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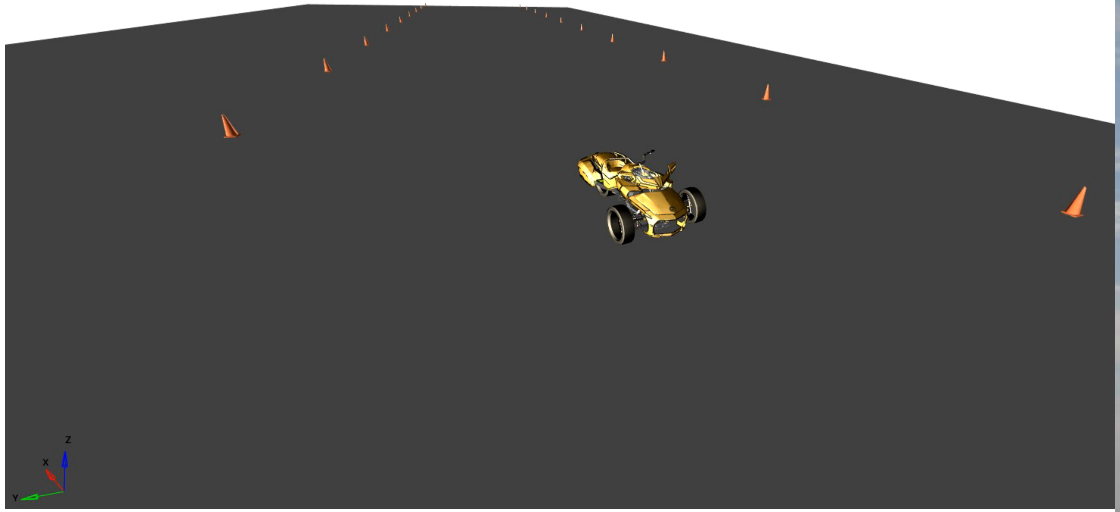
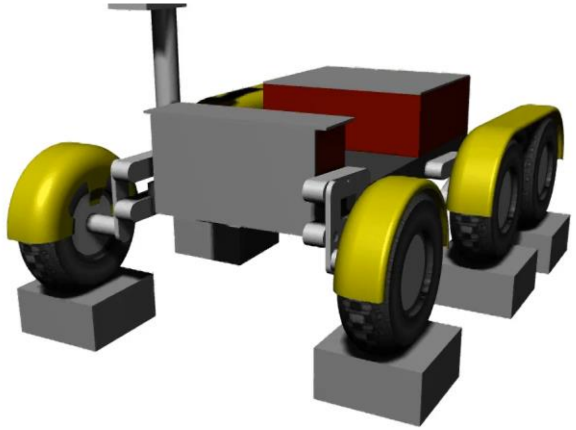
Use of AI for simulation and digital twins

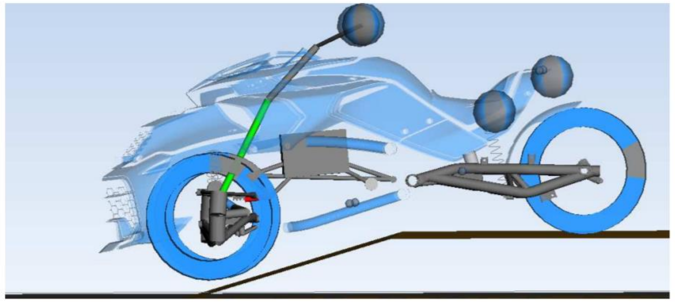
First, physics sandboxes are now key to develop and test vehicles

