INTRODUCTION

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CONTROL ENGINEERING WITH PYTHON

- 📖 Course Materials
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- 🏦 ITN, Mines Paris - PSL University

SYMBOLS

	Code		Worked Example
	Graph		Exercise
	Definition		Numerical Method
	Theorem		Analytical Method
	Remark		Theory
i	Information		Hint
	Warning		Solution

🏷️ CONTROL THEORY

A field of Mathematics that deals with the

- **modelling**,
- **analysis** and
- **control**.

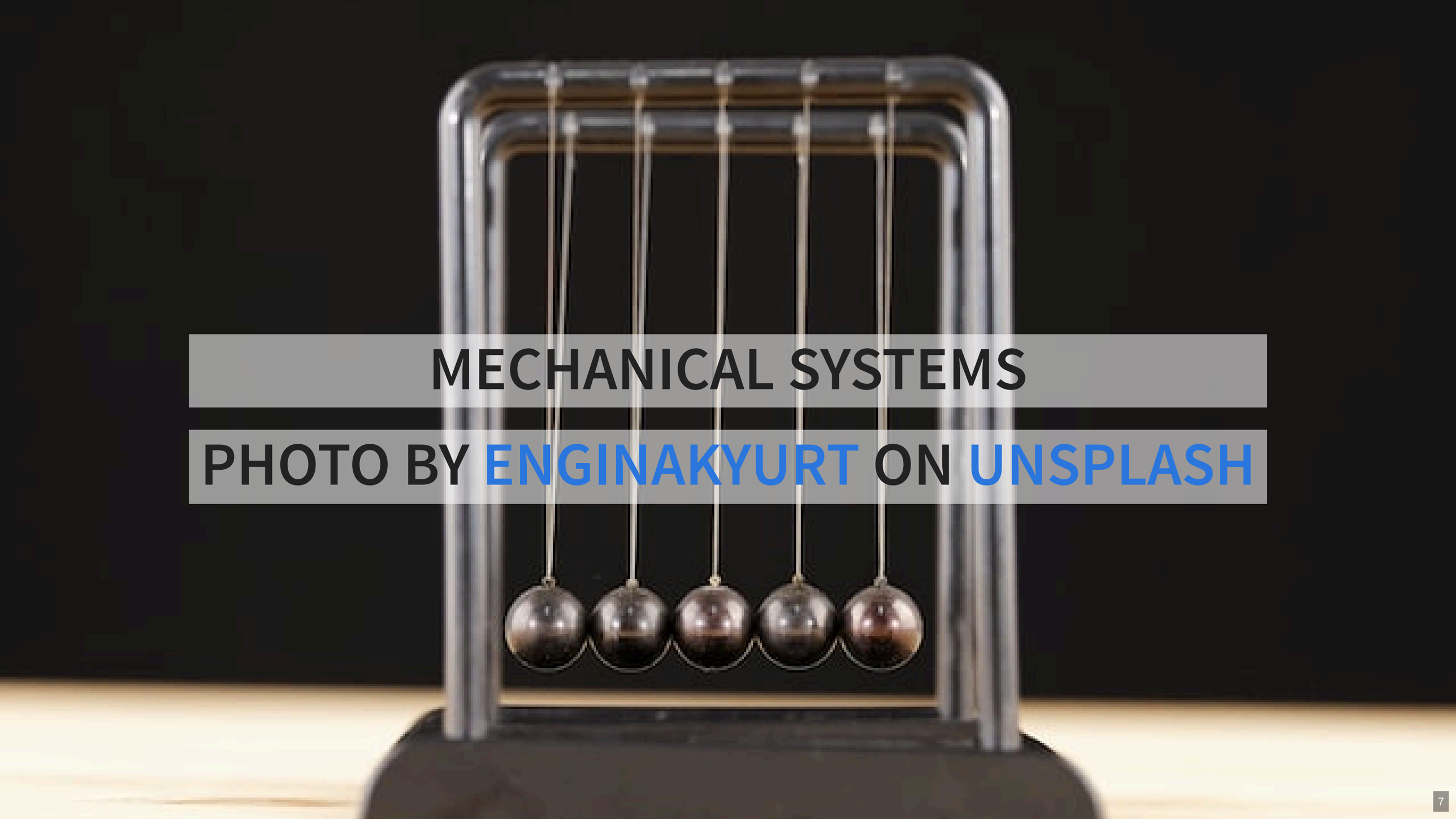
of abstract **dynamical systems**.

