

INSTITUT
POLYTECHNIQUE
DE PARIS

Digital Twin for Autonomous Earthwork in Virtual-Reality

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1. Context

2. System

3. Conclusion



1. Context

The Project



Autonomous Earthwork

1. Context

The Need

Remote fleet supervision :

- (1) **Understand** the scene
- (2) **Instruct** machines
- (3) **Unstuck** machines
- (4) Operates in **real time**

1. Context

The Need

Remote fleet supervision :

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```

nicolas@Sam-Heracles-Robotics: ~/ros2_ws
nicolas@Sam-Heracles-Robotics:~/ros2_ws$ ros2 run can_bus can_reader
nicolas@Sam-Heracles-Robotics:~/ros2_ws$ ros2 run can_bus can_writer
nicolas@Sam-Heracles-Robotics:~/ros2_ws$ ros2 run trax_firmware speed_control_node
nicolas@Sam-Heracles-Robotics:~/ros2_ws$ ros2 run trax_firmware position_control_node

nicolas@Sam-Heracles-Robotics:~/ros2_ws$ ros
nicolas@Sam-Heracles-Robotics:~/ros2_ws$ ros2 run trax_firmware
macro_actions_test_node macro_controller_node position_control_node --prefix
simulator speed_control_node
nicolas@Sam-Heracles-Robotics:~/ros2_ws$ ros2 run trax_firmware macro_actions_test_node

^C[INFO] [1667394724.986592786] [rclcpp]: signal_handler(signal_value=2)
nicolas@Sam-Heracles-Robotics:~/ros2_ws$ ros2 run trax_firmware macro_actions_test_node

nicolas@Sam-Heracles-Robotics:~/ros2_ws$ ros2 run trax_firmware macro_
macro_actions_test_node macro_controller_node
nicolas@Sam-Heracles-Robotics:~/ros2_ws$ ros2 run trax_firmware macro_controller_node

