AT-COM

Assisted teleoperation for unmanned construction machines

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system robotic teleoperation

Hes·so

ute Ecole d'Ingénierie
genieurwissenschaften

Intro

Arnaud Demion

- PhD in theoretical Physics
- Numerical modeling
- @HEVS since 06.2022

Smart Process Lab

https://spl.hevs.io/

- *Industry 4.0*
- *Artificial Intelligence*
- *Smart manufacturing*
- *Process Optimization*
- *Digitalization*

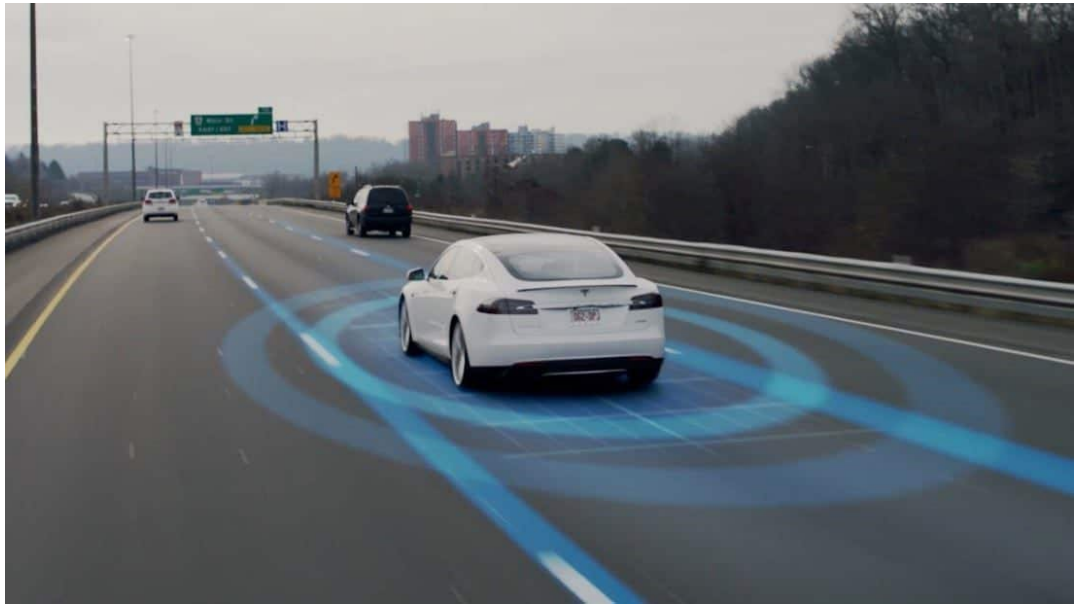
Gilles Mottiez

- Bachelor HES-SO Systèmes industriels – Infotronics
- @HEVS 2019-2021 - SPL
- @Syrto AG since 09.2021

https://www.syrto.ch/

- *Teleoperations (AT-com)*
- *Automation (syBaKa)*
- *Security systems for ski stations (syBaB)*

AT-COM : Assisted teleoperation for unmanned construction machines



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BOWA RECYCLING AG

Goals and challenges

- **Goals**
  - Reduce down-times between operations
  - One teleoperator manages 2 or 3 cooperatives machines
  - Reduce risks of an operator driving in hazardous areas (contaminated sites, mountain roads, …)
  - Fuel consumption reduction
- **Challenges**
  - Safety on the site and around the machine
  - Weight of the wheel loader
  - Environment can change around the machine
  - Different materials to load and unload
  - Latency for teleoperations

Goals and challenges

- **Autonomous loading**
  - Heap recognition
    - Position
    - Shape
    - Material
  - Relative position of WL
  - Optimal loading
    - What is “optimal”?
  - Creating a crash into the heap...

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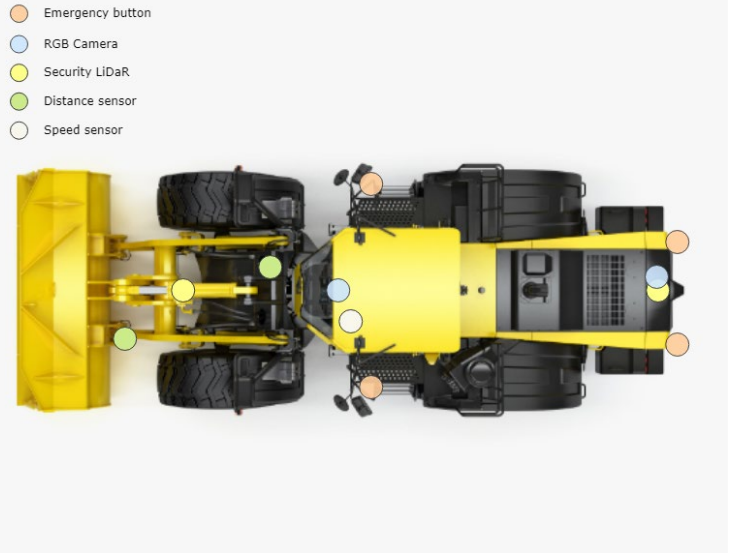
Goals and challenges

- **Autonomous unloading**
  - Precision of the wheel loader position
  - Height of the target (truck)
  - Unload the full bucket
  - Do not crash the bucket against the truck...