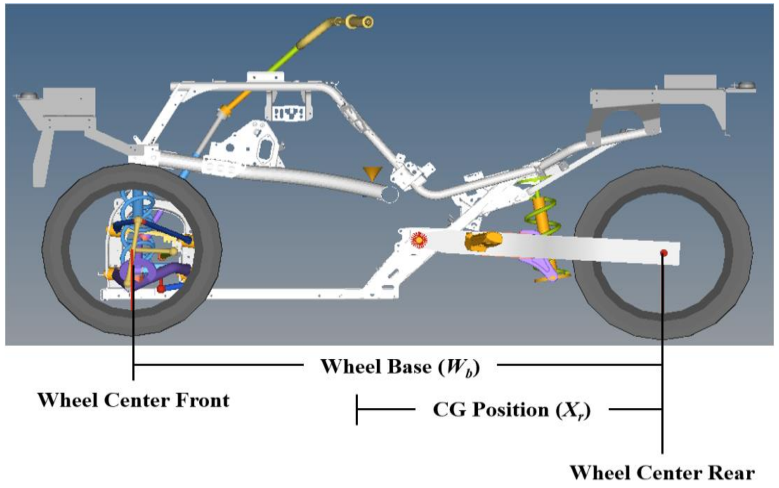


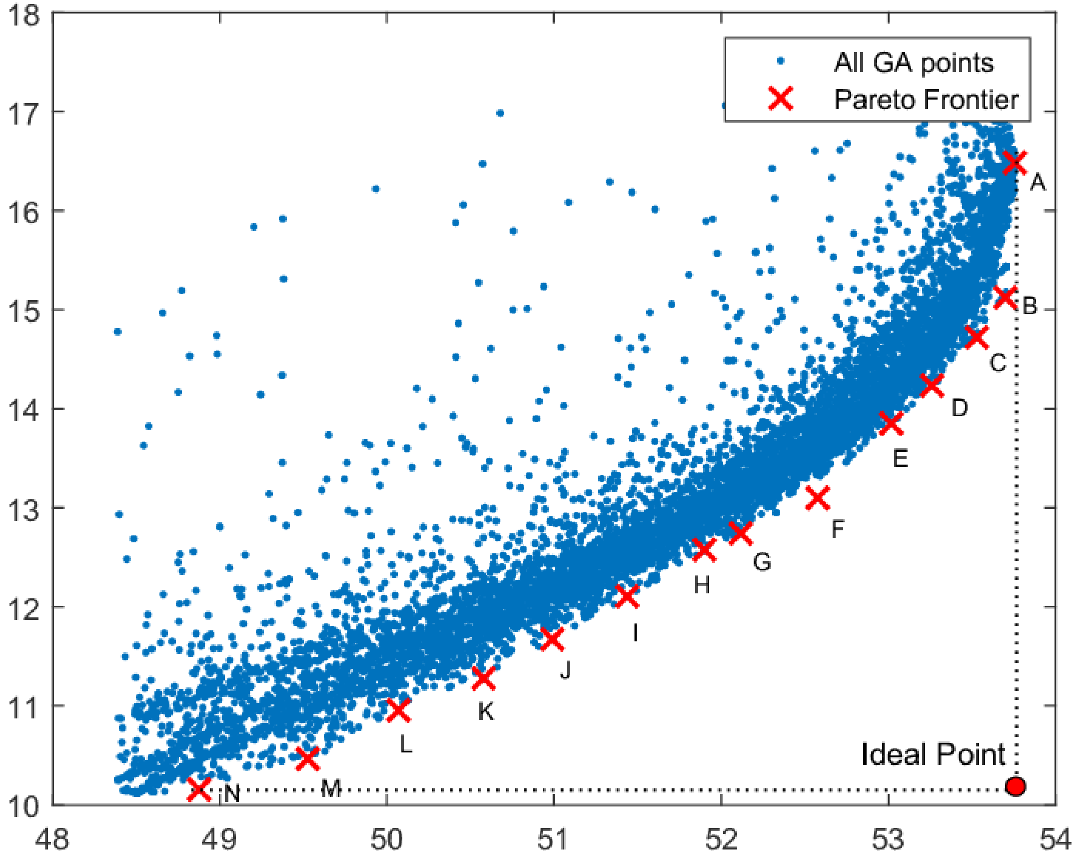


Those digital twins have been used to guide design choice and find best trade-offs

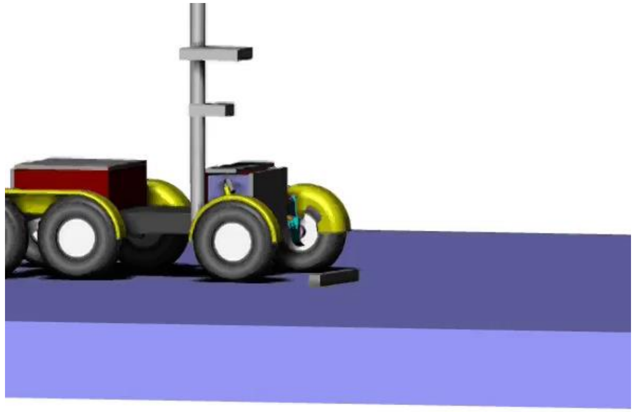
- By optimizing multiple parameters and find best trade-offs using DOEs and optimization



