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Road Surface Analysis for Driving Assistance

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Robotics and Mechanic Systems Lab

1st International Workshop on 3D Robot Perception with Point Cloud Library

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PhD student, University of Salento

Introduction

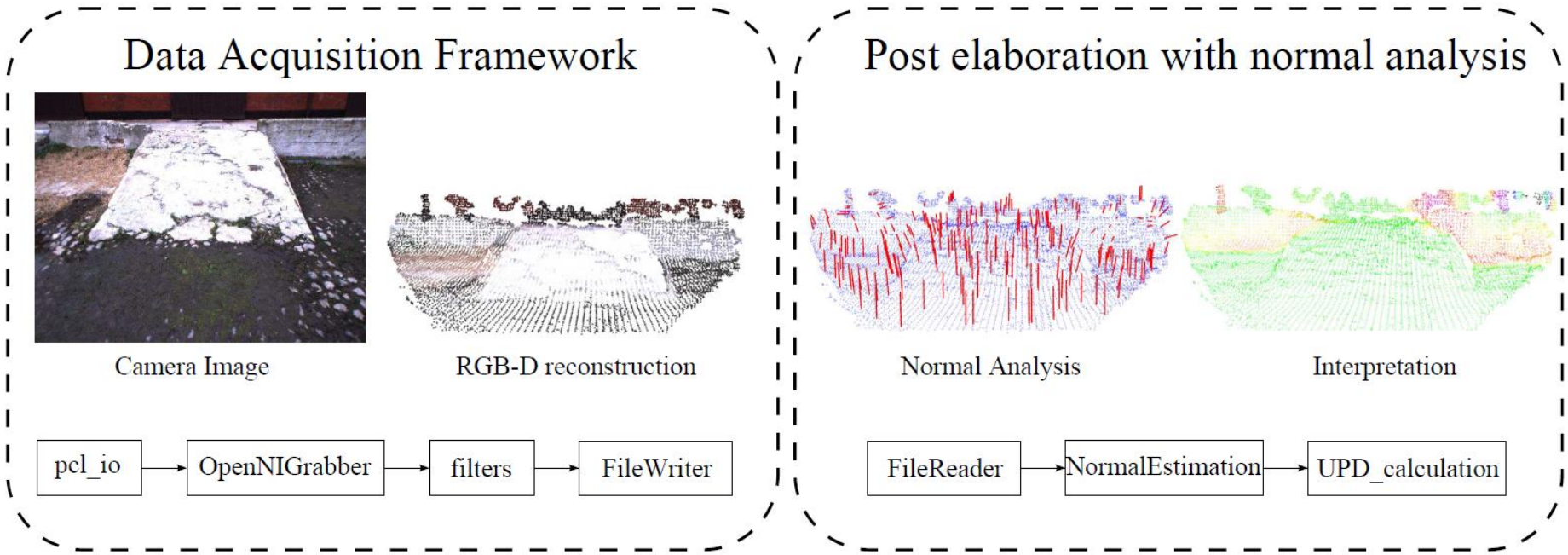
- Terrain description aimed at safe navigation for autonomous vehicles;
- Investigation of advanced perception techniques using 3D points cloud;
- Perception systems for autonomous driving;

Which is the problem ?