Source : https://mk-dt.ch/transport-de-materiel-pour-chantier/

Embedded vision sensors

- **3D modelling for autonomous functions**
  - 360° LiDAR for environment mapping
  - 2x safety LiDARs
- **Teleoperations**
  - 4 cameras



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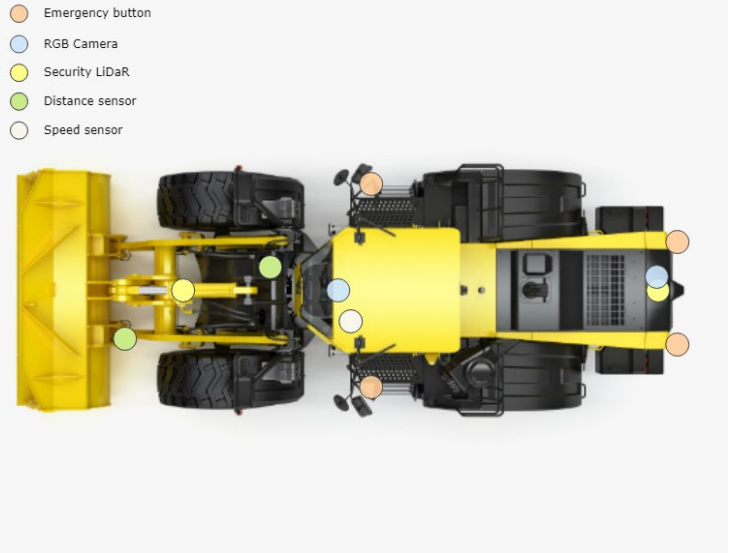
Machine control sensors - safety

- **CAN interface**
  - Speed, gear speed, pressures, angles, ...
- **IMU**
- **Safety**
  - Emergency buttons
  - Position sensors
  - SIL-2/3
  - Dedicated safety PLC with direct controls on machine



