

Module

Simulation and Validation

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Chapters

1. Introduction
2. Simulation Use Cases in ADAS / AD
3. Simulation Environments
4. The Digital Twin
5. Sensor Simulation
6. Quality of Simulation
7. Verification and Validation
8. Hands-on Session

Chapter 1

Introduction

Simulation in all its Flavors

Development Processes

Simulator Components

Summary

What is Simulation?

“A **simulation** is the *imitation* of the *operation* of a real-world process or system over time.”^[1]

➡ *Imitation* vs. Replica

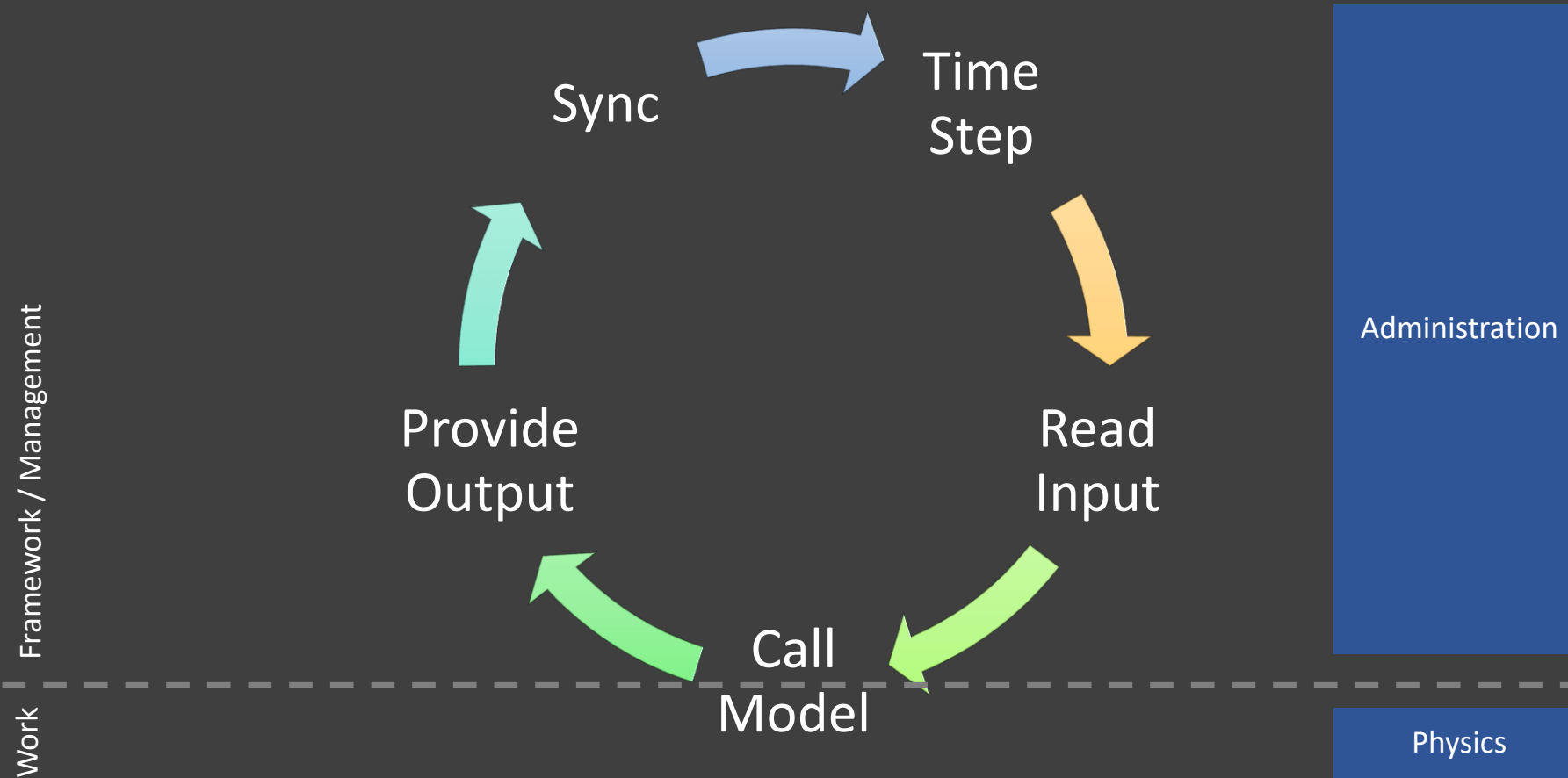
➡ *Behavior* vs. State

➡ Simulation is an approximation

➡ Simulation has limits in accuracy and applicability

1. J. Banks; J. Carson; B. Nelson; D. Nicol (2001). *Discrete-Event System Simulation*. Prentice Hall. p. 3. [ISBN 978-0-13-088702-3](https://en.wikipedia.org/wiki/Simulation), found on <https://en.wikipedia.org/wiki/Simulation>

Framework and Model



Focus of this Course

- Numerical Simulation

- Fluid Dynamics
 - Particles in Motion
- Chemical Simulation
 - Elements in Action
- Financial Simulation
 - Money for Nothing

- Electromagnetic Simulation

- Radar Waves and Light
- Multi-Body Physics
 - Dynamics of Parts
- Acoustic Simulation
 - Sound Waves

- etc.