nicolas@Sam-Heracles-Robotics:~/ros2_ws$ ros2 topic list
/CommandArm
/CommandBucket
/CommandTraxAngular
/CommandTraxLinear
/PositionArm
/PositionBucket
/PositionYaw
/SpeedArm
/SpeedBucket
/SpeedTraxAngular
/SpeedTraxLinear
/State
/feedback
/parameter_events
/request
/resetPositionPID
/resetSpeedPID
/rosout
nicolas@Sam-Heracles-Robotics:~/ros2_ws$

```



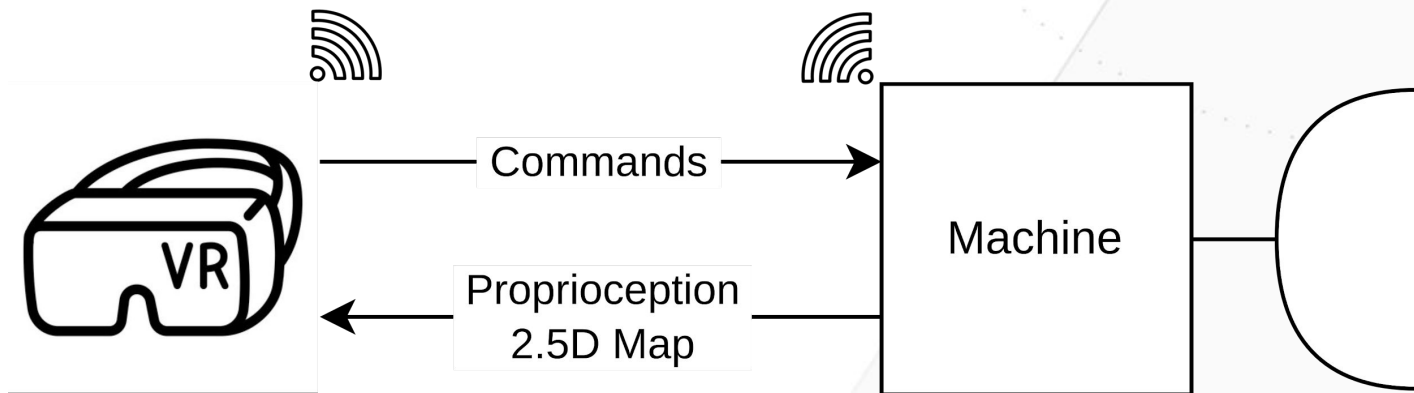

1. Context
- 2. System**
3. Conclusion