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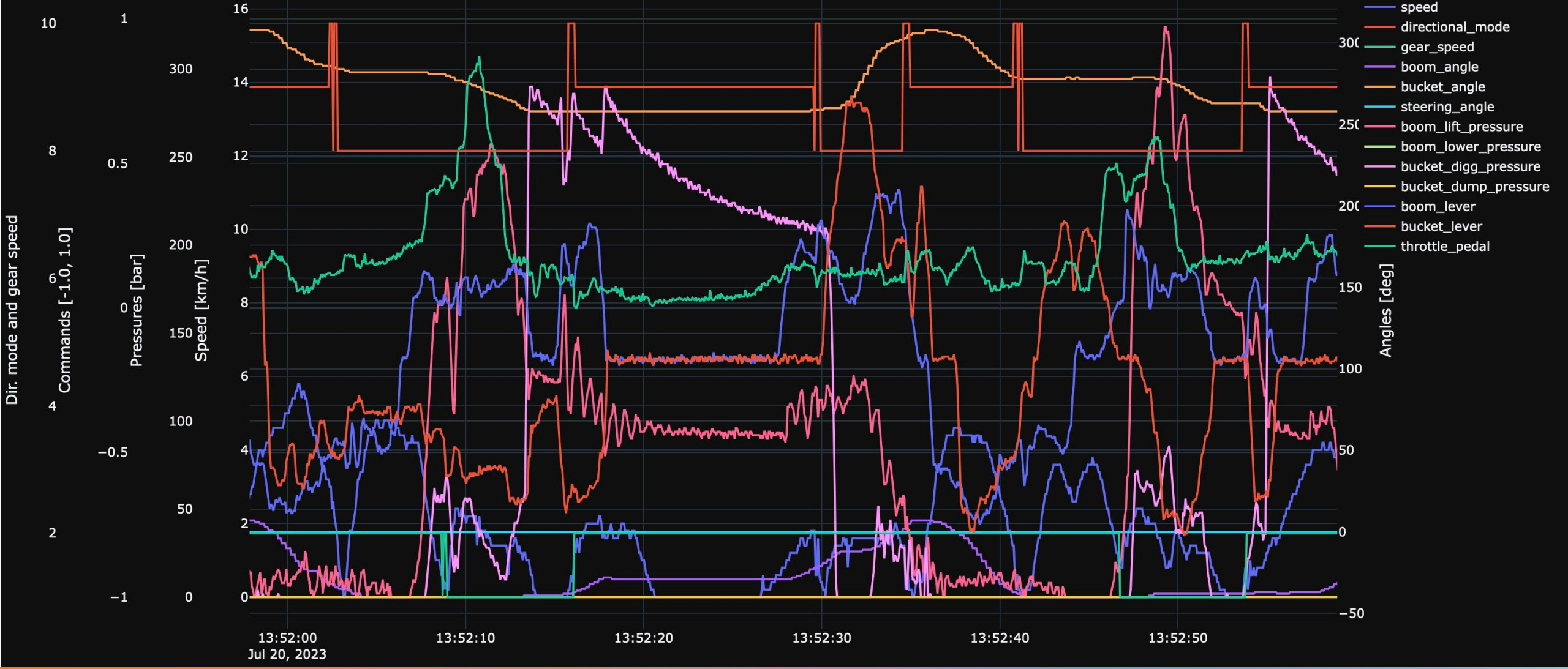
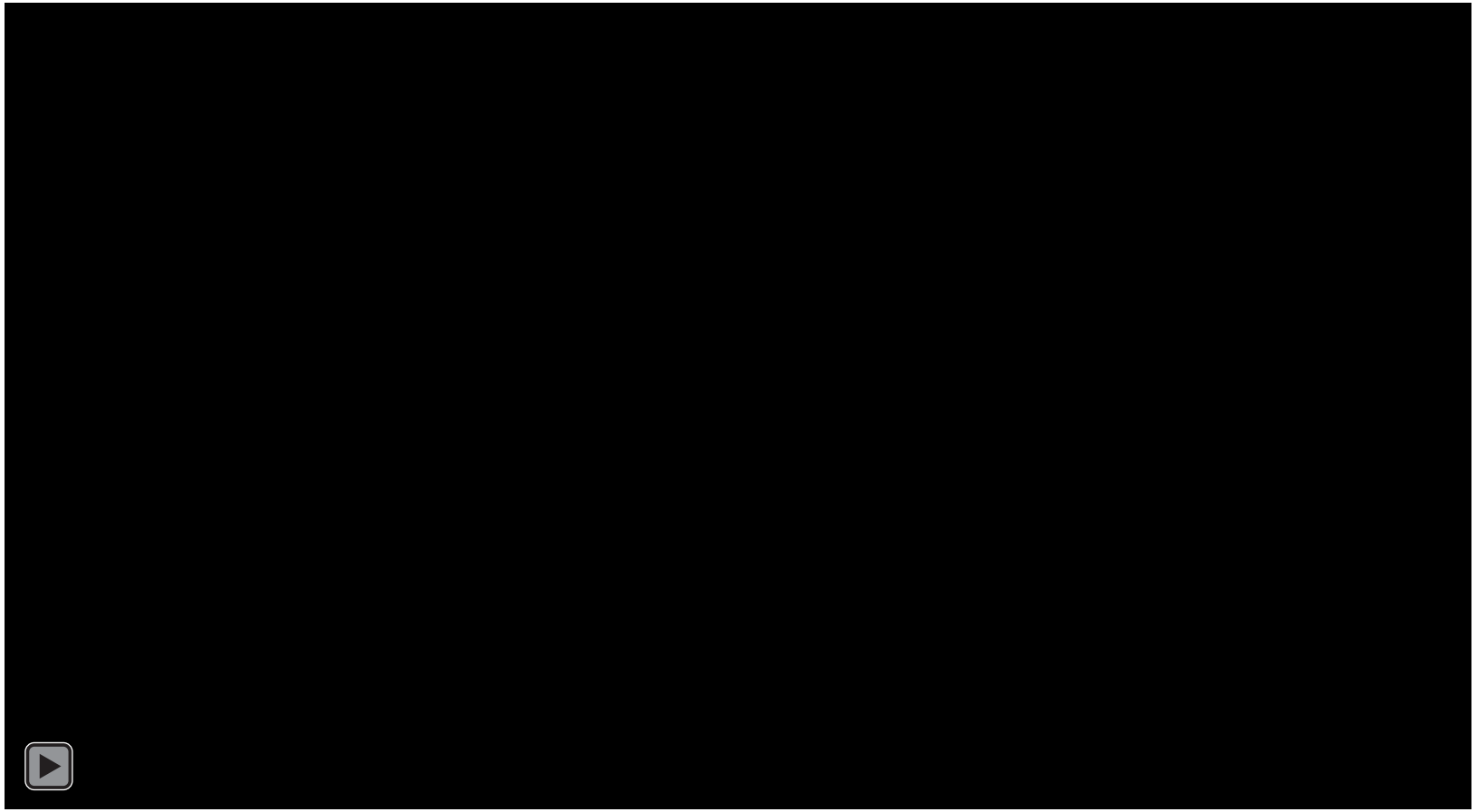


