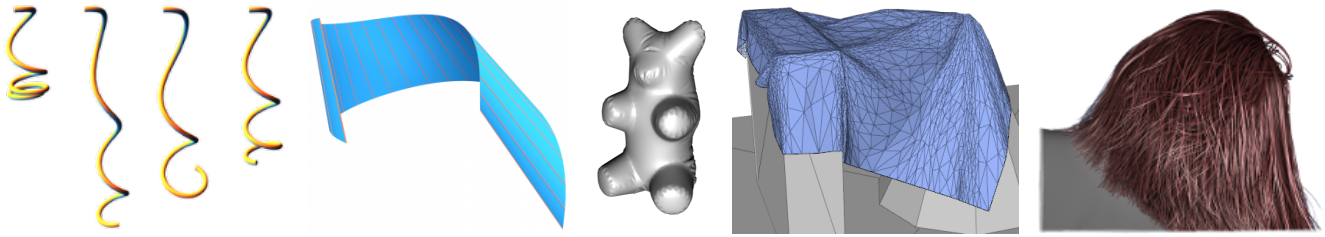
Class on numerical mechanics:

From Lagrangian mechanics to simulation tools for computer graphics



Florence Bertails-Descoubes [1], Thibaut Métivet [2], Jean Jouve [3]

2022, September 20 - Ensimag

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[2] thibaut.metivet@inria.fr
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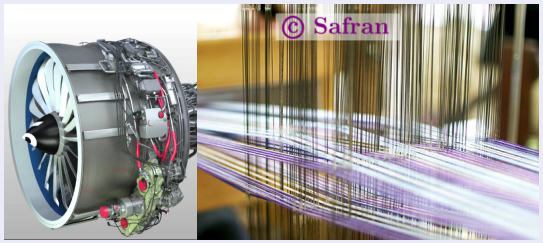
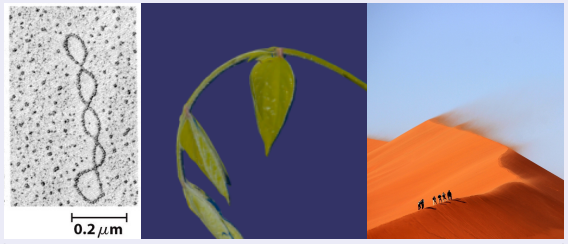
Motivation

Increasing need for effective mechanical simulators

Movie industry



Virtual prototyping



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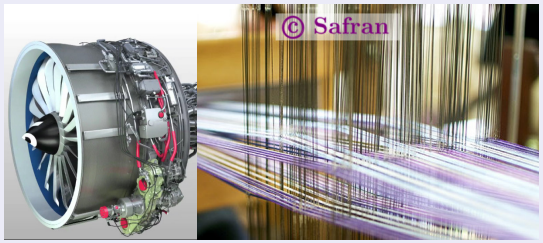

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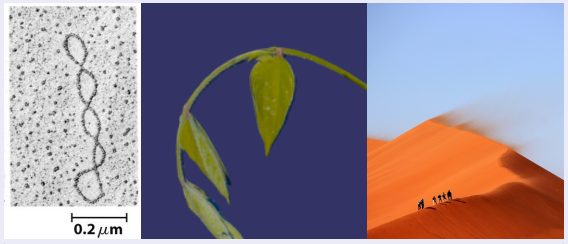
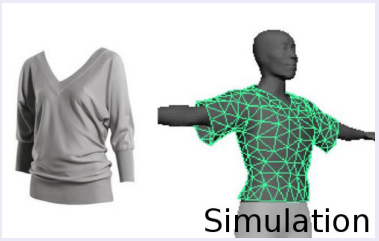
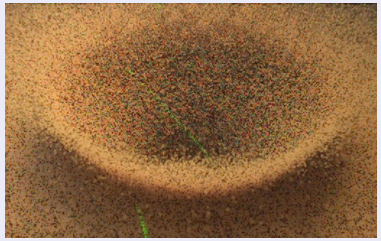
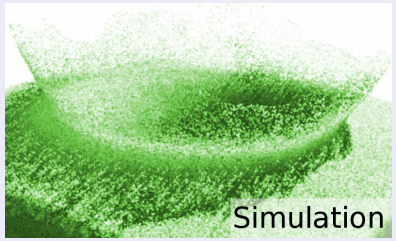


Natural sciences

Requires the numerical modeling of objects with complex shapes and motion







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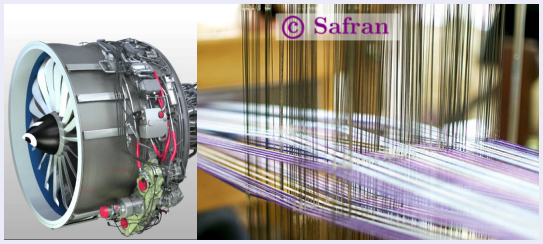

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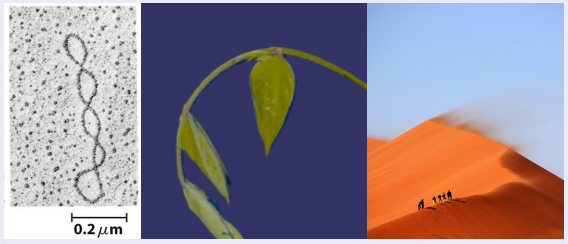

