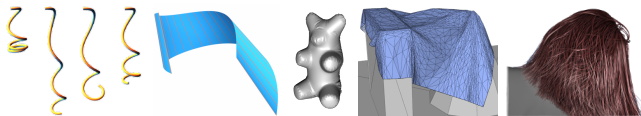


Class on numerical mechanics:

From Lagrangian mechanics to simulation tools for computer graphics



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

inria



2023, October 3 - Ensimag

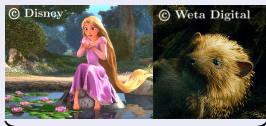
¹florence.descoubes@inria.fr

²thibaut.metivet@inria.fr

³jean.jouve@inria.fr

Motivation

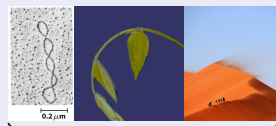
Increasing need for effective mechanical simulators



Movie industry



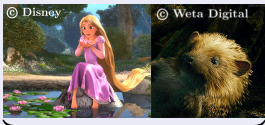
Virtual prototyping



Natural sciences

Motivation

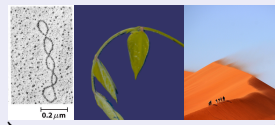
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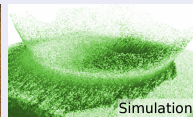
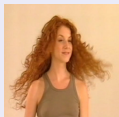


Virtual prototyping



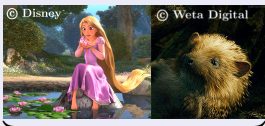
Natural sciences

Requires the **numerical modeling** of objects with **complex shapes** and **motion**



Motivation

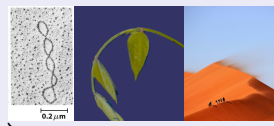
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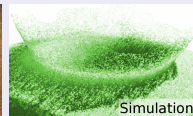
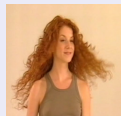


Virtual prototyping



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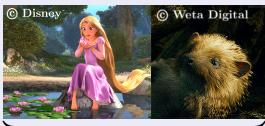
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→ Challenges: **nonlinear** and even **nonsmooth** regimes

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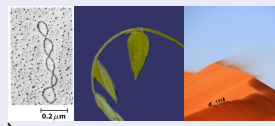
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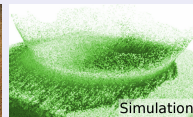
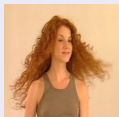


Virtual prototyping



Natural sciences

Requires the **numerical modeling** of objects with **complex shapes** and **motion**



→ 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 (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!
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- A balanced mix between mechanics and numerics
- A balanced mix between theory and practice
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Fourth time we deliver (partly) this course, second time in this form and for Ensimag
→ 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)
at Elan team: <https://team.inria.fr/elan/>

Organisation

Schedule

- 36 hours in total, weekly, starting from now and ending on January 9 (exam)
- Break: during Toussaint holidays (no class on October 31)

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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 → 9 teams ?)
- Recommended programming 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 January 9 (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!