- System Simulation

- Chaotic Systems
 - Weather Forecasting
- Distributed Entities
 - Orchestration of Troops
- Factory Operation
 - Optimizing Processes
- System Operation
 - Predictive Maintenance

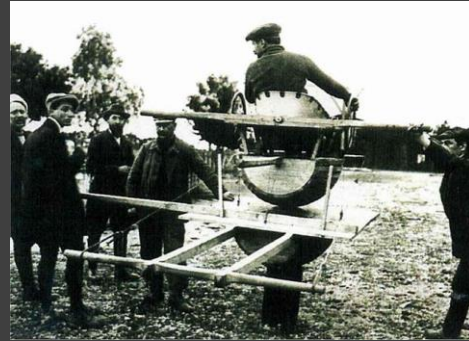
- Vehicle Systems

- ADAS / AD / Sensors
- Environment Simulation
 - Traffic / Terrain

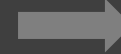
- etc.

History (as relevant for this course)

Hardware



Training rig for Antoinette aircraft, 1909 ^[1]

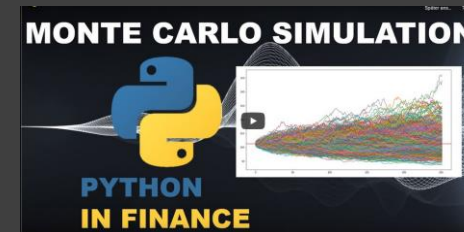
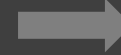


Full Flight Simulator, 2021 ^[3]

Methods



Monte-Carlo Simulation, John von Neumann and Stanislaw Ulam , WWII ^[2]

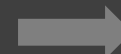


Monte-Carlo Simulation in Python ^[4]

Content



Hands-on Terrain ^[5]



Procedural Terrain Generation ^[6]

1. https://commons.wikimedia.org/wiki/File:Antoinette_sim_2.jpg
2. <https://towardsdatascience.com/monte-carlo-simulations-with-python-part-1-f5627b7d60b0>
3. <https://www.cae.com/civil-aviation/aviation-simulation-equipment/training-equipment/full-flight-simulators/cae7000xr/>
4. <https://www.youtube.com/watch?v=cHXdcUxBfTM>
5. <https://www.festungsmuseum.ch/nur-bei-uns/fasip>
6. <https://paralleldomain.com/data-visualizer>

History (as relevant for this course)

- Driver Assist System Simulation (1963 and today)

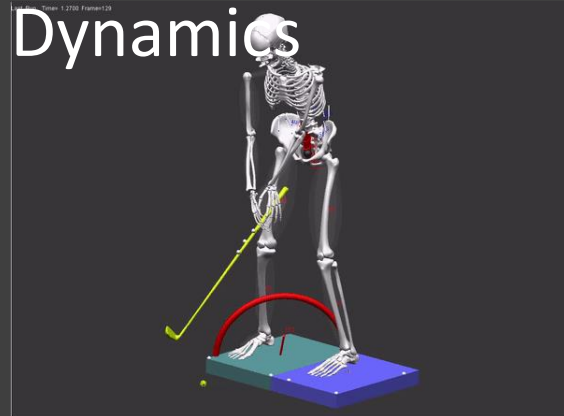


<https://www.youtube.com/watch?v=OnssnUGnpdM> (min 10:30+)



<https://www.vi-grade.com>

Applications



<https://www.mscsoftware.com/product/adams>



<https://www.youtube.com/watch?v=p2d0ma6W6bM>



NVIDIA DRIVE-SIM at
<https://www.youtube.com/watch?v=gPaFgNEF82Q>



https://asr-simulator.com/driving-simulator/#Lightbox/gallery_image_1/4



https://www.vi-grade.com/en/products/cable-driven_dim_dynamic_simulator



<https://www.avl.com/-/avl-drivingcube>



<https://www.ptvgroup.com/de/loesungen/produkte/ptv-vissim/>

Chapter 1

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Simulation in all its Flavors ✓

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