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UNIVERSITÀ DEGLI STUDI DI PADOVA

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MORPHEUS: A FIELD ROBOTICS TESTBED FOR SOIL SAMPLING AND AUTONOUMUS NAVIGATION

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Overview

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- Introduction
- Rover Mechanics
- Rover Electronics
- Rover Software
- Project Status and Conclusions

Background & Motivations

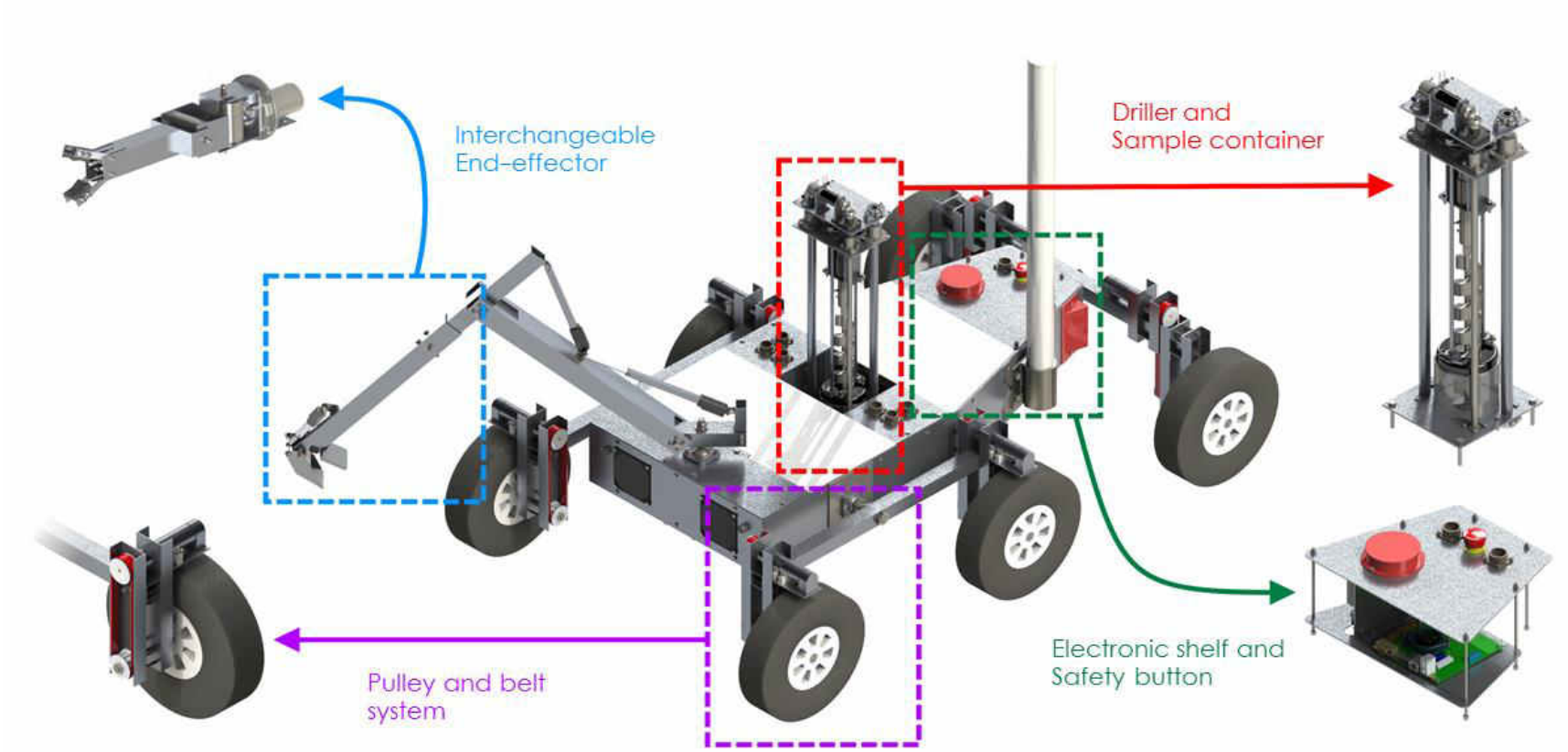
MORPHEUS (**M**ars **O**perative **R**over of **P**adova **E**ngineering **U**niversity **S**tudents) is a testbed for planetary robotic exploration technologies:

- soil and rocks extraction and sampling
- autonomous navigation in unstructured environment

European Rover Challenge guidelines has been adopted in the rover design phase

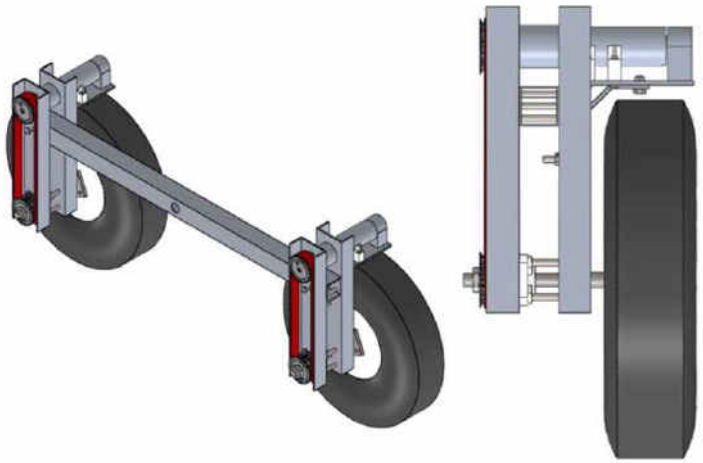
"Hard" engineering skills	**"Soft" skills**
• Mechanical and electronic Design • Fabrication • Testing • C++/Pyhton coding	• Project management • System level thinking • Creative problem solving • Interpersonal skills • Outreach

Rover Mechanics

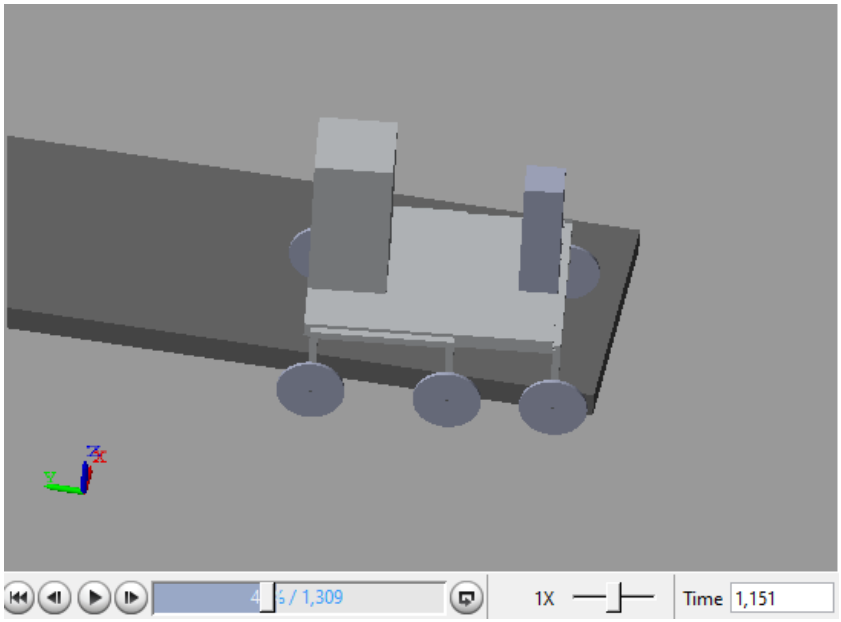


- Remotely controlled
- Six motorized wheels
- The rover drives in skid steering configuration