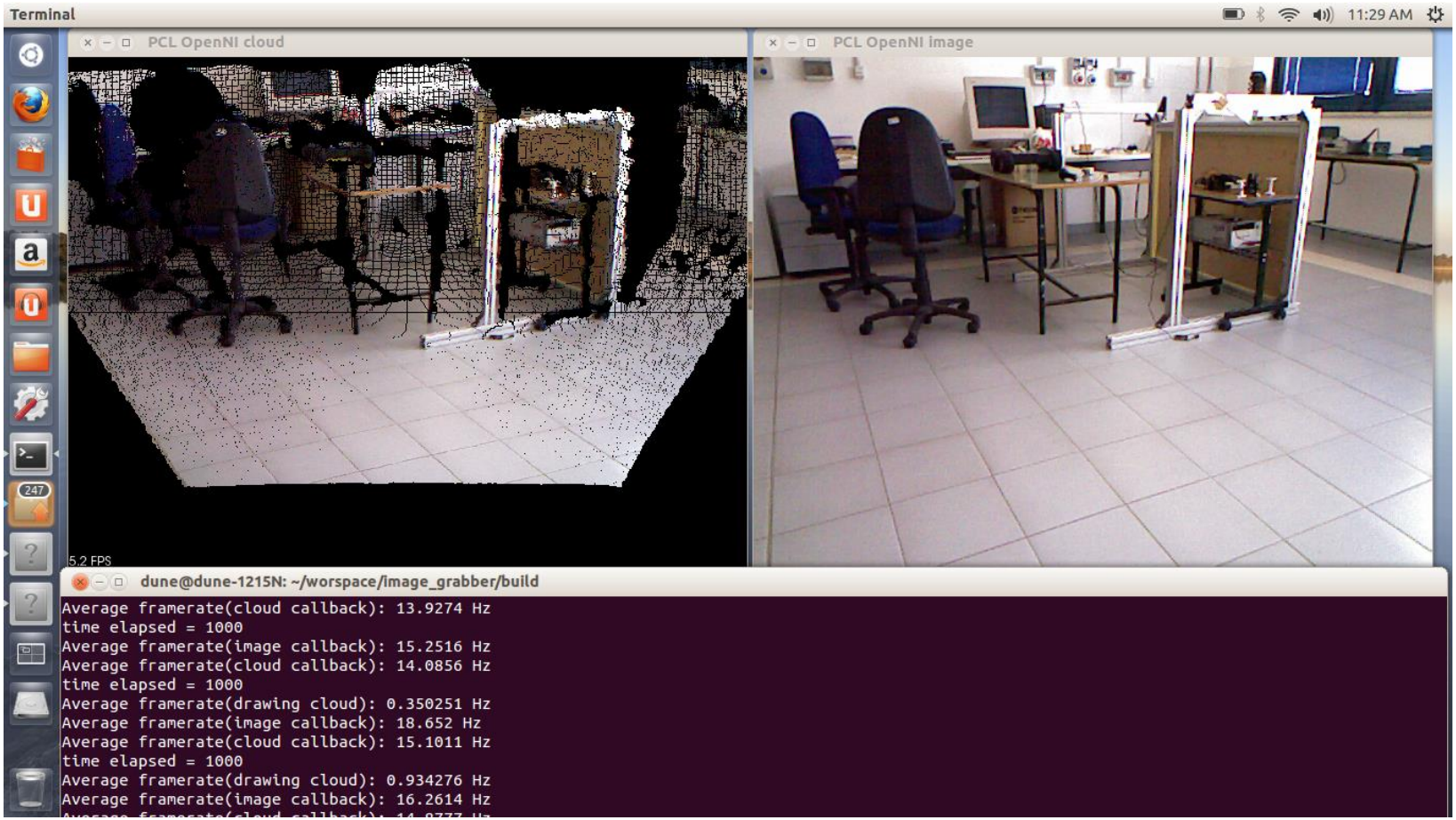
Road Hazards Avoidance

Terrain Analysis & Road Hazards Detection

«ground» segmentation in outdoor environments ➔ Terrain Analysis



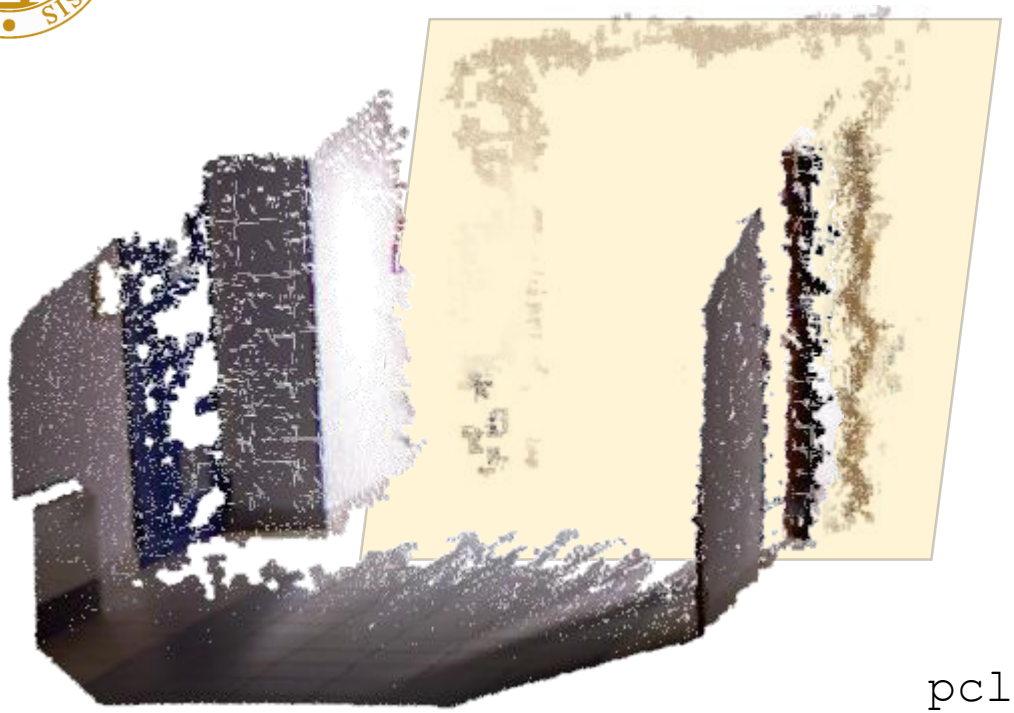
Acquisition via OpenNI Grabber in PCL



OpenNI Grabber Framework in PCL - callbacks

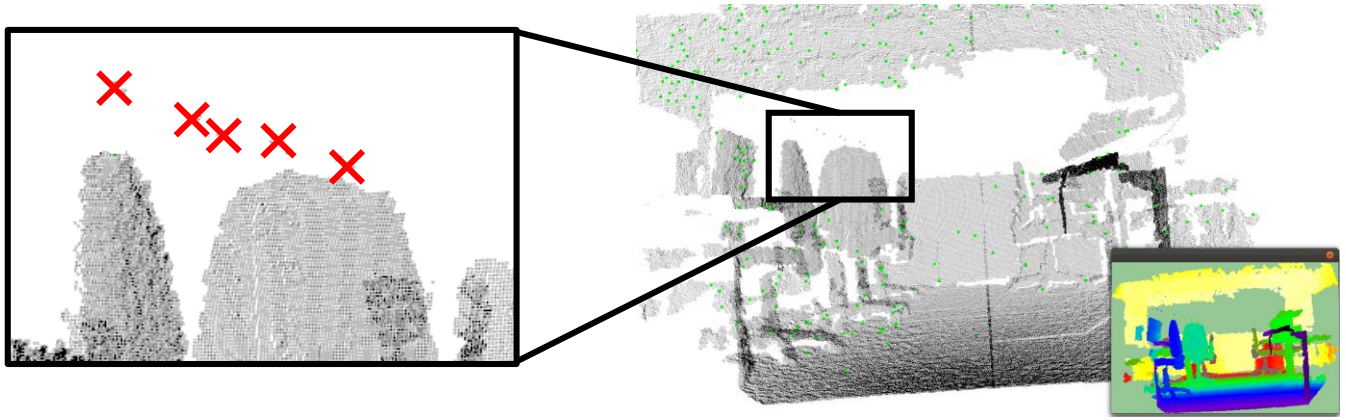
`pcl::OpenNIGrabber` `openni_wrapper::Image`