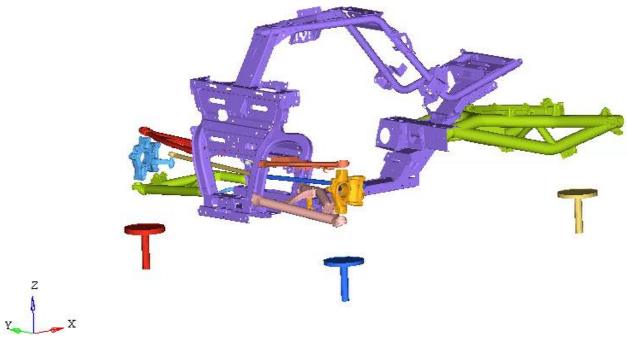




And evaluate input loads on the structure



Tire-model agnostic



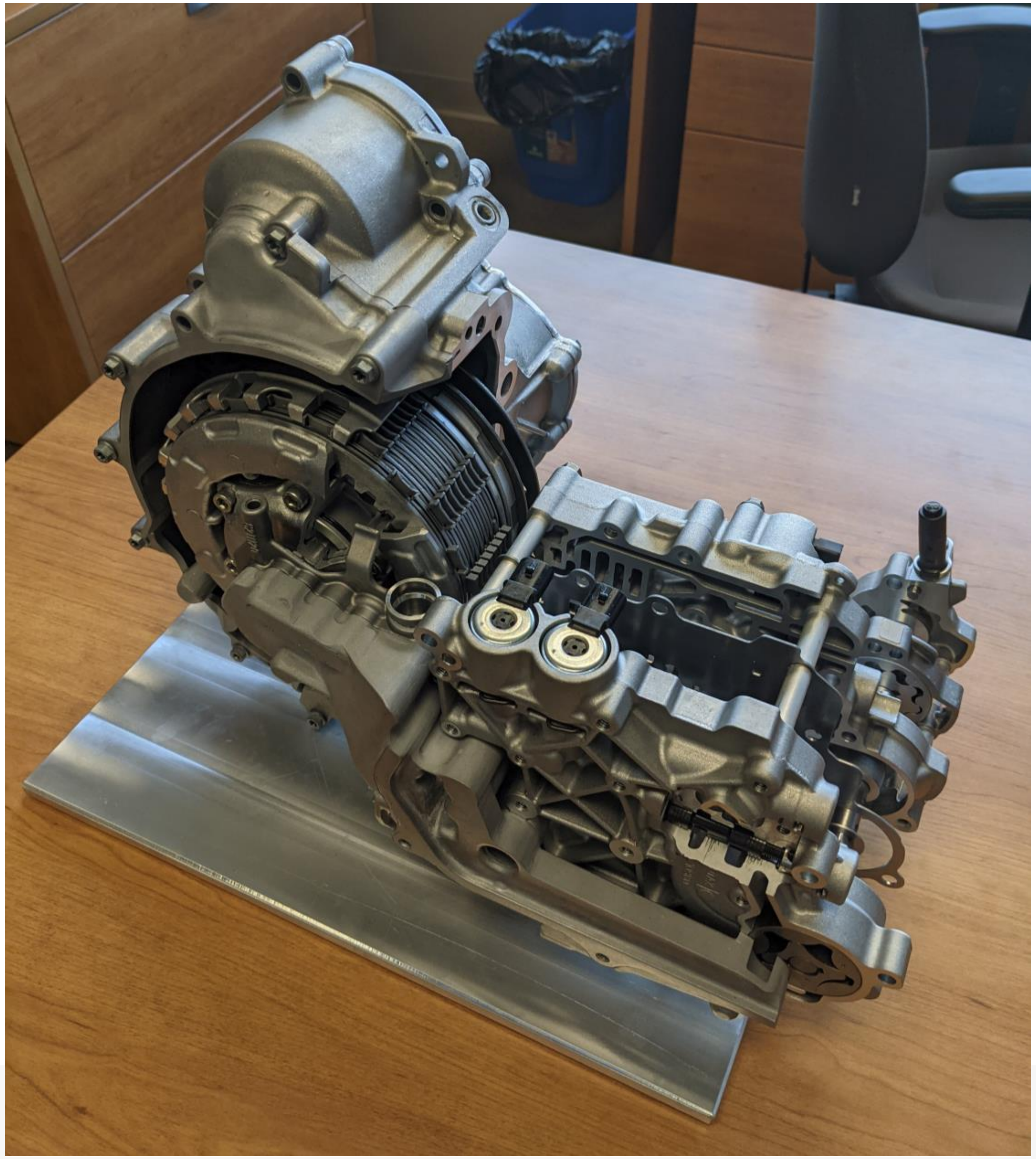
They allow making new vehicle that will operate in different gravity