Data collected in "local" mode

Why it is difficult…



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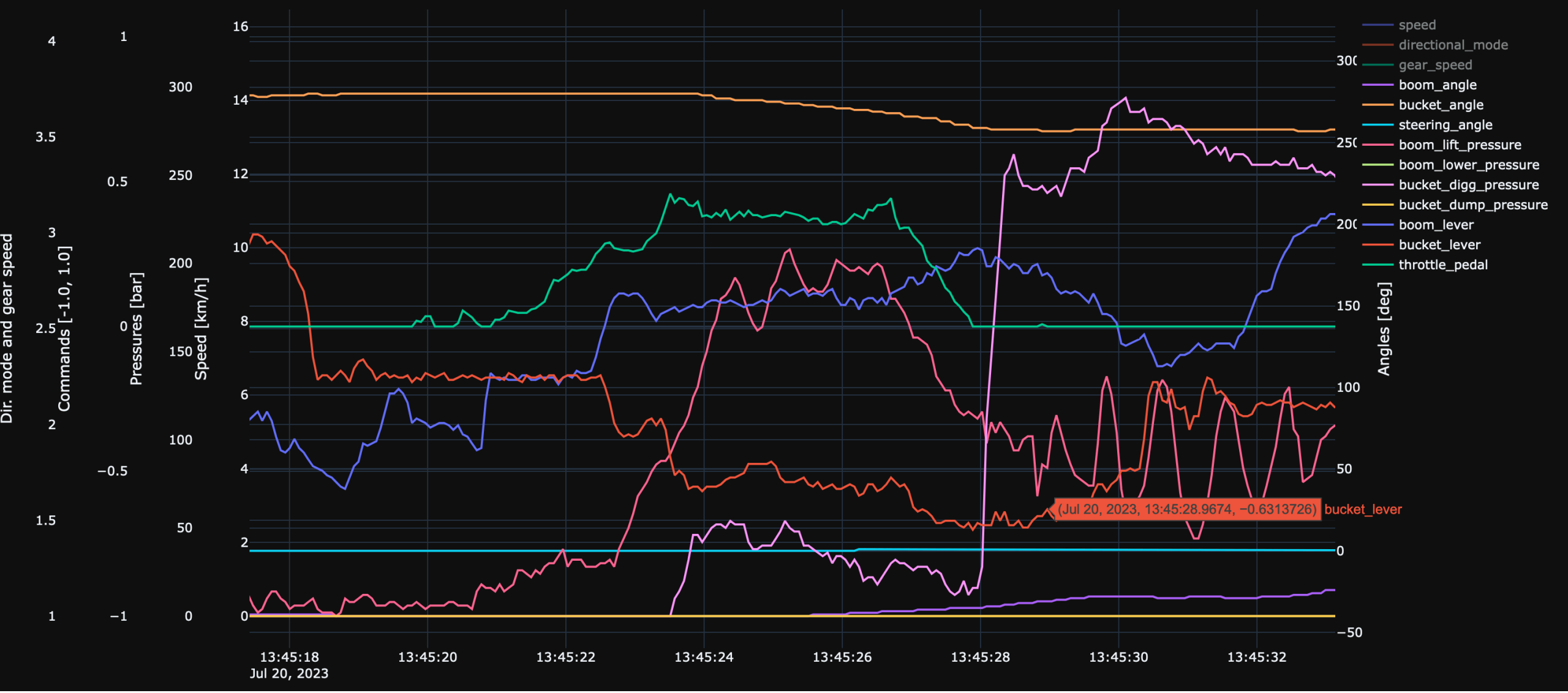
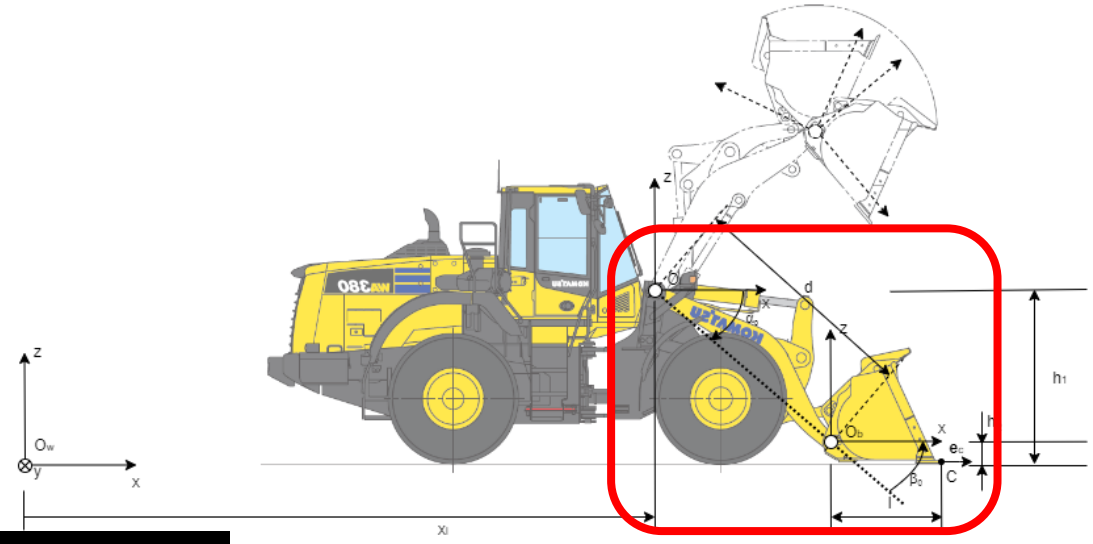
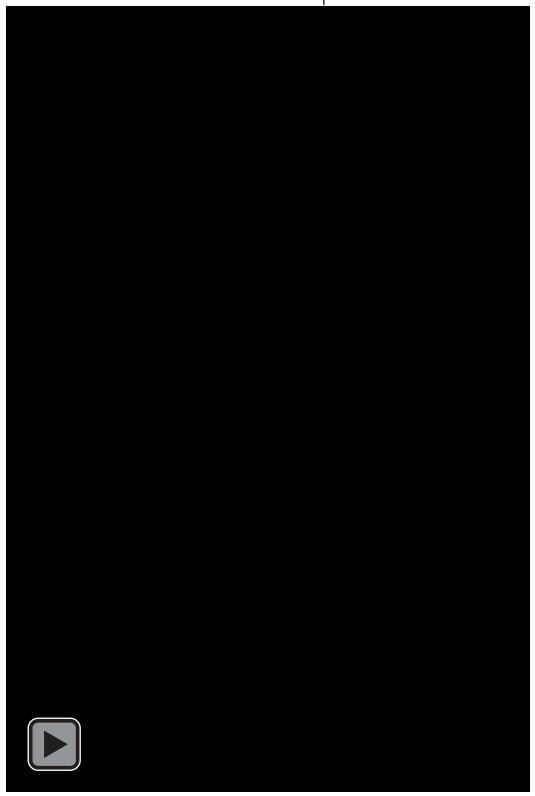