Locomotion

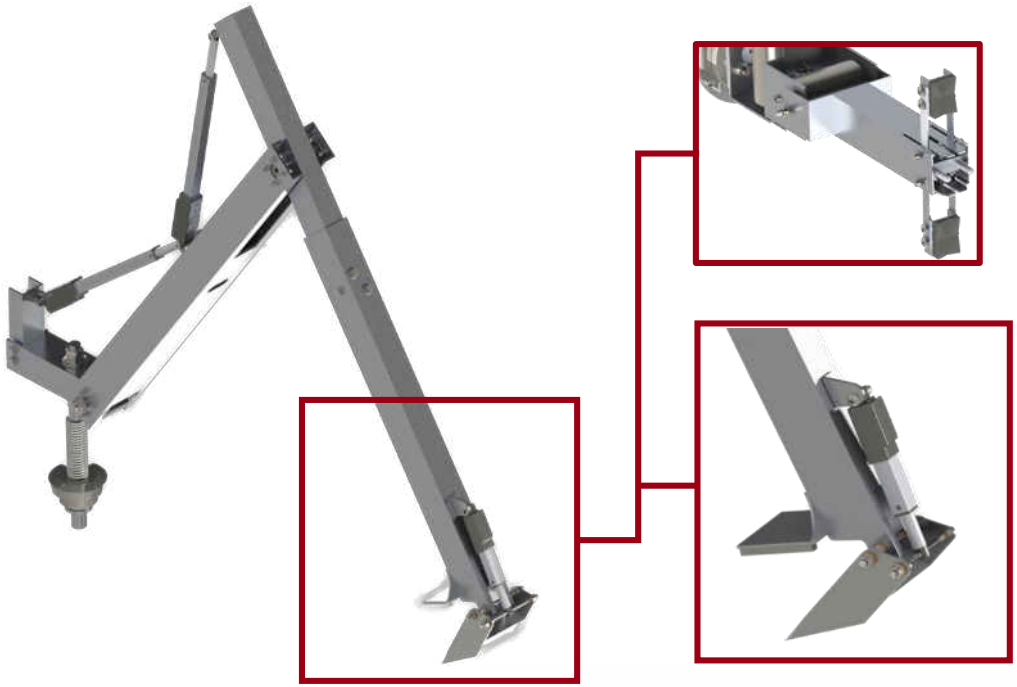


Dimensions	820x130x1000mm
Mass	50kg
Rover kinematics	six wheeled skid-steer
Maximum speed	1m/s
Max slope	15°



Tire/soil interaction model

Robotic Arm and Driller



Maintenance Task:

- use a set of switches
- measure current and voltage

Solution: 6 Degrees of Freedom manipulator

Science and Assistance Task:

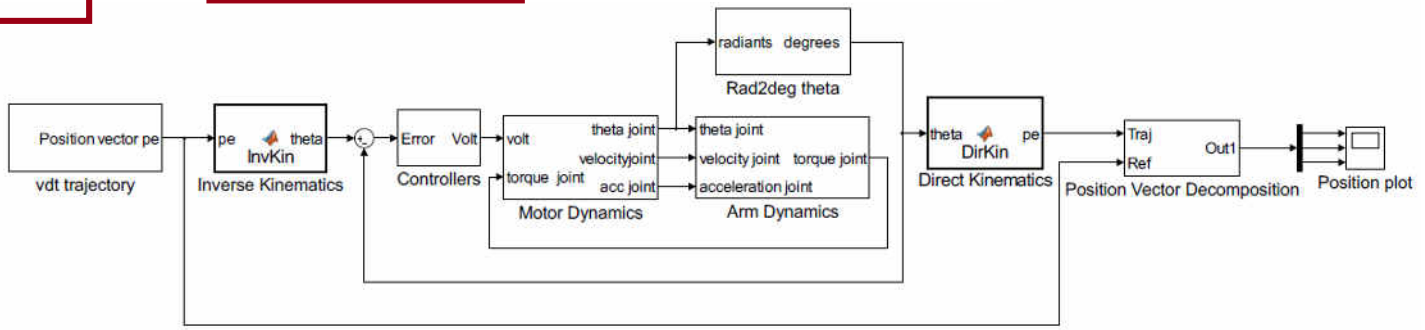
- rocks and soil sampling

Solution: 3 Degrees of Freedom bucket

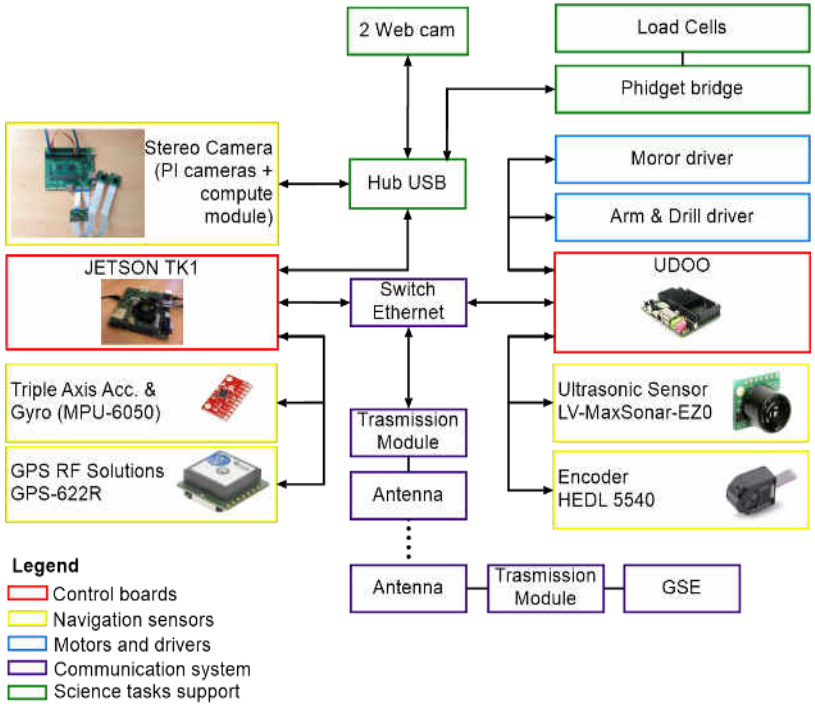
- deeper soil extraction

Solution: Driller

3DOF robotic arm decentralized control scheme in Simulink



MORPHEUS Navigation Subsystem

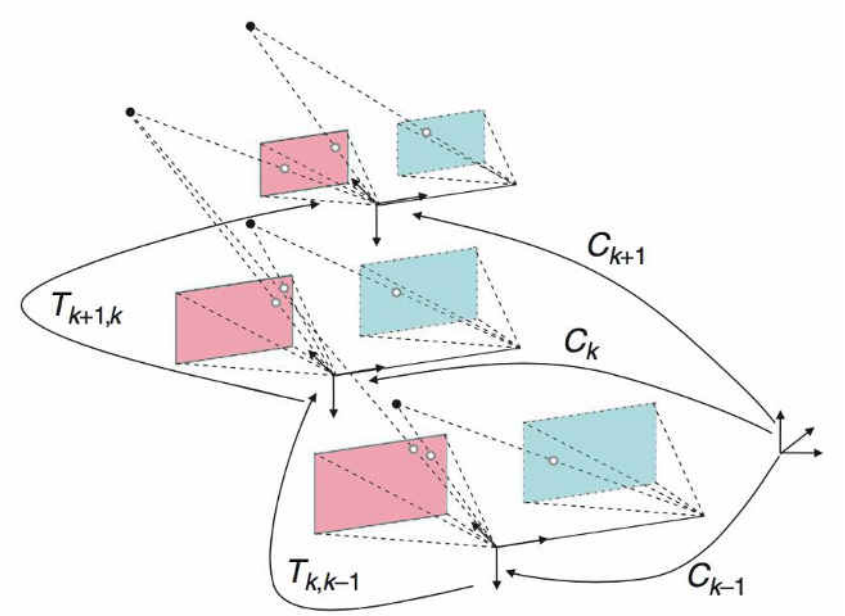


NAVIGATION SENSORS
Stereo Camera
IMU (MPU-6050)
GPS (GPS-622R)
LV-MaxSonar_EZ0
Encoder HEDL 5540