Points Cloud filtering

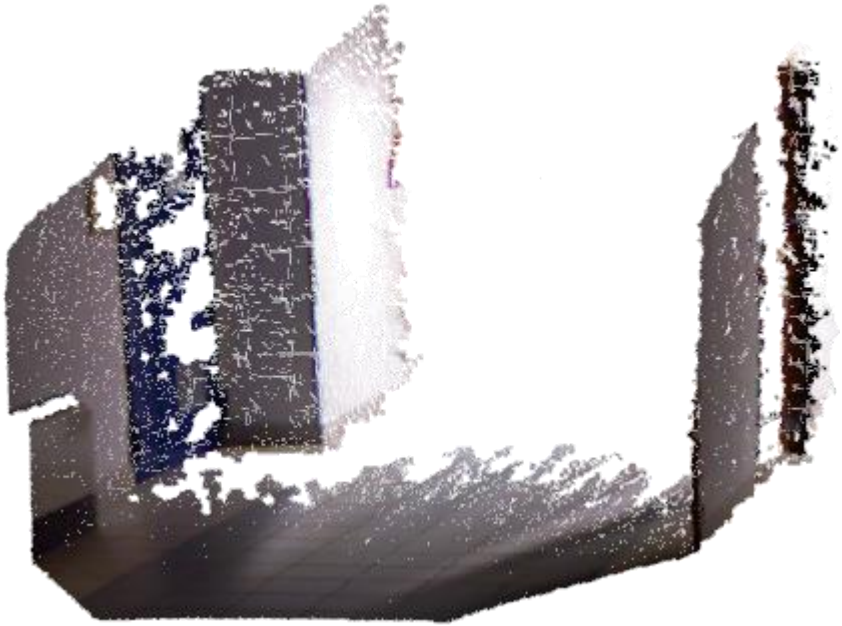


`pcl::PassThrough`

`pcl::StatisticalOutlierRemoval`

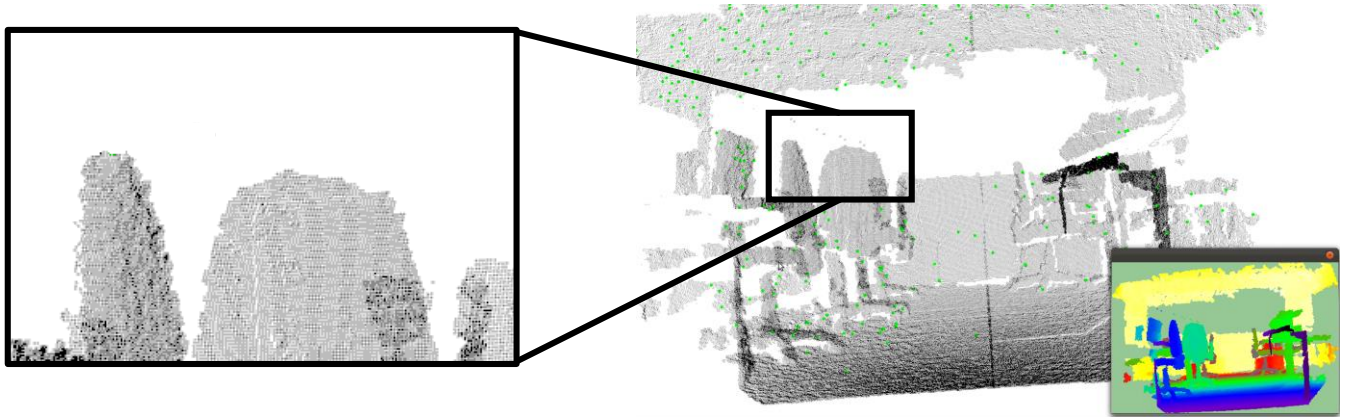


Points Cloud filtering

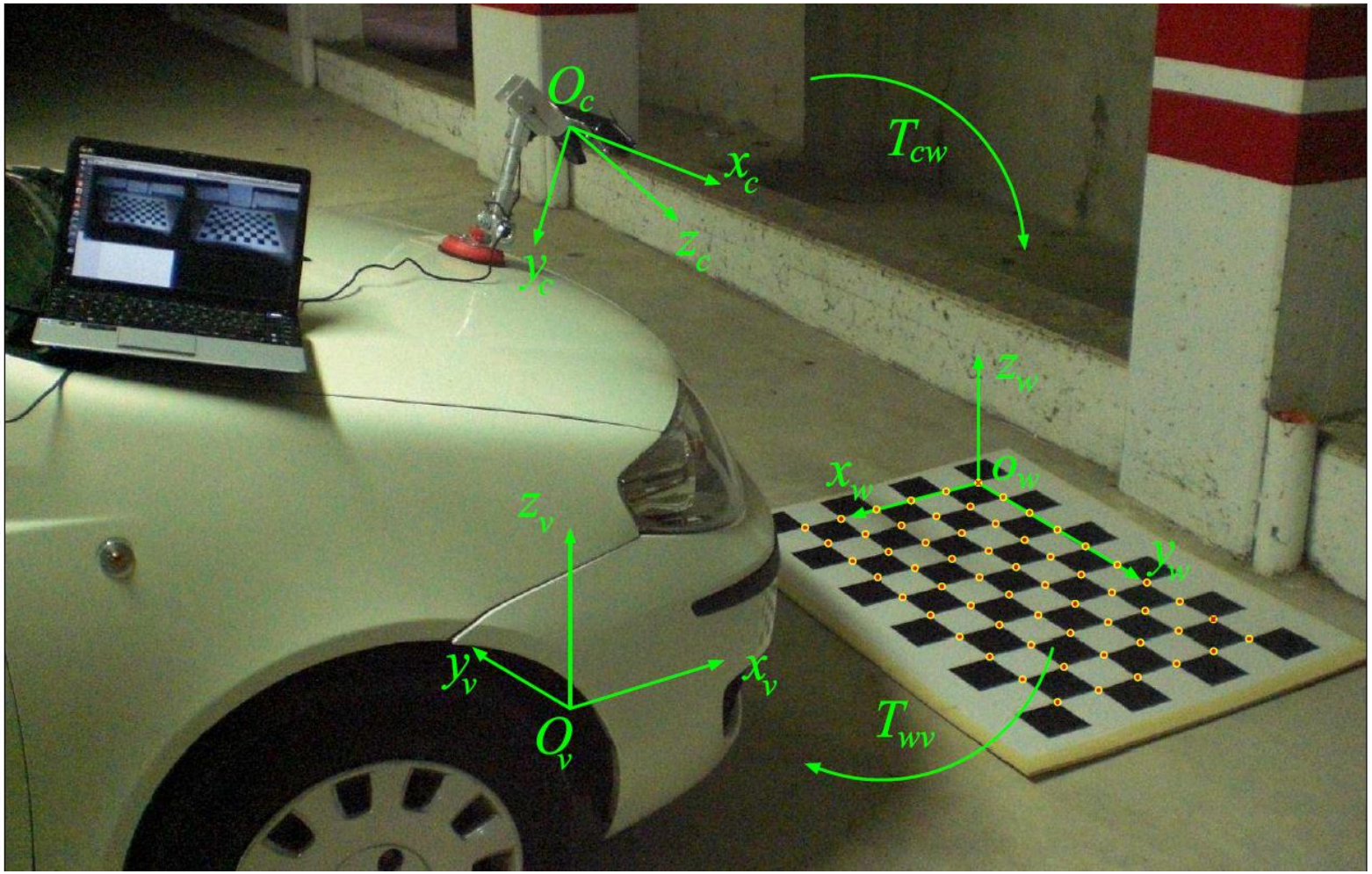


`pcl::PassThrough`

`pcl::StatisticalOutlierRemoval`

