IX JORNADA DE JÓVENES INVESTIGADORES DEL I3A

Data Learning of Fluid Dynamics for Physically Informed Digital Twins

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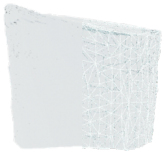
OBJECTIVES

Develop an **intelligent living digital twin able to learn fluid dynamics** with artificial intelligence.

- Provides augmented information in manipulation of fluids.
- Application in robotics reasoning.

What is a living digital twin?

A living digital twin emulates the behaviour of a real object or process and interacts with the real world in realtime.



HYPOTHESIS

✖ Black box models deviate from ground truth in long term simulations.

Physical rigour ensures higher temporal stability.

METHOD

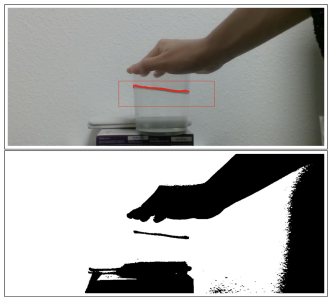
DATA ACQUISITION
Tracking of the *features* of the real container and the fluid.

RECOGNITION
Random forest classifyier trained for fluid recognition.

SIMULATION
Machine learning based on *GENERIC* formalism to ensure **thermodynamic consistency** of the model.

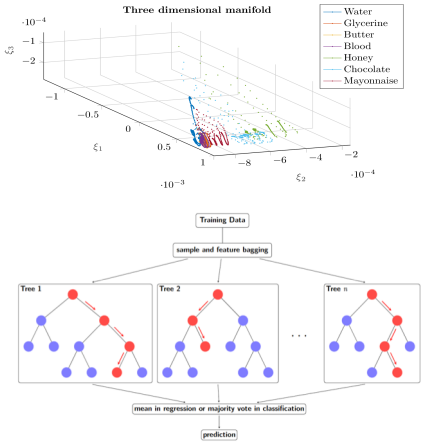
FREE SURFACE DETECTION

Optimal perception of free surface from binarized image.



FLUID RECOGNITION

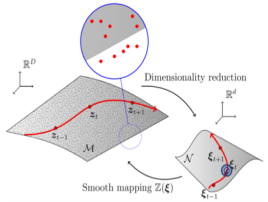
Random forest over projection of data into 3D manifold.

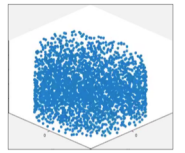


LEARNING DYNAMICS

[GENERIC] Learning dynamics from coarse description of the evolution of Energy ***E*** and Entropy ***S*** in terms of state variables ***z:***

$$\frac{dz}{dt} = \boldsymbol{L}\frac{\partial E}{\partial z} + \boldsymbol{M}\frac{\partial S}{\partial z}$$



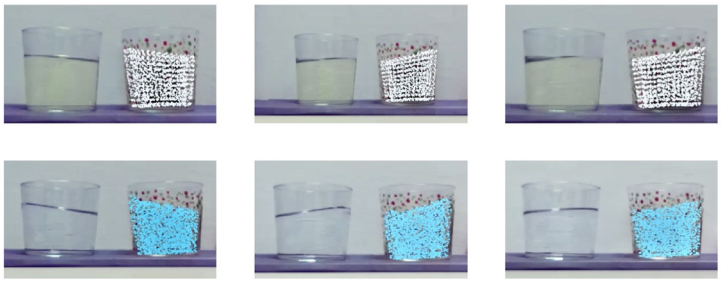


RESULTS

- ✓ Fluid recognition with pseudo-experimental data: 95.93% global accuracy.
- ✓ Learning of Newtonian and non-Newtonian fluids.
- ✓ Digital emulation of the twin: mean deviation up to 1.74 mm.

FUTURE RESEARCH LINES

- **Development of a hybrid twin able to learn corrections from free surface data, such us new material behaviour.**



LINK TO VIDEO

SCAN ME

REFERENCES

ÖTTINGER H.C., Beyond Equilibrium Thermodynamics (Wiley, 2005)

MOYA B., GONZALEZ D., ALFARO I., CHINESTA F., CUETO E. Physically sound, self-learning digital twins for sloshing fluids. Plos One June 16, 2020

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