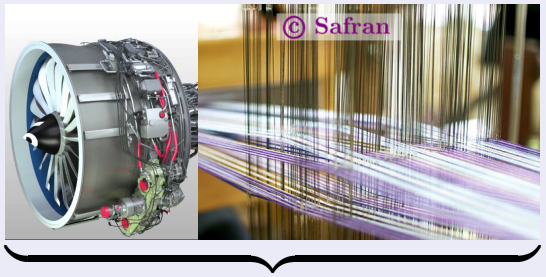

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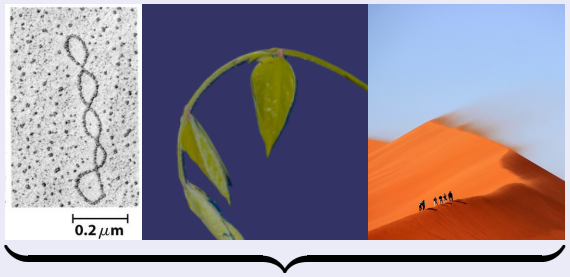

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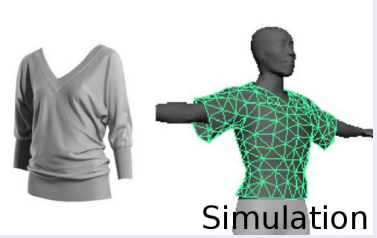

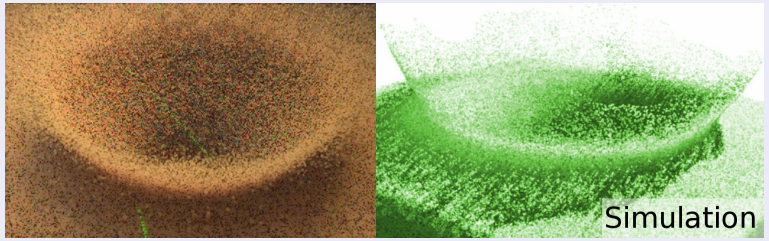

→ Challenges: nonlinear and even nonsmooth regimes

Goal: design dedicated numerical models

Realism + robustness + efficiency + user control

Objectives of the course

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Discover important concepts and techniques behind simulation

- acquire some fundamentals of numerical mechanics

  at least for deformable solid objects
- get a sense of good practices for numerical modeling
- have the right pointers to go further by yourself...

  and at some point create your own impressive simulations!

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How we have built this course

- The kind of course we would have liked to have ourselves before our PhD!
- Not a review of recent research papers, but really a course on fundamentals
- A balanced mix between mechanics and numerics
- A balanced mix between theory and practice
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First time we deliver this course $\rightarrow$ feel free to give us feedbacks!!

Content of the course

Mechanics + Numerics

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- Class 1: Lagrangian mechanics and finite differences
- Class 2: 3D elasticity and first steps into finite elements
- Class 3: Thin elastic rods and numerical optimization
- Class 4: Inverse problems and constraint-based optimization
- Class 5: Frictional contact and nonsmooth optimization

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Teaching team

- Lecturers: Mélina Skouras and Florence Bertails-Descoubes (Inria researchers)
- Teaching assistant: Mickaël Ly (3rd year PhD student at Inria)

Organization

Morning

- 8h45 am - 10h15 am: Lecture on mechanics + exercises
- 10h30 am - 12h am : Lecture on numerics + exercises

Lecturers: F. Bertails-Descoubes (weeks 1,3,5) and Mélina Skouras (weeks 2,4)

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Afternoon

- 1h30 pm - 4h45 pm : Practice on machine (python)

Teaching assistant: Mickaël Ly (+ presence of the morning lecturer)

Evaluation

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Write practice reports

- Each afternoon of the course, one practice sheet will be given to you
  5 practice sheets in total
- Contains a series of problems to implement and think about, with the help of **python**
- You have to write one report to describe your solution and analyze your results
- The report in PDF has to be sent each week to mickael.ly@inria.fr
- Deadline: Monday 9 pm of the week following the course
- Can be done individually or by pairs of students
- Evaluation scores will be delivered at the end of the course series ($\approx$ mid-October)

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Recommendations (more this afternoon)

- Don't wait the last minute to write your report
- The report should be well-written, clear and concise (done in LaTeX)
- It should be a (well-argumented) analysis of your results
- It should not contain code listings (code is not evaluated by itself)
- Don't hesitate to include figures and algorithms in pseudo-code
- Feel free to ask as many questions as you want during the course, or by email!

Let's start