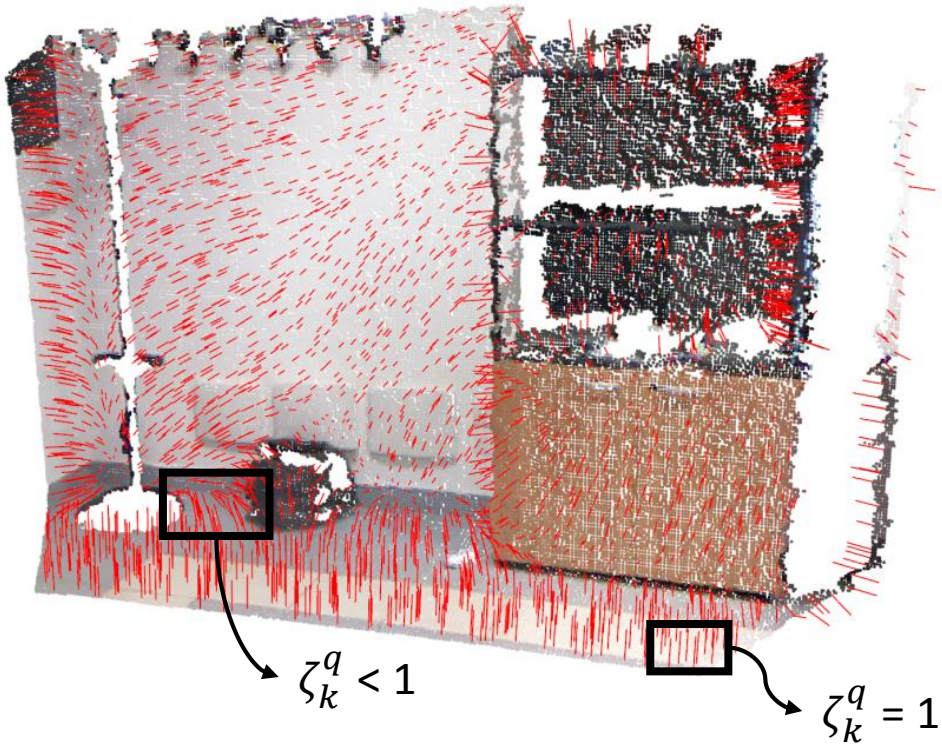


Reference Frame Transformation




```
pcl::transformPointCloud (in, out, Eigen::Matrix)
```

Terrain Analysis Through Normal Vectors



$$\text{UPD} = F\left(p_q, P^k\right) = \left\{r_x^q, r_y^q, r_z^q, \zeta_k^q\right\}$$