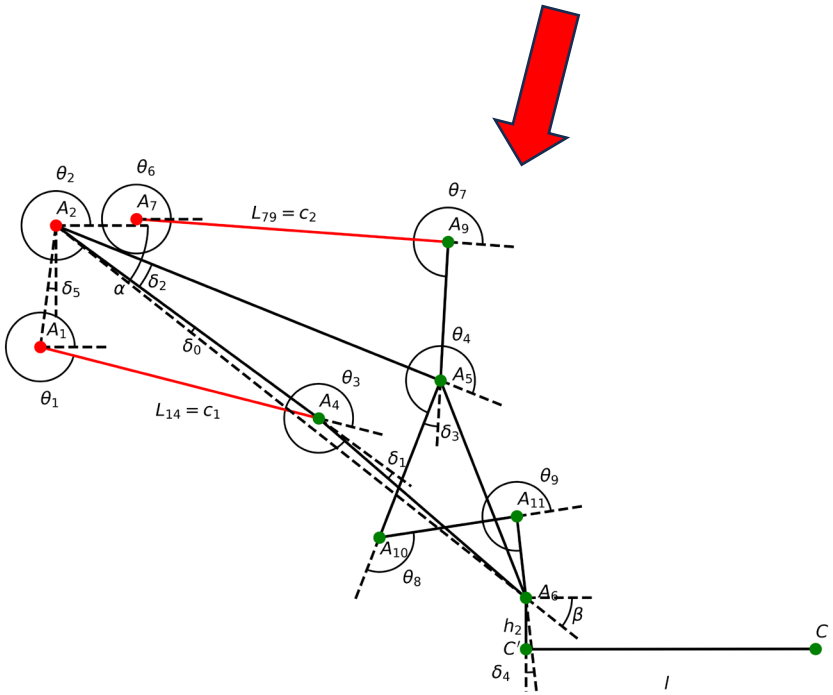
Data of loading cycle performed by an operator in local mode

Automatic loading

- **Mechanical description + control theory**
  - Inverse kinematics
  - Signal processing
  - PID
- **Impedance control?**
  - Inverse dynamics (ouch!)
- **Or reinforcement learning?**
  - Physical simulation (Unity)







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The simple way works!