- MESR vehicle seen at NASA's Ohio proving ground

We are now building driver-in-the-loop and immersive simulators using said models

Second, Machine learning and AI applications in vehicles are exploding in popularity

- This clutch is fully automated on the Can-am Spyder thanks to machine learning
- The hydraulic pressure sent to the clutch is adapted continuously for:
  - Tolerance variation
  - Wear
  - Coefficient of friction loss



Allowing to learn and adapt in complex systems

- The machine learning algorithm correlates the clutch torque to the pressure during the launch if favorable conditions are met
- It finds the kisspoint pressure and coefficient of friction

US008744709B2

(12) United States Patent
Gauthier et al.

(10) Patent No.: US 8,744,709 B2
(45) Date of Patent: Jun. 3, 2014

(54) VEHICLE CLUTCH CONTROL METHOD

(73) Assignee: Consortium de Recherche BRP—Université de Sherbrooke S.E.N.C., Sherbrooke (CA)

(21) Appl. No.: 13/996,677

(22) PCT Filed: Mar. 14, 2011

(86) PCT No.: PCT/CA2011/000277

(87) PCT Pub. No.: WO2012/083411

PCT Pub. Date: Jun. 28, 2012

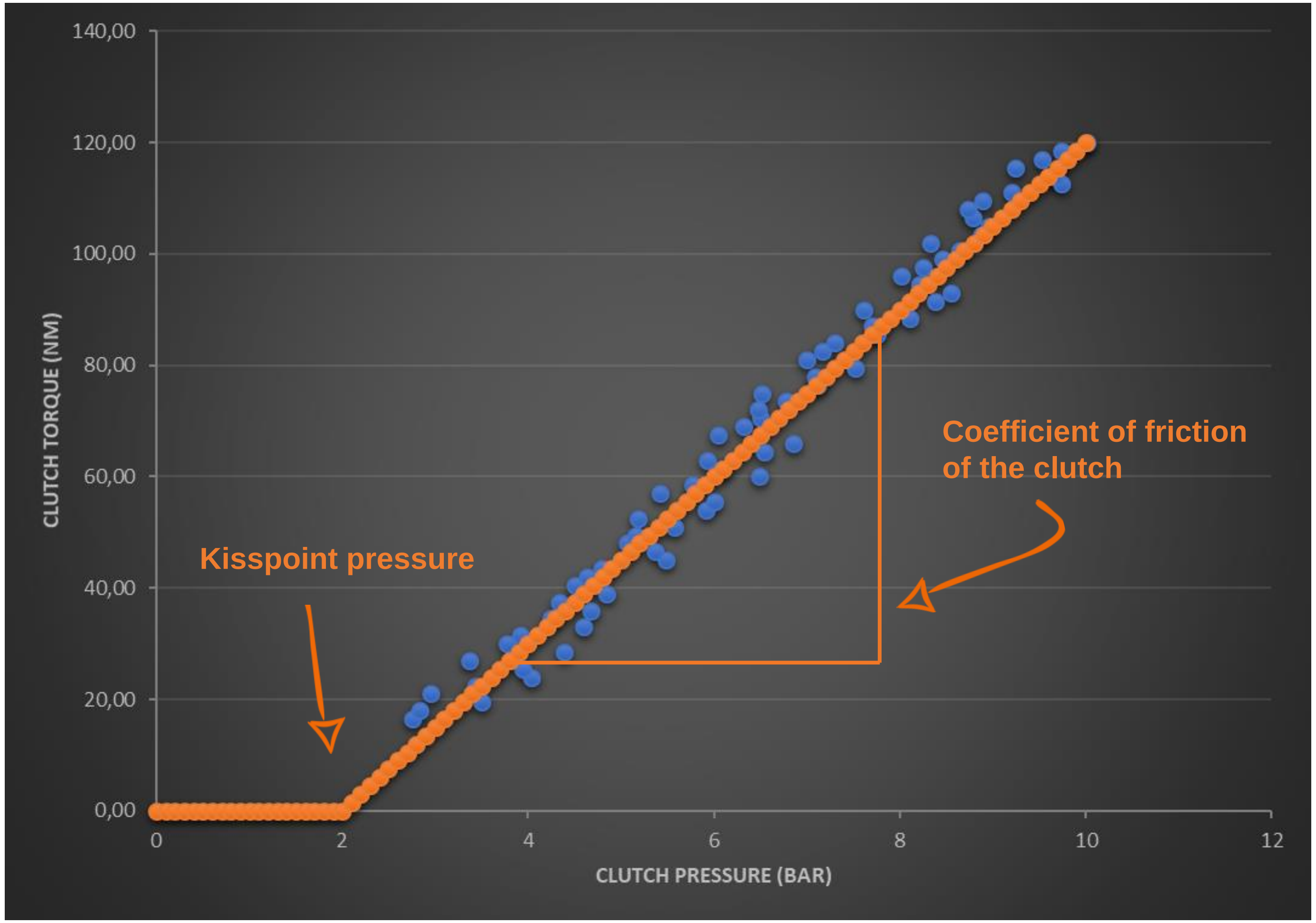
(56) References Cited

U.S. PATENT DOCUMENTS

OTHER PUBLICATIONS

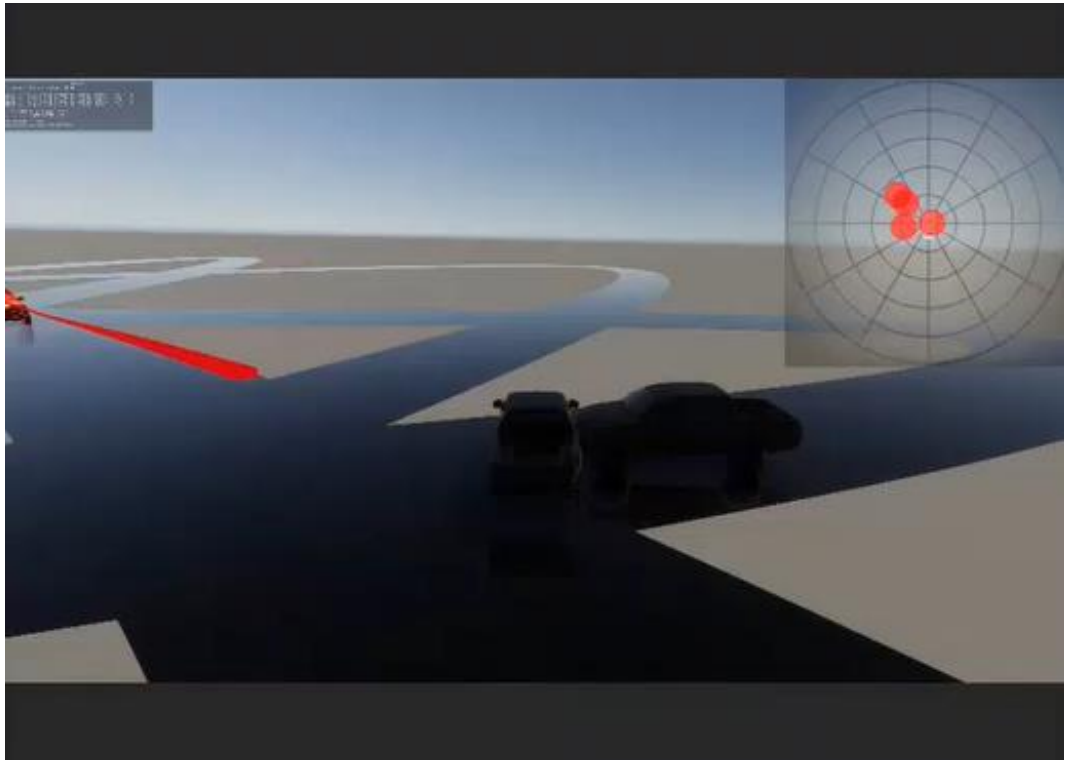
(57) ABSTRACT

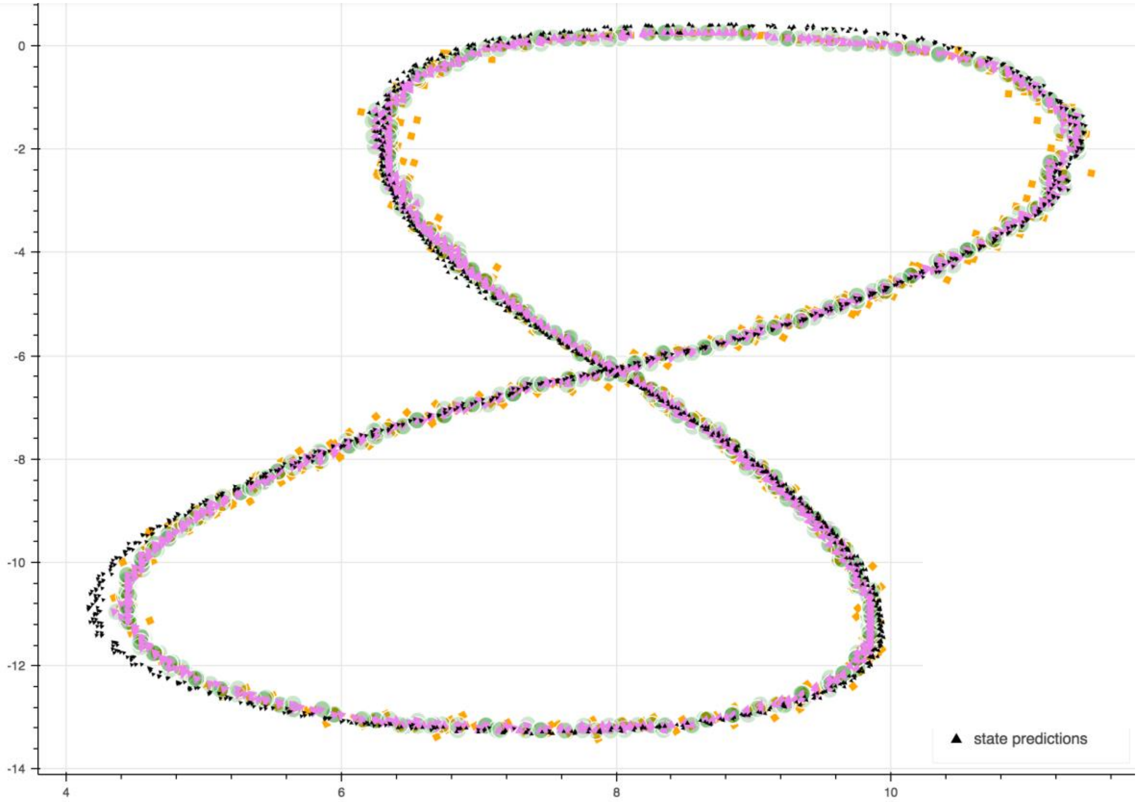
21 Claims, 11 Drawing Sheets