CONTROL BOARDS	
NVIDIA JETSON TK1	• Computational capabilities to process stereo-camera images and navigation algorithms.
UDOO	• Control the Arm, the Driller and the rover motion motors.

- Remote human operator control
- Autonomous navigation: point-to-point navigation & hazard avoidance

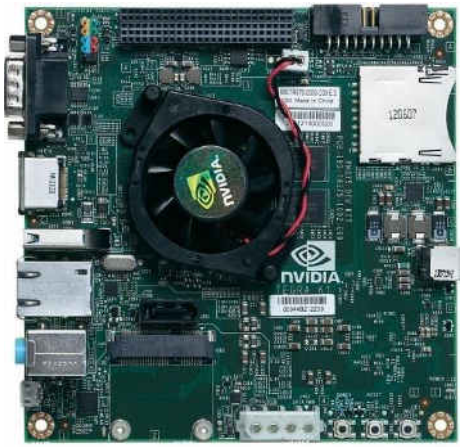
Visual Odometry



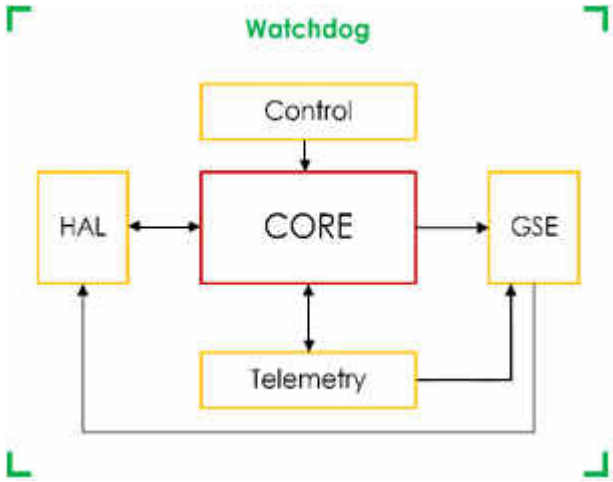
- Image Sequence
- Feature Detection
- Feature Matching (or Tracking)
- Motion Estimation
  - 2D-to-2D
  - 3D-to-3D
  - 3D-to-3D
- Local Optimization (Bundle Adjustment)

IMPLEMENTATION

PC Matlab → PC C/C++ → Single Board Computer (Nvidia Jetson TK1) C/C++ → Single Board Computer **GPU** C/C++ (6.58 s -> 1.91 s)



Software



The software has been divided into five major modules, interconnected each other thank to a robotic open source platform: **Robot Operating System (ROS)**

- HAL (Hardware Abstraction Layer), which contains the drivers.
- "State Machine", manages the rover during the tasks.
- "Control", which contains class to perform the tasks.
- GSE (Ground Segment Equipment), which remotly control the rover and manages tracking.
- "Watchdog", checks that the boards and processes do not lock.

Outreach

- Web page
- Facebook page
- YouTube channel
- Local journals

Project Status and Conclusions

DONE
• Mechanical design • Electronic design • Algorithms implementation (Matlab/C++/Python) • Web site, Facebook page, YouTube channel creation
WORK IN PROGRESS
• Mechanical components manufacturing • Custom electronic board manufacturing • Integration of rover main software on Robot Operating System (ROS) • Web site, Facebook page, YouTube channel updating
TO BE DONE
• Subsystems testing • Overall rover testing • Web site, Facebook page, YouTube channel updating

Conclusions

Thanks for your attention! Questions?