At least for sand and fine materials…

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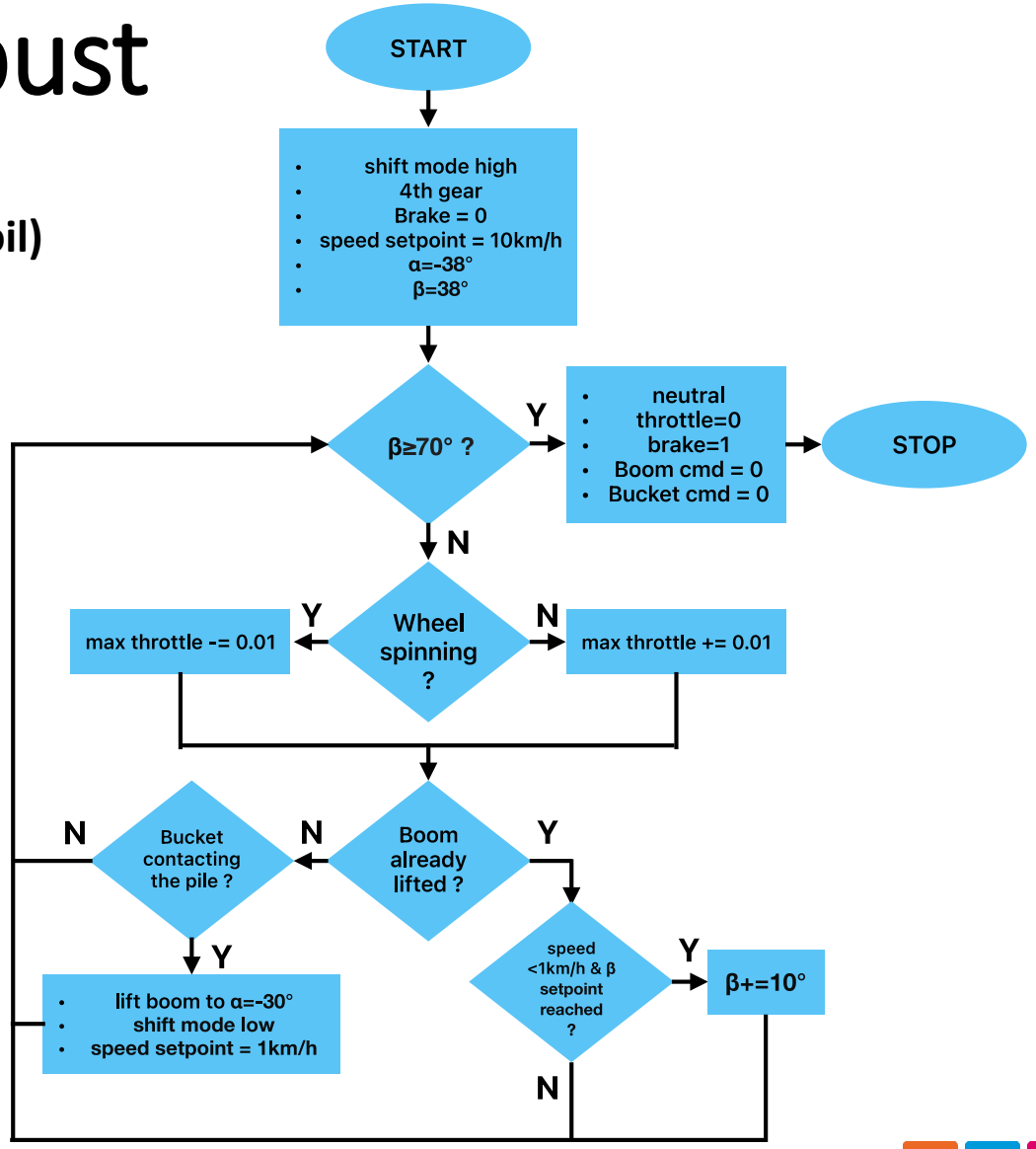
It is however pretty robust

- It can handle sticky/wet soil
- It avoids wheel spin (thus preserving tires and gasoil)
- It maximizes bucket filling
- It uses a simple PID which is highly predictable



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What about highly heterogeneous materials?

- **Impedance control:**
  - We need to know the mass of every moving part
  - … and to solve the inverse dynamics problem