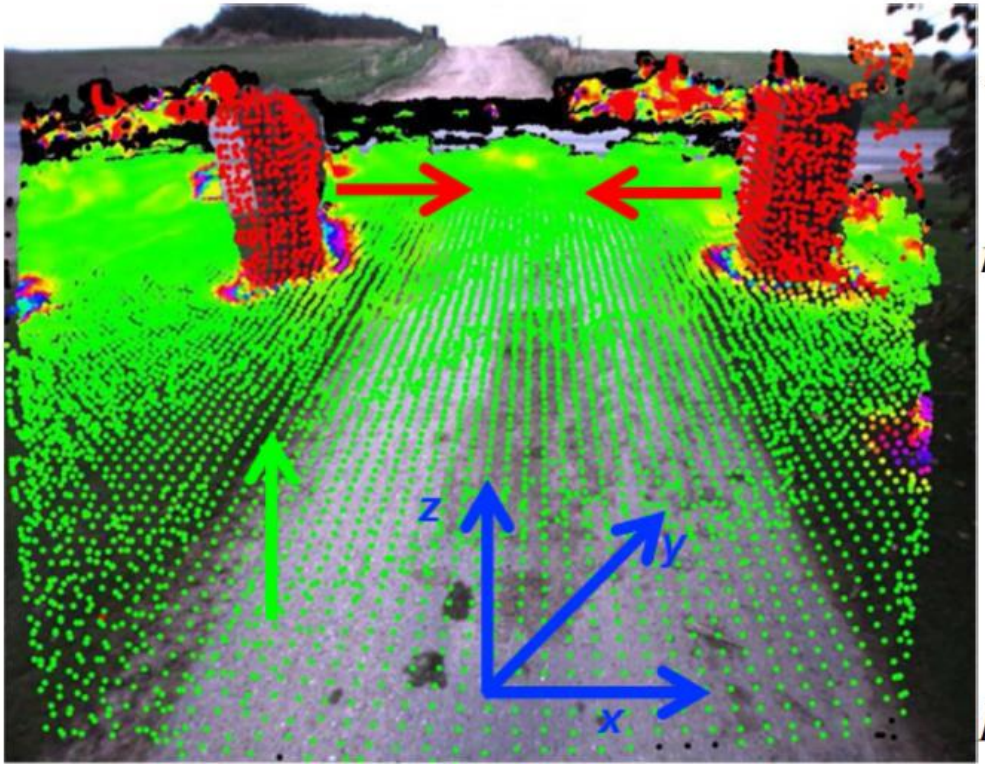
orientation

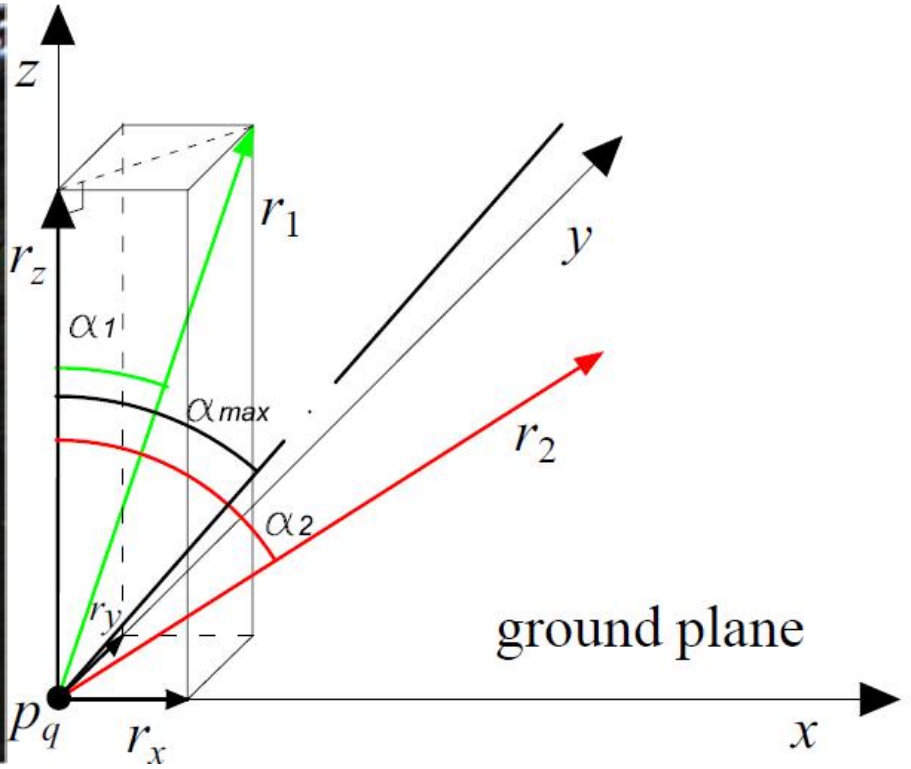
homogeneity

`pcl::NormalEstimation` ➔ normal estimation using Principal Componet Analysis

`pcl::KdTreeFLANN` ➔ fast neighbourhood selection using KdTrees

Orientation Analysis





All vectors whose orientation is higher than a solid angle α, are defined as ***NON GROUND***

Test beds

DUNE:

- Mobile robot featuring a 4-wheel independent drive steering and a rocker-bogie passive suspension system;
- 3-dimentional vision via Microsoft Kinect sensor;
- Vision range – 4m.

CLAAS AXION 840 4WD:

- Commercial Agricultural tractor equipped with a robotic vision system;
- Stereoscopic vision via Bumblebee XB3 camera;
- Vision range – 22m.

Alfa 147:

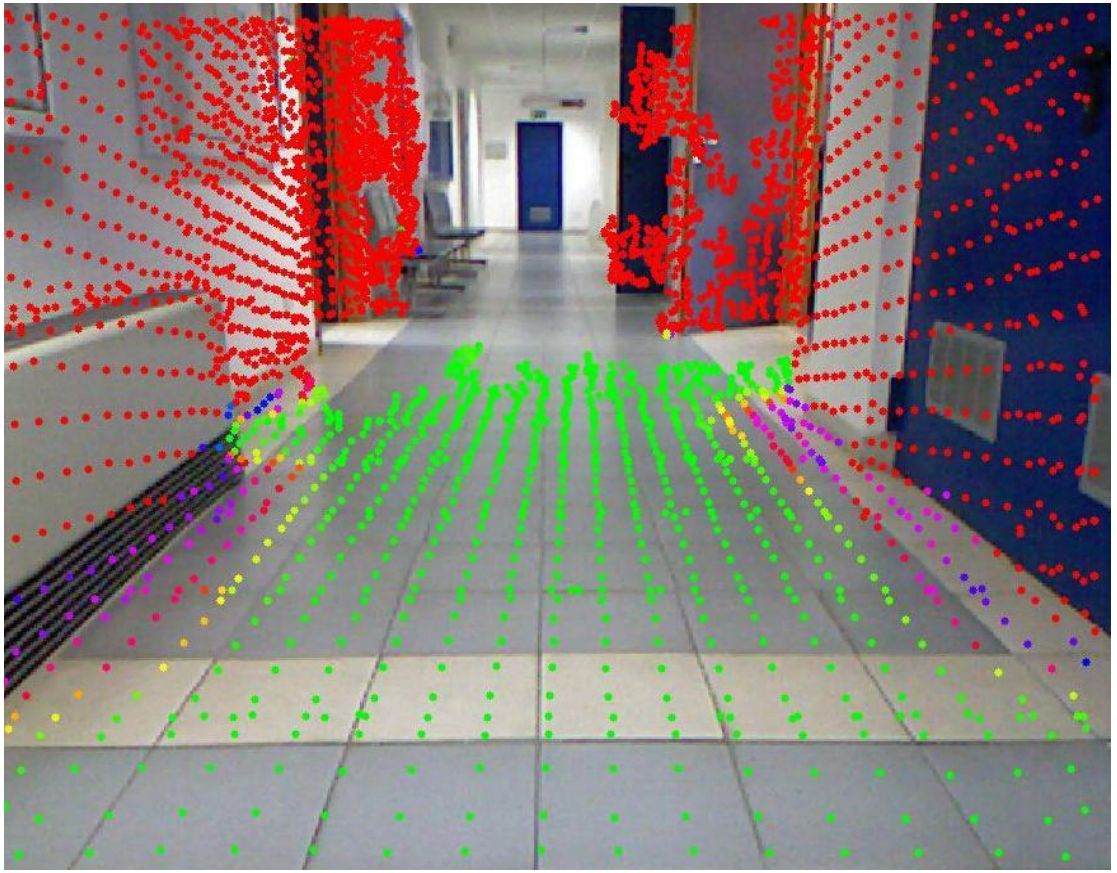
- Commercial car;
- 3-dimentional vision via Microsoft Kinect sensor;
- Vision range – 4m.