We use AI to estimate vehicle trajectories

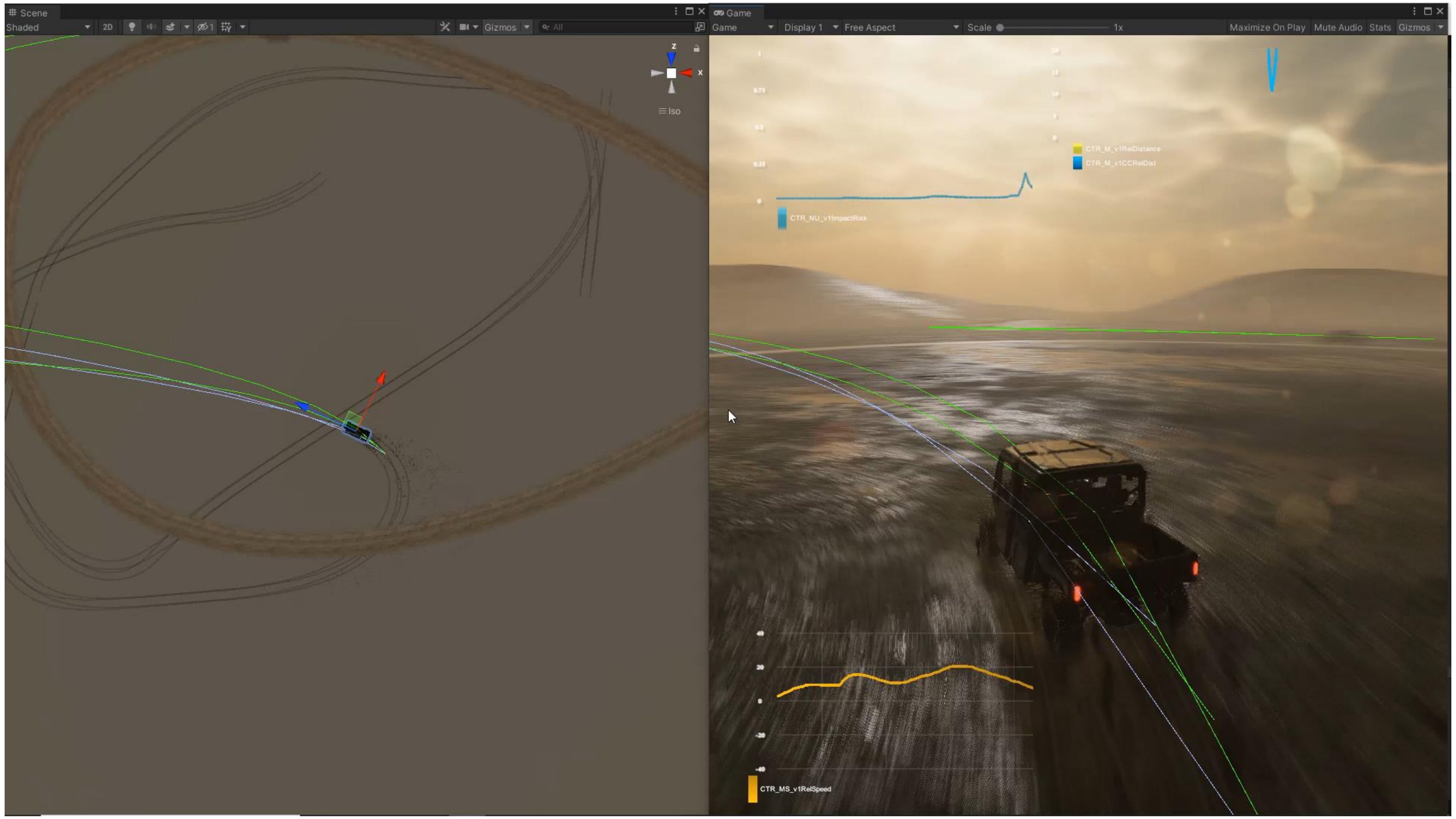
- Fusing GPS, yaw rate sensor, steering, throttle and brake
- And avoid future collisions





A 2nd order Vold-Kalmann gives excellent results for trajectory prediction

- This could be used for collision avoidance for example or issuing warnings
- Very light in terms of resources and can be done for the closest 10 vehicles if C-V2X information is received