🇺🇸 Control Theory → 🇫🇷 **Automatique**.

🏷️ DYNAMICAL SYSTEMS (ABSTRACT)

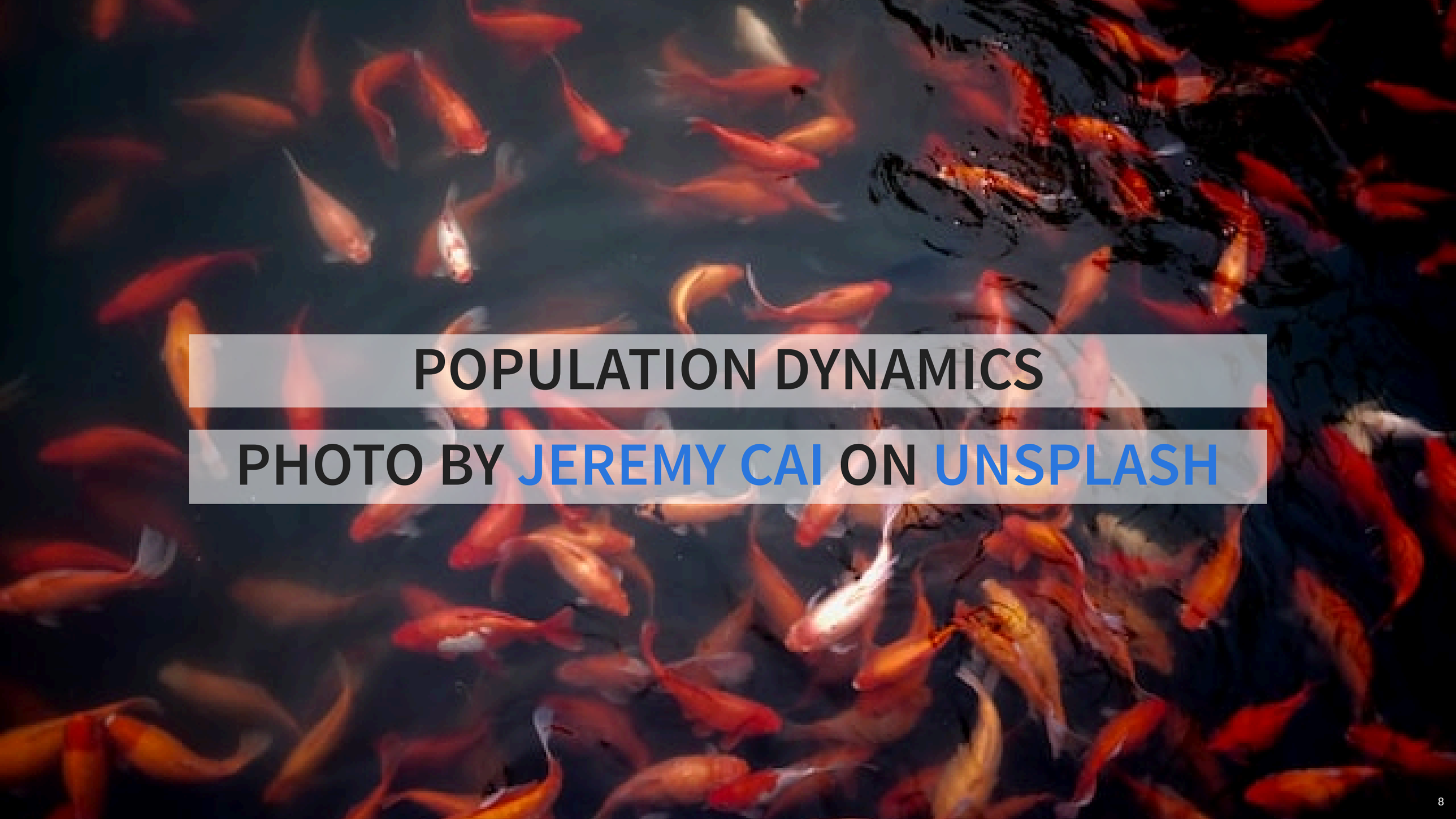
- Described by a set of time-dependent variables,
- which are governed by mathematical equations,
- that connects the system past, present and future.