ICT AGRI era-net

Ambient Awareness for Autonomous Agricultural Vehicles

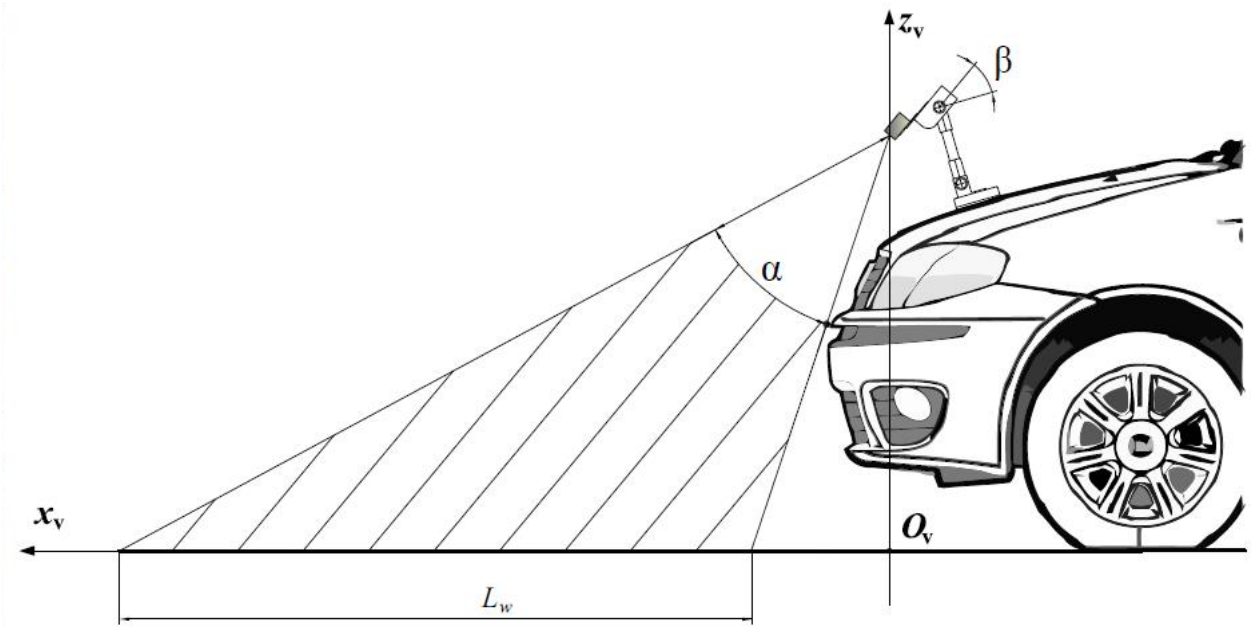
Indoor Test

Typical indoor scenario: The floor is correctly detected as a traversable region, whereas walls are correctly classified as non traversable

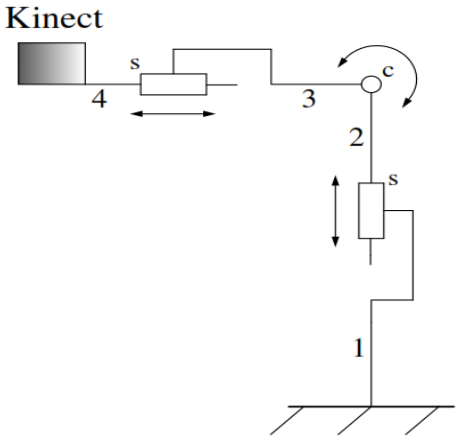


Typical indoor environment

Road Hazards Detection - Mechanic System



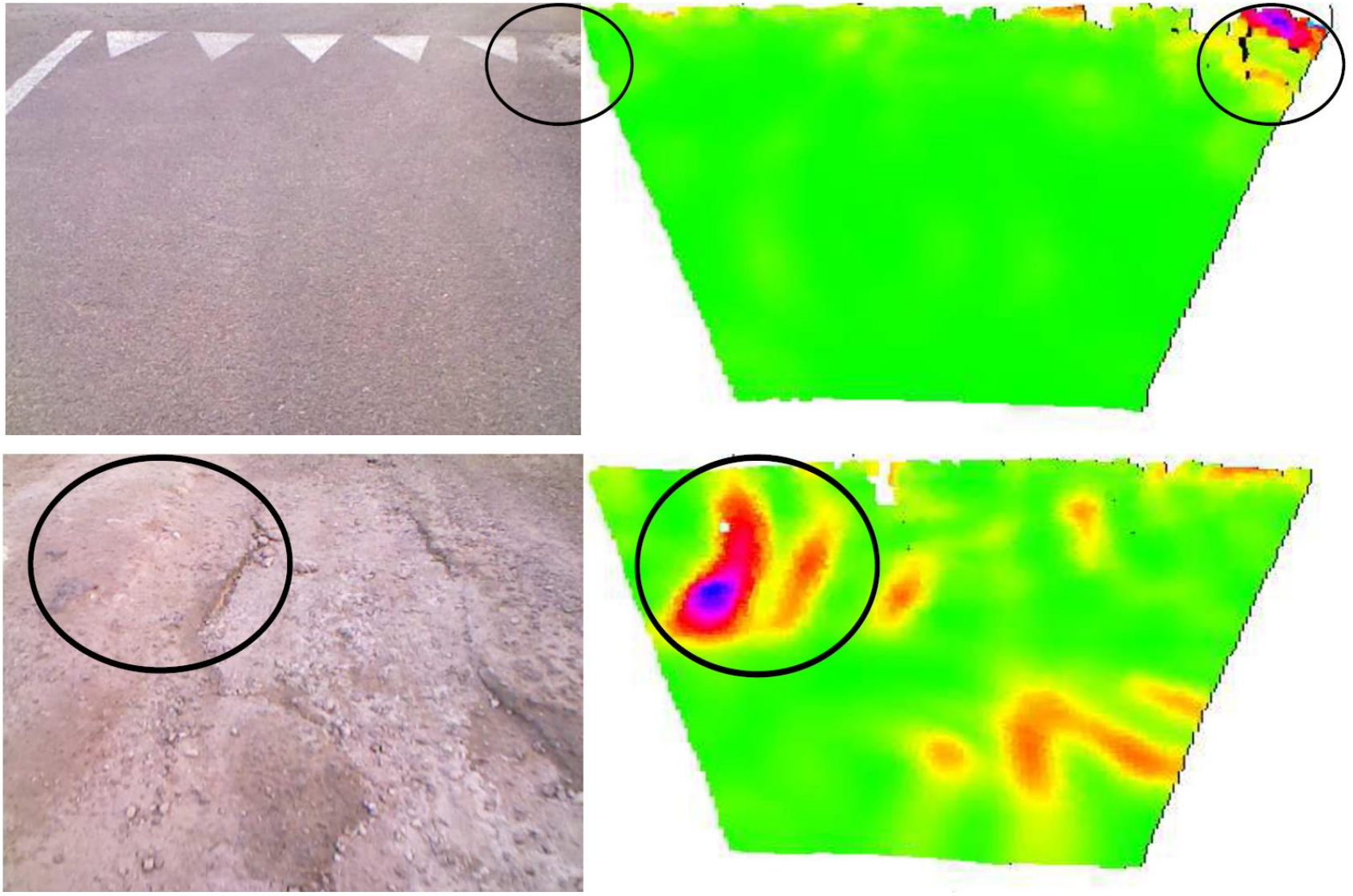
Holding system design (b) where, α is the view angle, β is the sensor inclination angle, and L_w is the look-ahead distance