AI and Digital Twins can be used together

to accelerate development despite the growing complexity

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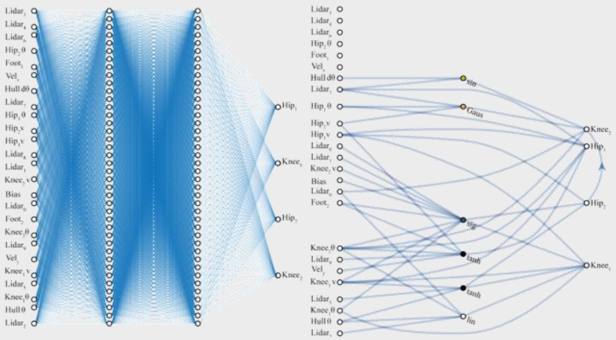
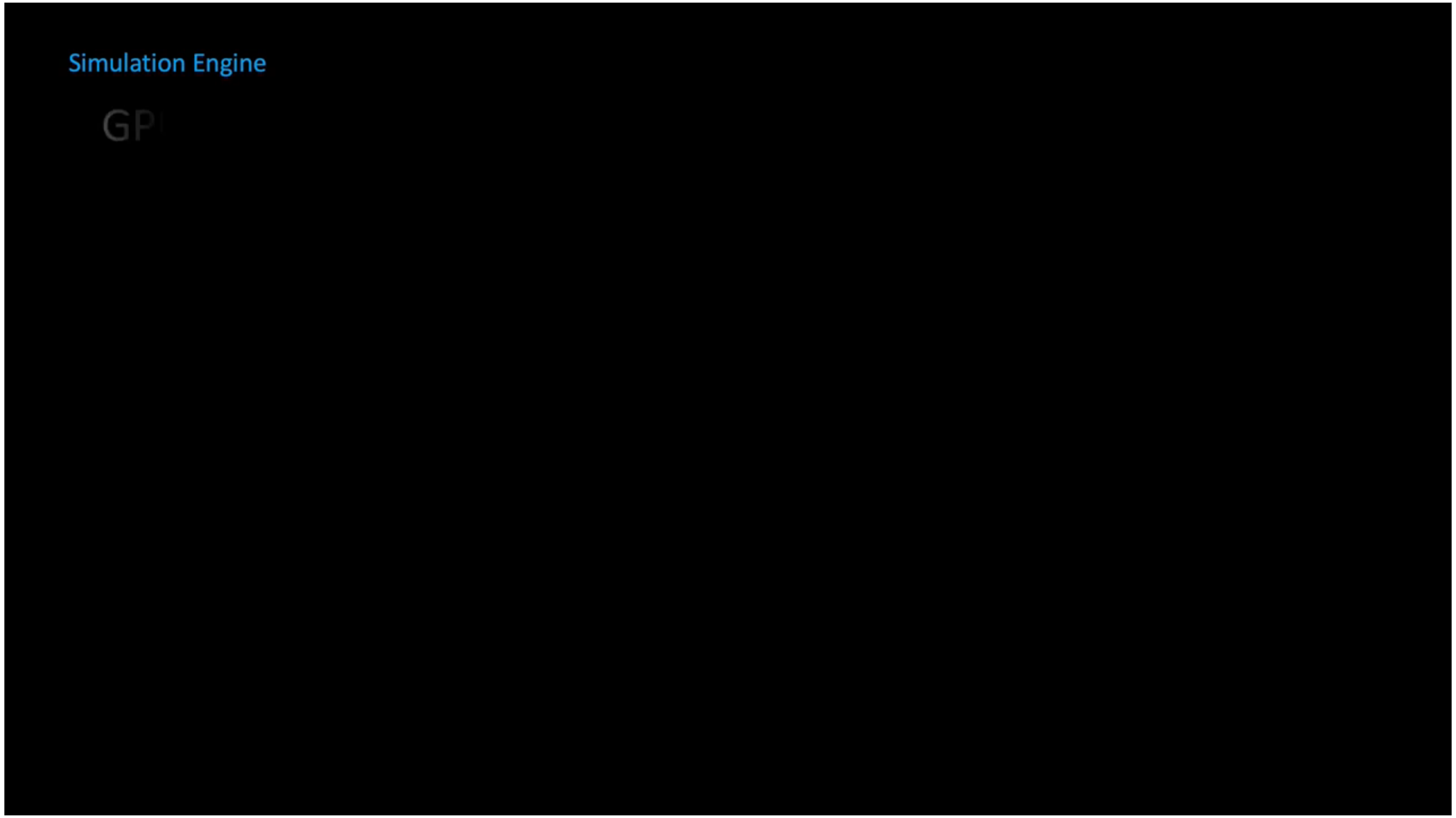


We are beginning to simulate virtual sensors and validate software stack for autonomous driving in a virtual environment



Source: LG SVL

Digital vehicle + Digital environment

- We already have high-fidelity digital twins for dynamic behavior
- We plan to scan our real test environment with LiDAR

We can use this to develop bots that drive the vehicle on an off-road test track

- In a virtual sandbox:
  - We are starting to use Reinforcement Learning to control Throttle, Brake and Steering
    - Rewards for staying on track
    - Rewards for maintaining a high speed and scoring good checkpoint times
    - We randomize parameters such as weight and traction to make the controller robust
- Once satisfied with our model, we will try zero-shot generalization from simulation to natural environments
    - Using GPS, cameras, flash lidars and radar with Nvidia Drive
    - Having a C-V2X collision avoidance supervisor and Geofencing to limit collision risk and avoid vehicle leaving certain areas

Pan, Georgia Institute of Technology

Lee et Al.
Robotic Systems Lab, ETH Zurich, Zurich, Switzerland

CTA

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UNIVERSITÉ DE SHERBROOKE