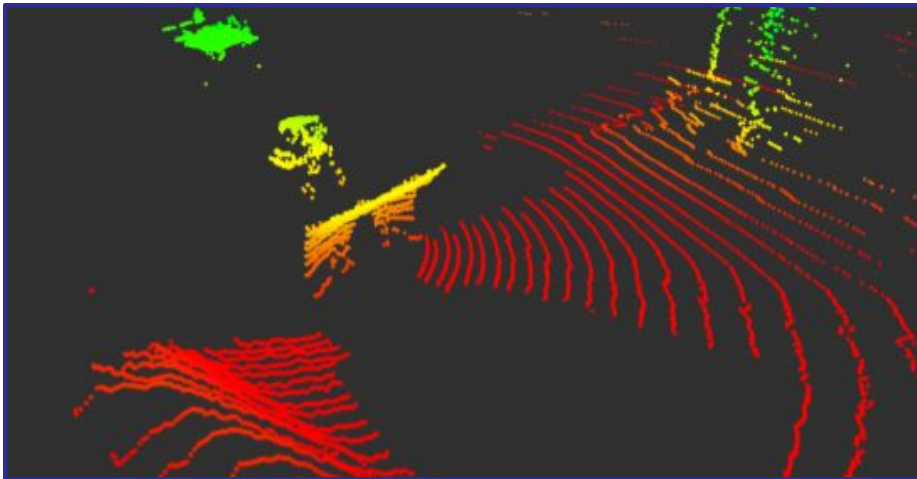
System

VR Digital Twin

Work In Progress

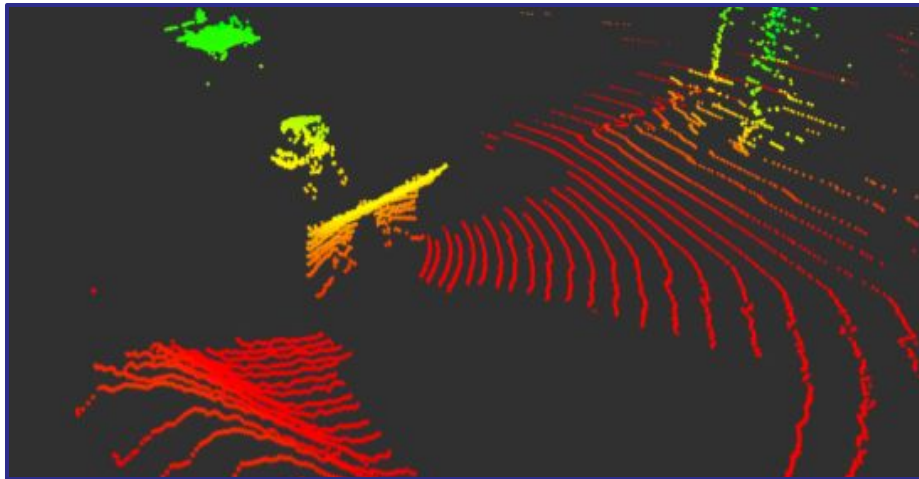
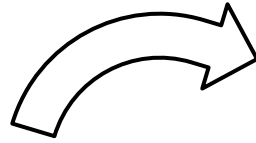


System Mapping



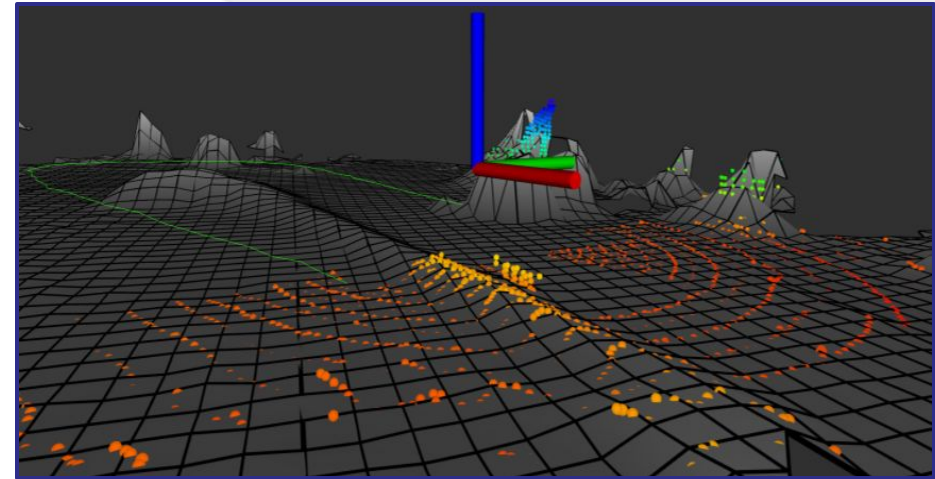
LiDAR's Point Cloud

System Mapping

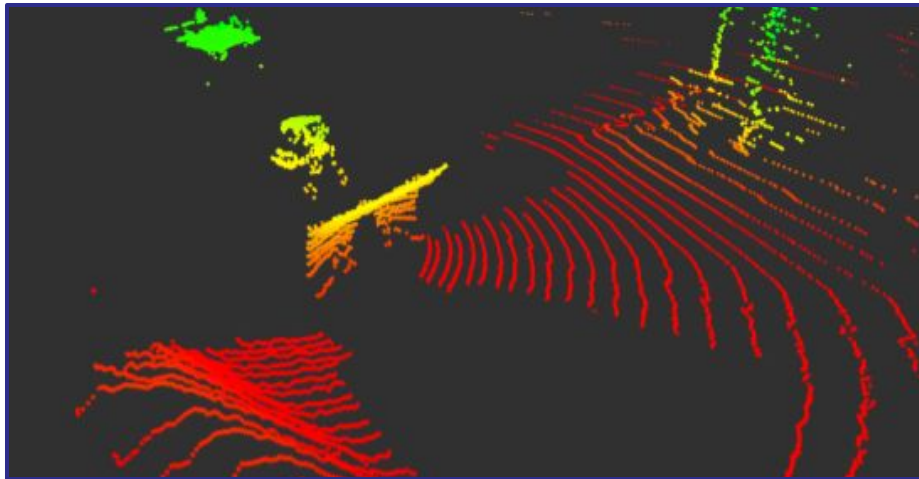


LiDAR's Point Cloud

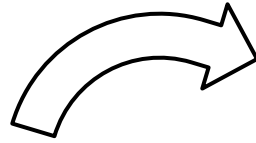
2.5D Mapping



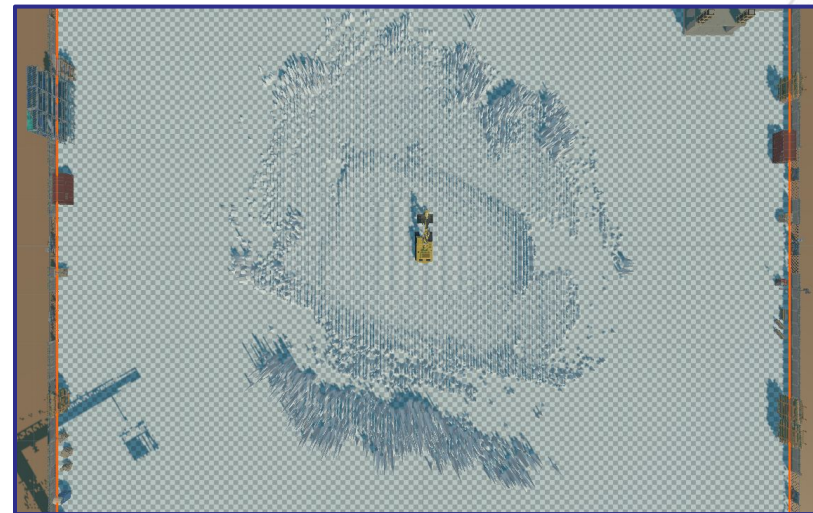
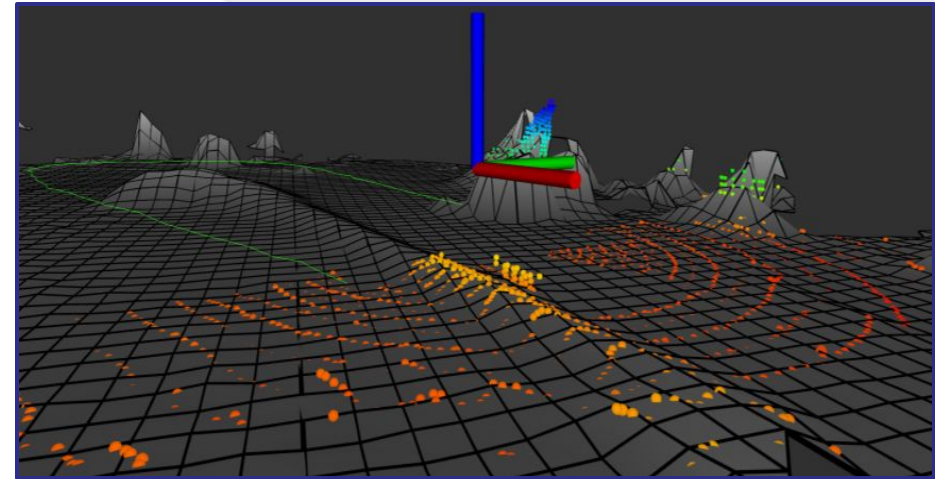