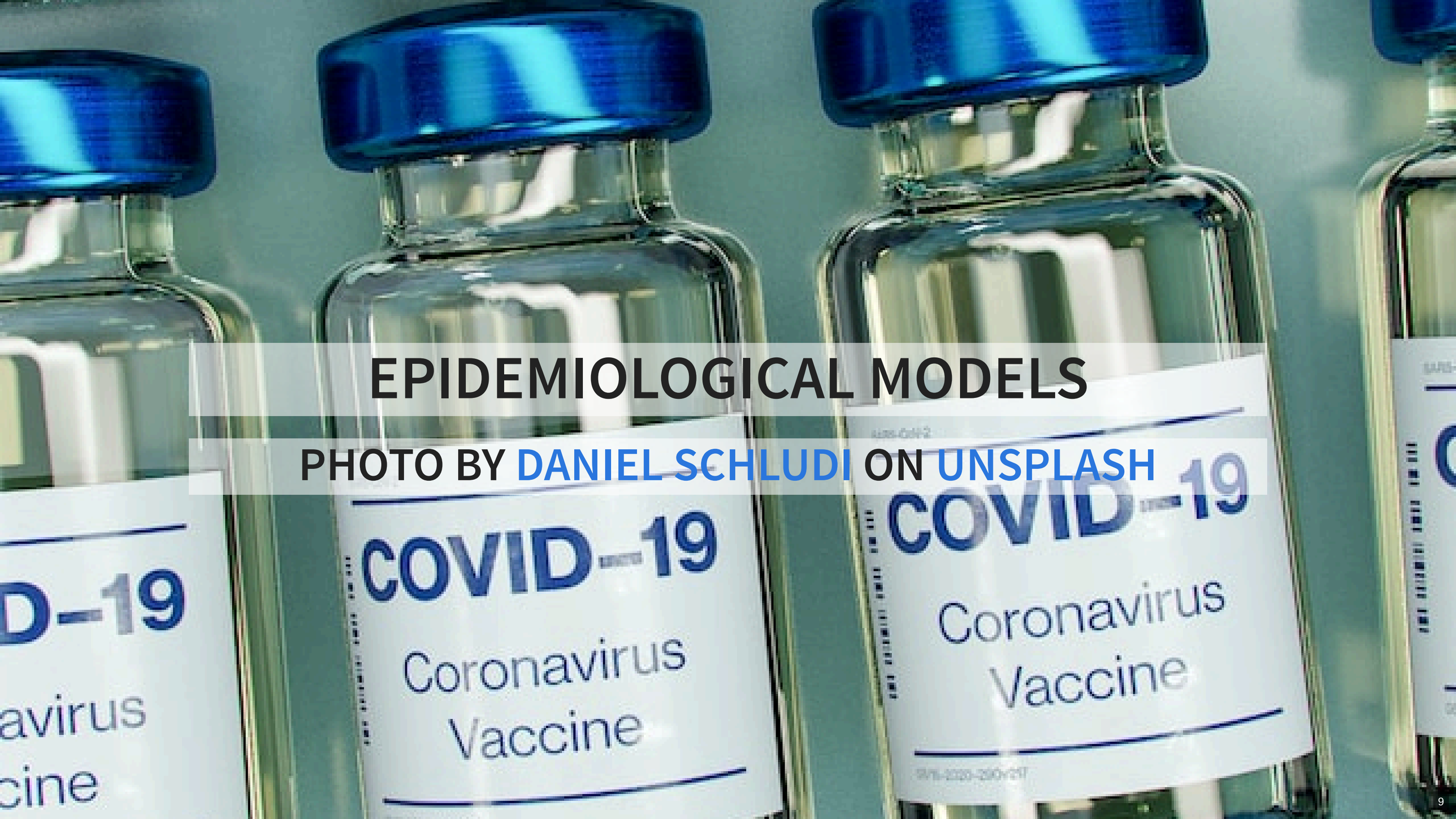
EXAMPLES



MECHANICAL SYSTEMS

PHOTO BY ENGINAKYURT ON UNSPLASH


POPULATION DYNAMICS
PHOTO BY JEREMY CAI ON UNSPLASH



EPIDEMIOLOGICAL MODELS

PHOTO BY DANIEL SCHLUDI ON UNSPLASH

🏷️ CONTROL ENGINEERING

Apply Control Theory to **design & build** concrete dynamical systems with specified behaviors.

Overlaps with and complements:

- 🔌 Electrical Engineering
- 🔧 Mechanical Engineering
- 🖥️ Software Engineering
- …

APPLICATIONS

ROBOTICS

POSSESSED PHOTOGRAPHY ON UNSPLASH

🤖 OR 🧑?

Consider:

- 💸 Cost analysis
- 🎨 Creative/complex work?
- 🦾 Strength, speed, precision
- 🏜️ Hostile work environment

MANUFACTURING

Automated Manufacturing Robots - FABTECH


EUROFIGHTER TYPHOON
PHOTO BY RAY HARRINGTON ON UNSPLASH

- twin-engine, canard delta wing, multirole fighter
- air superiority fighter / agile / dogfighter
- ⚠️ **aerodynamically unstable in subsonic flight!**

“The design of the Typhoon is such that without input to any control surfaces the aircraft will pitch up during flight extremely quickly.”

“Although this improves the agility of the aircraft it also requires a system to enable controlled flight to be maintained.”

“This is achieved through the Fly By Wire 🏷️ **Flight Control System** […].”

“With this system the pilot has no direct link to any of the aircraft’s control surfaces.”