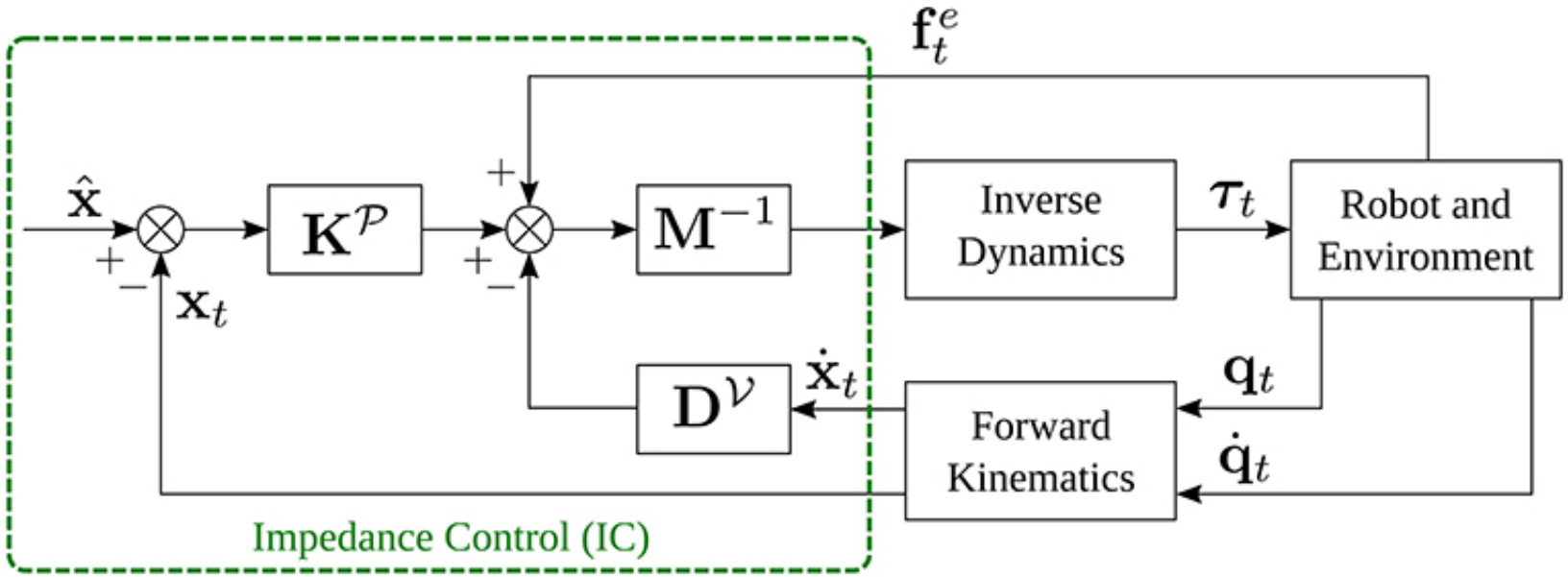

Image taken from Variable Impedance Control and Learning—A Review, Frontiers in Robotics and AI

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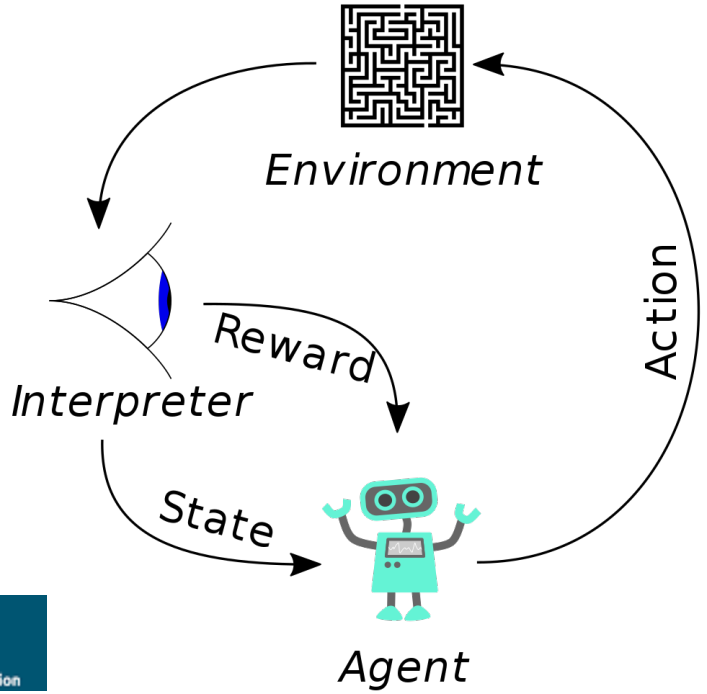
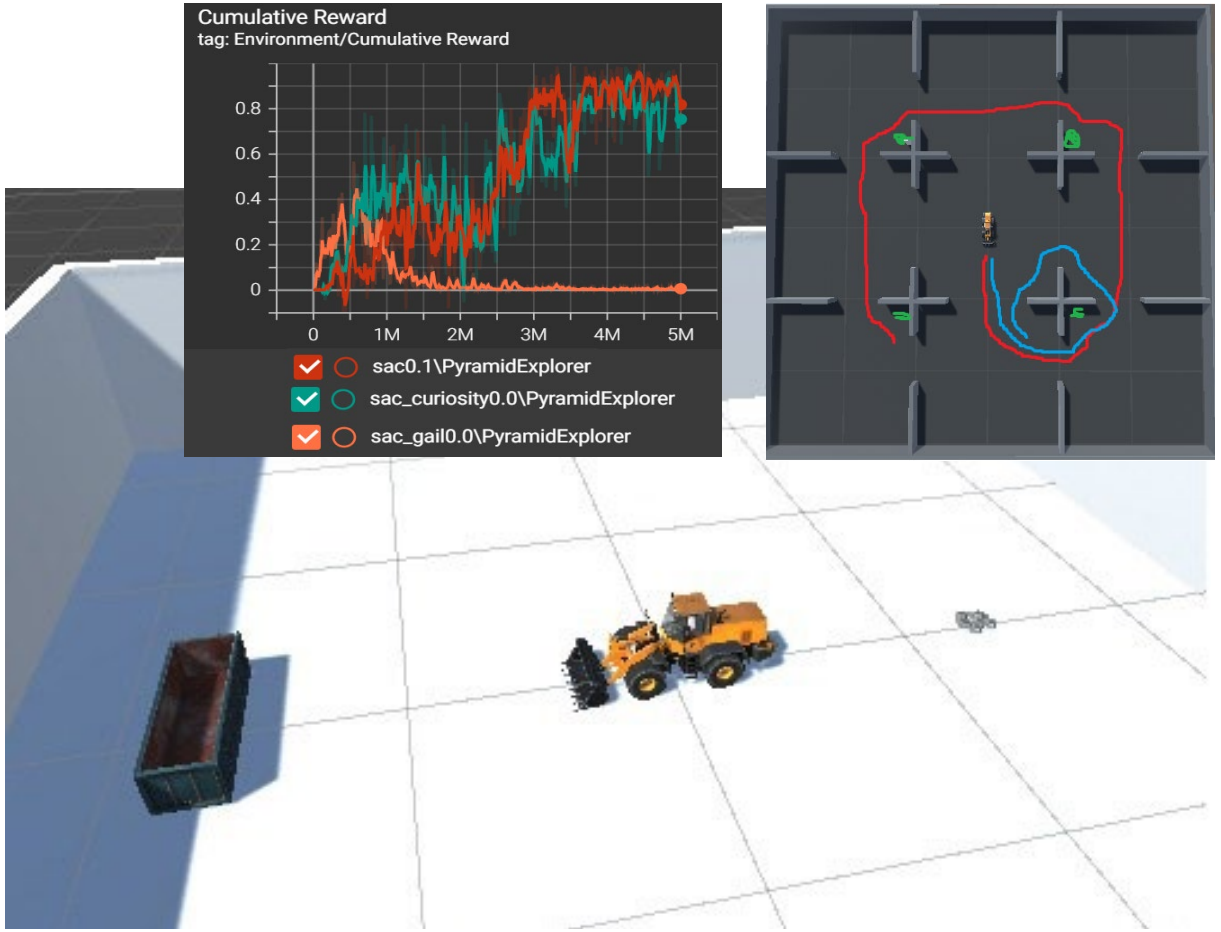
What about highly heterogeneous materials?