System Mapping



LiDAR's Point Cloud



2.5D Mapping



VR Heightmap

System

Control

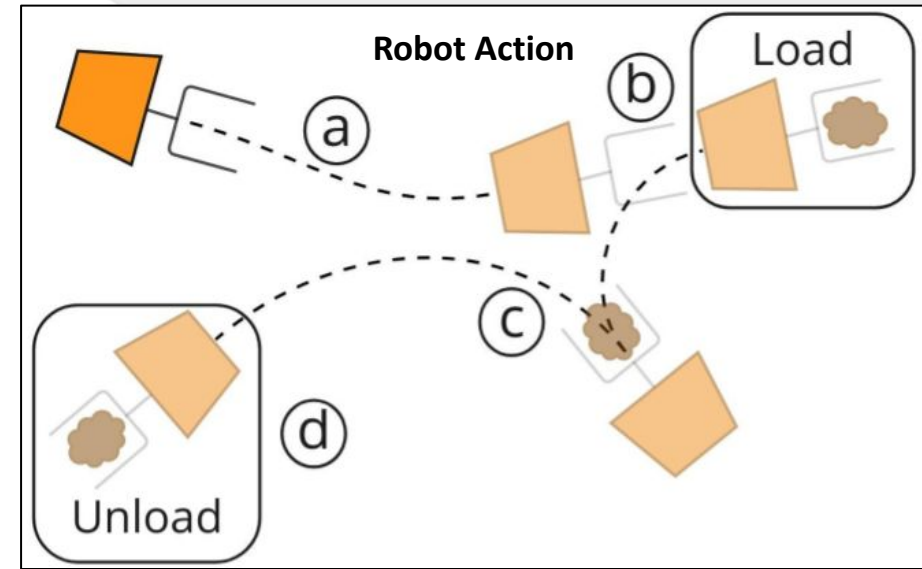
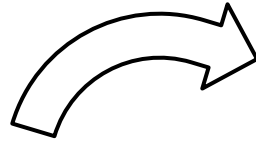


VR Inputs

System Control



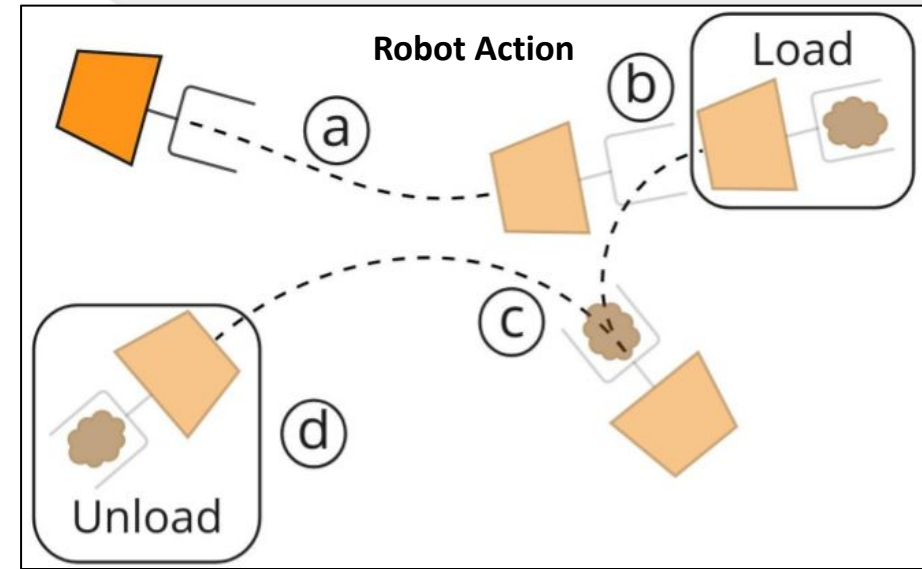
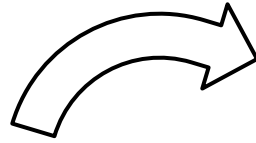
VR Inputs



System Control



VR Inputs



Robot Motion

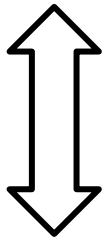


System Control

Low-Level Action



VR Controllers