“Instead, **all movements of the throttle, stick or pedals are interpreted by the FCS and an appropriate control response taken.**”

LEARN MORE

- 📖 Negative Stability (Aerodynamics)
- 📖 Eurofighter Typhoon FCS
- 🖼️ Eurofighter Typhoon Photos

BOEING 737 MAX

PHOTO BY JUSTIN HU ON UNSPLASH

BOEING 737 MAX

4th generation of Boeing 737.

Larger and more powerful engines.

→ ⛽ fuel consumption reduced by 14%

→ 💸 profit!

→ ⚠️ engines located further forward and higher

→ ⚠️ pitch-up tendency that needs to be controlled

→ 🏷️ **Maneuvering Characteristics Augmentation System (MCAS)**

FATAL CRASHES

✈️ **Lion Air Flight 610** (2018, Indonesia)

“MCAS pushing the aircraft into a dive due to data from a faulty angle-of-attack sensor.”

✈️ **Ethiopian Airlines Flight 302** (2019, Ethiopia)

“Evidence suggests, that […] the aircraft was configured to dive, similar to Lion Air Flight 610.”

→ 🛑 **global 737 MAX groundings.**

LEARN MORE

- 📖 Boeing 737 Max (Wikipedia)
- 📖 Boeing MCAS
- 📰 Boeing 737 Max Plane Crashes
- 📰 What is the Boeing 737 Max MACS?
- 📰 Boeing 737 Max adjustable stabilizer

ROCKET BOOSTER LANDING

🚀 SPACEX'S STARSHIP

ADAS & SELF-DRIVING CARS

🏷️ **ADAS:** Advanced Driver-Assistance Systems

📆 **2025:** fully autonomous cars are not 100% there yet.