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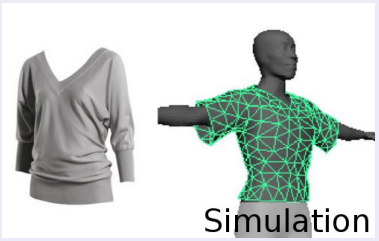

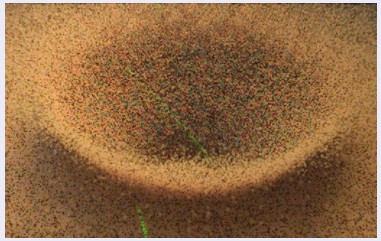

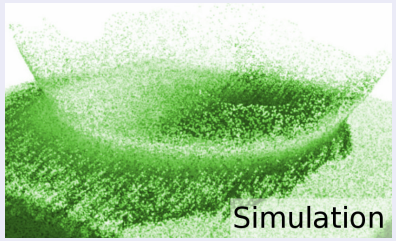

→ Challenges: nonlinear and even nonsmooth regimes

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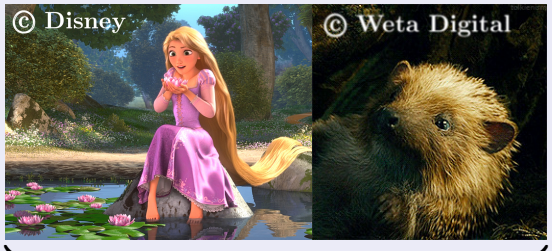

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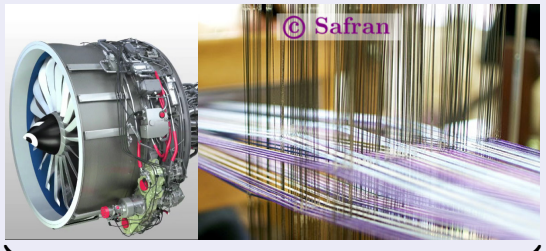

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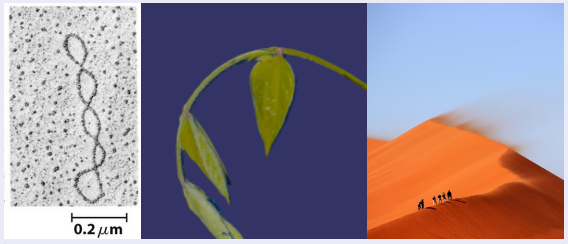

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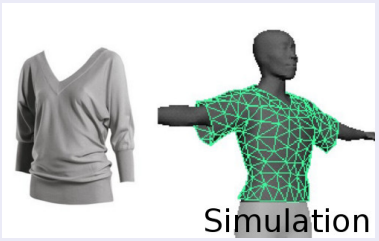

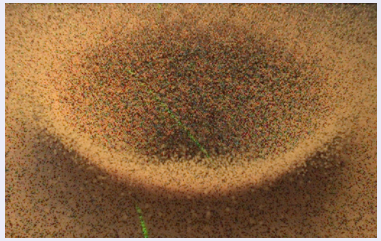

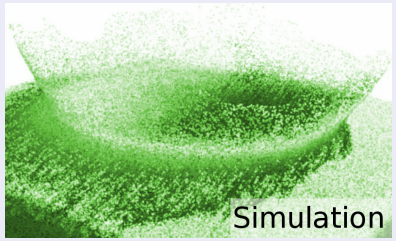

→ Challenges: nonlinear and even nonsmooth regimes

Goal: design dedicated numerical models

Realism + robustness + efficiency + user control


$\mu = 0.3$

Objectives of the course

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Discover important concepts and techniques behind simulation

- acquire some fundamentals of numerical mechanics

  at least for (articulated) rigid bodies
- 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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Third time we deliver (partly) this course, first time in this form and for Ensimag
$\rightarrow$ feel free to give us feedback!!

Content of the course

Mechanics + Numerics

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- Topic 1: Lagrangian mechanics and finite differences
- Topic 2: 3D rigid bodies and integration on SO(3) groups
- Topic 3: Contact detection and acceleration structures
- Topic 4: Hertzian contact and penalisation methods
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Teaching team

- Lecturers: Florence Bertails-Descoubes, Thibaut Métivet (Inria researchers) and Jean Jouve (PhD student, ENS Rennes)

Organisation

Schedule

- 36 hours in total, starting from now and ending on 23/11
- Break: around Toussaint holidays (no class during $\sim$ 1 month)

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Second slot

In general, practice on machine (**python**)

- First practicals: guided
- Other practicals: work on a **personal project**

Evaluation

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A personal code project

- Goal: choose, implement and study one simulation scenario **of your choice**

  by applying and deepening one or several techniques learnt during classes
- Should be done by pairs of students (18 students $\rightarrow$ 9 teams ?)
- Recommended programmation language: **python**
- Advice: choose your simulation scenario carefully
  - Not too simple, not too ambitious
  - Set incremental milestones over time
  - Split the work equally in the team

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Evaluation

- **Oral defence** on 23rd Novembre (last course)
- Around 20 minutes per team in total (15 min pres + 5 min Q&A)
- Evaluation criteria:
  - **Originality** and **difficulty** of the chosen scenario
  - **Success** of the implementation, related to the difficulty of the chosen scenario
  - **Depth of analysis** of results (even in case of a failure), **mastery** of the topic
  - Project **organisation** and **team management**
  - **Quality** of the oral presentation and answers to questions

Let's start!