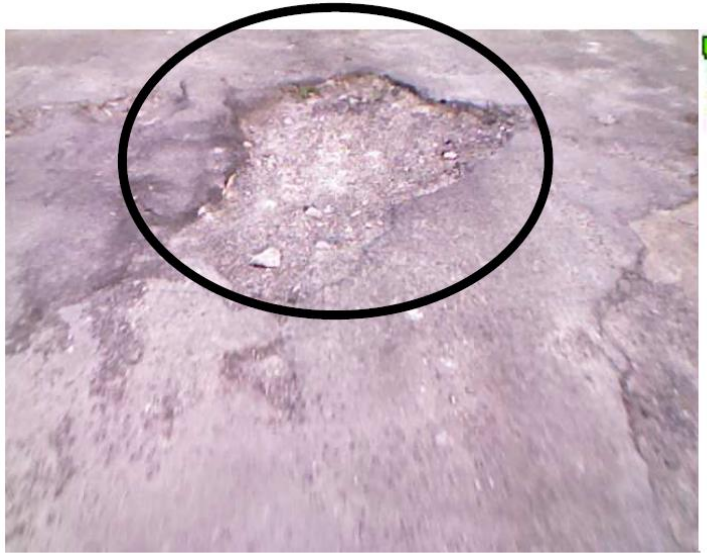
Kinematic chain

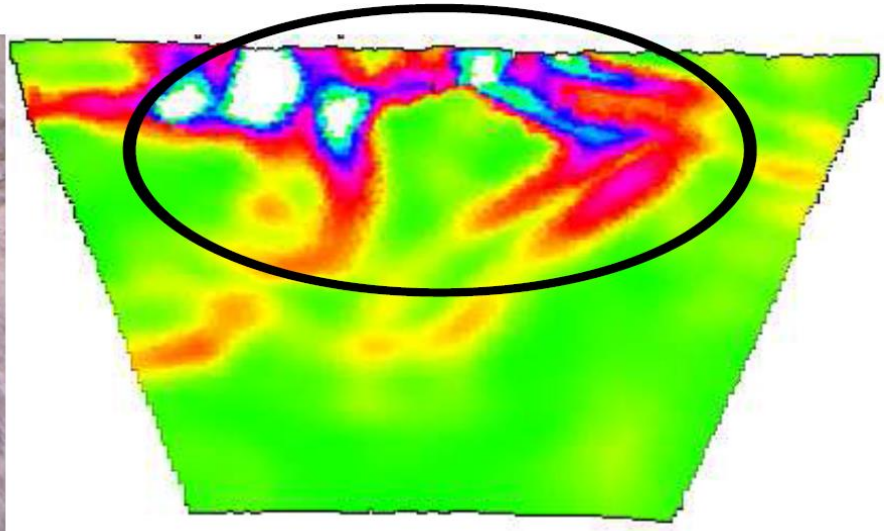
The experimental test bed equipped with a Kinect camera

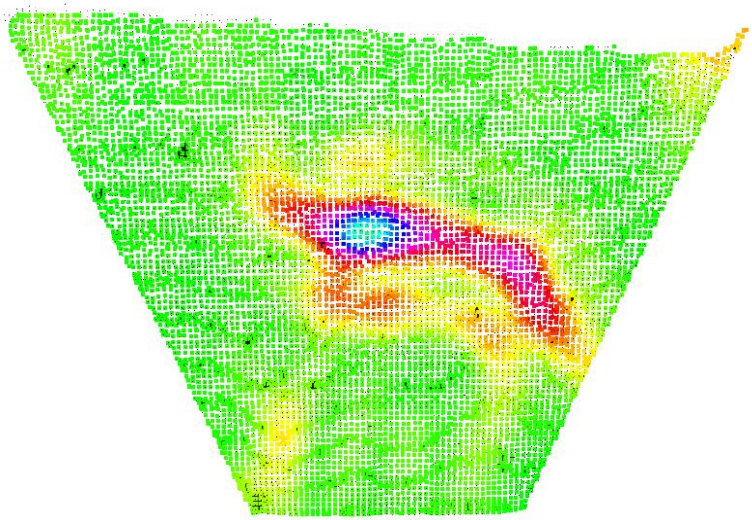
Road Hazards Detection - Results



Road Hazards Detection - Results







Road Hazards Detection - Results

Link on YouTube: https://www.youtube.com/watch?v=X8badVvQ3Q4

Road Surface Analysis for Driving Assistance

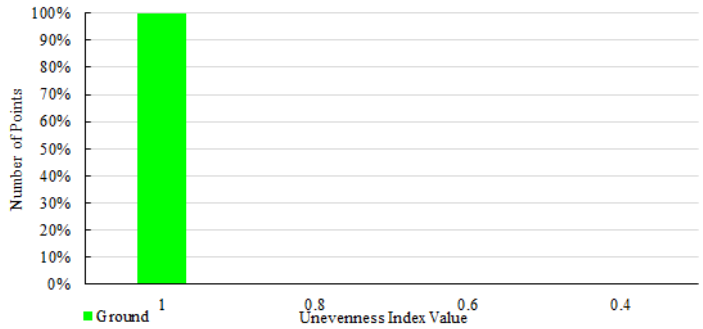
UNIVERSITÀ DEL SALENTO

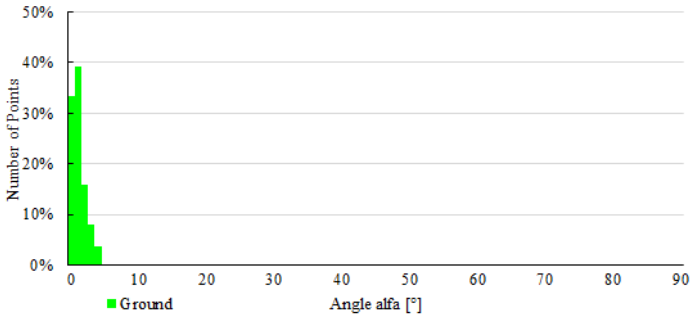
Dipartimento di Ingegneria dell'Innovazione