Actors: Tesla, Mercedes-Benz, Waymo, etc.

SAE LEVELS

🏷️ **SAE** : Society of Automobile Engineers

- **Level 0:** ~ No automation
- **Level 1:** ~ Hands on
- **Level 2**: ~ Hands off ← Telsa Autopilot
- **Level 3:** ~ Eyes off ← Mercedes Drive Pilot (2021)
- **Level 4:** ~ Mind off ← Mercedes Testing (2024)
- **Level 5:** ~ 🚀 **Self-driving** ← Not achieved yet

LEVEL 1 ADAS

Single feature automation.

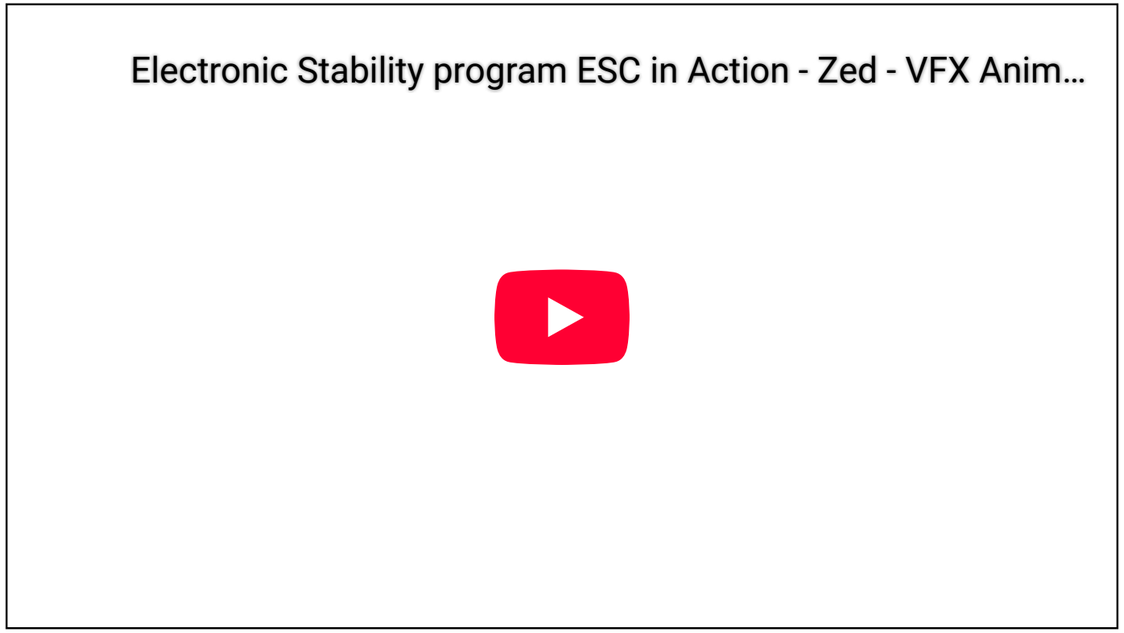
- 🏷️**CAS: Collision avoidance systems**
- 🏷️ **CC: Cruise control**

🏷️ ACC: CAS + CC

ADAPTATIVE CRUISE CONTROL

🏷️ ESC/ESP

ELECTRONIC STABILITY CONTROL



LEARN MORE

- 📰 Tesla’s self-driving technology fails to detect children […]
- 📰 Mercedes Drive Pilot Beats Tesla Autopilot By Taking Legal Responsibility
- 📰 Mercedes-Benz Wins World’s First Approval For Level 3 Autonomous Cars
- 📖 ADAS, CAS, CC, ACC, ESC/ESP.