- Reinforcement learning
  - We need a fairly realistic and fast numerical simulation

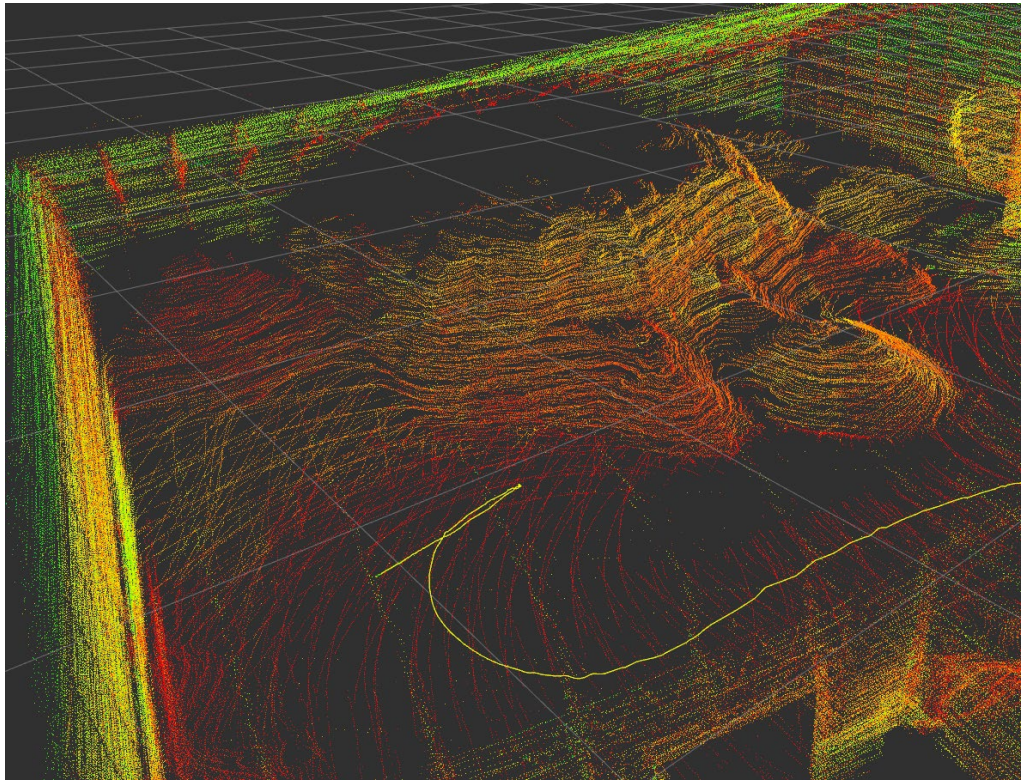




Travail Bachelor: **Thomas Zimmermann**

And the autonomous navigation?

- **The wheel loader must be able to self localize**
  - LiDAR & IMU
  - Simultaneous Localization and Mapping (SLAM)
- **… to generate its own path from point**
  - Wheel loader kinematic model
  - Path planning algorithms
- **… and then to follow the path**
  - Controllers



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And the autonomous navigation?

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In the future:

- **Improve loading with reinforcement learning?**
- **What about high level decision making?**
- **People detection for safety?**

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People detection – one more safety option, to help teleoperator