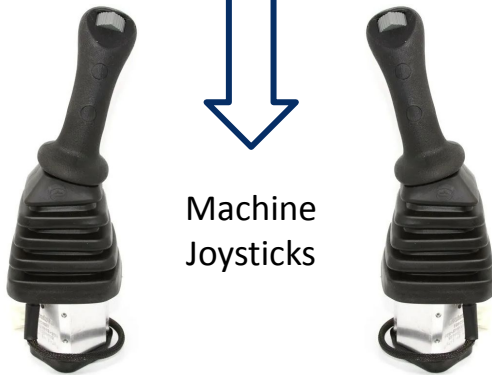
Machine
Joysticks

System Control

Low-Level Action

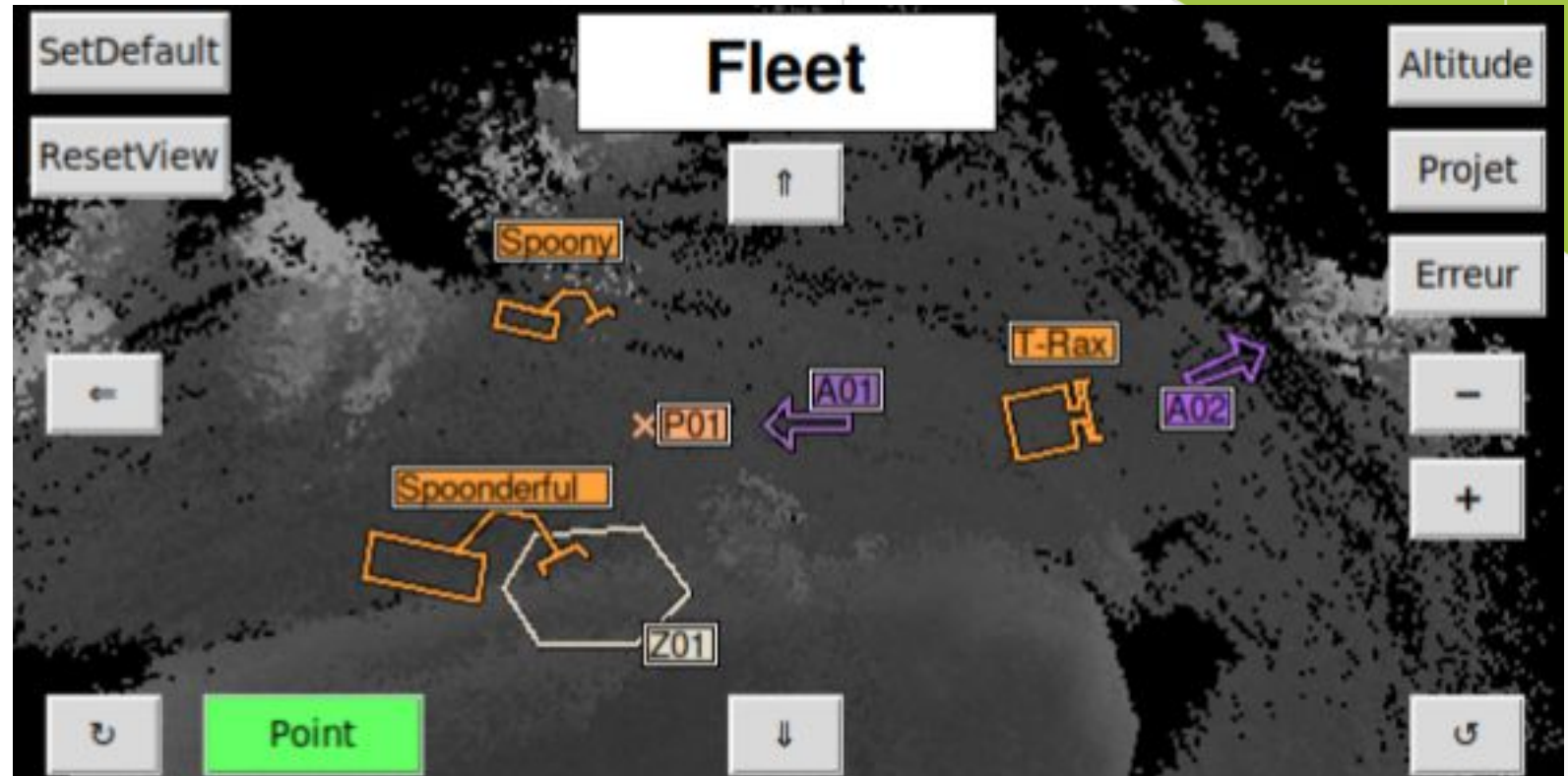
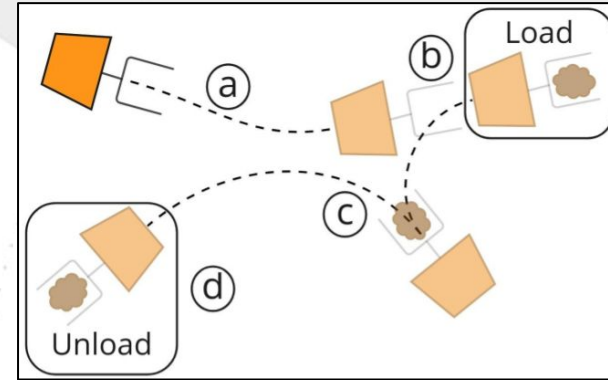


VR Controllers



Machine Joysticks

High-Level Action



System

Results

Current results :

- Digital Twin of one simulated machine
- Real-time technological lock lifted
- Dynamic 2.5D real-time Mapping



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Conclusion

Results & Perspectives

Perspectives :

- Link to actual machine instead of simulation
- Develop user interface :
 - Increase visibility w/ Eye-Tracking
 - Monitor stress & motion sickness w/ EEG
- Implement macro-actions :
 - From geometric primitives
 - Intermediary controls
- Cross-machines interface (Trax, Excavator..)
- Supervise entire site
- Operator training program

Special thank to :

- Léa Saunier
- Samuel Prouten
- Oumayma Serroukh