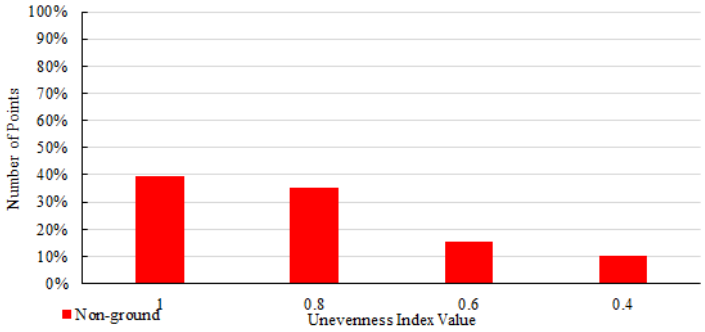
Robotic Mechanical Systems Lab

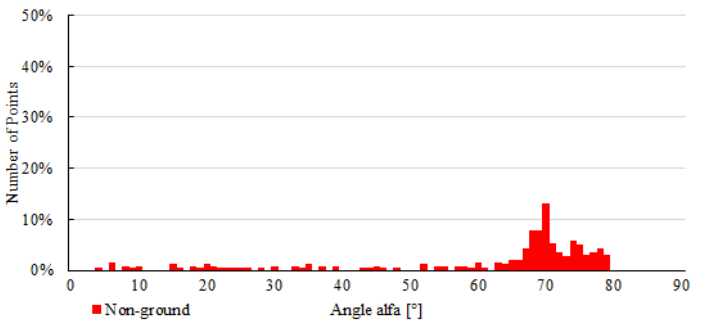
June 2014

Histogram Analysis

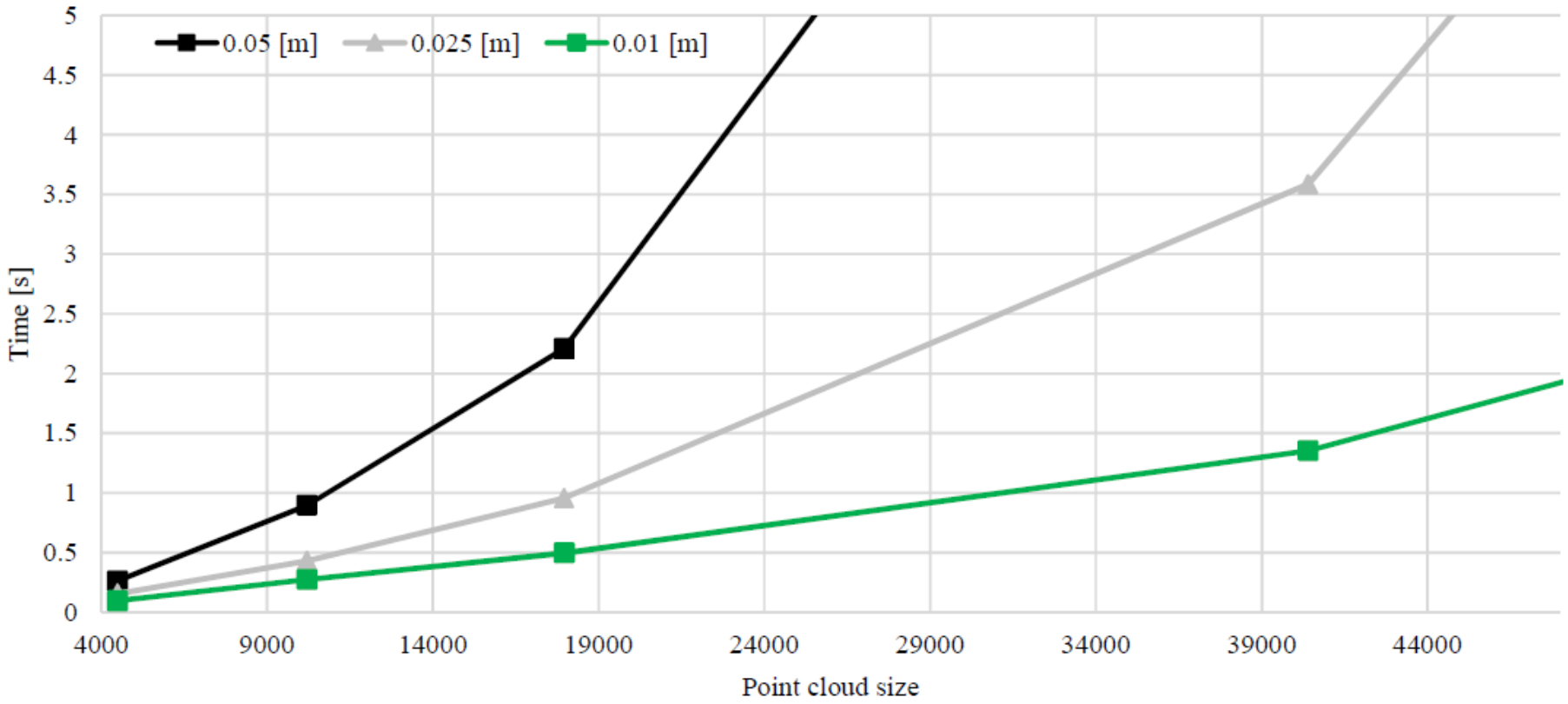








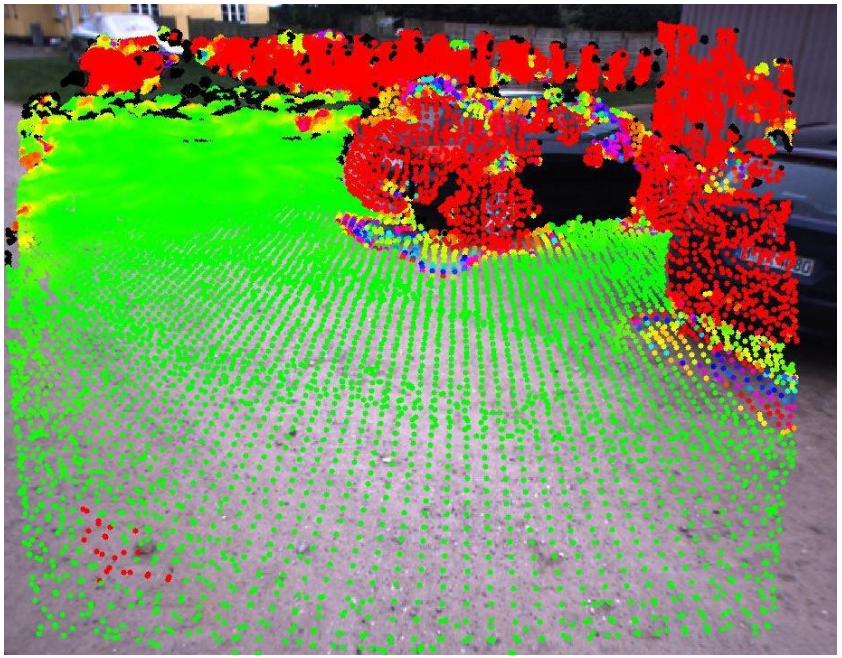
Computational Time



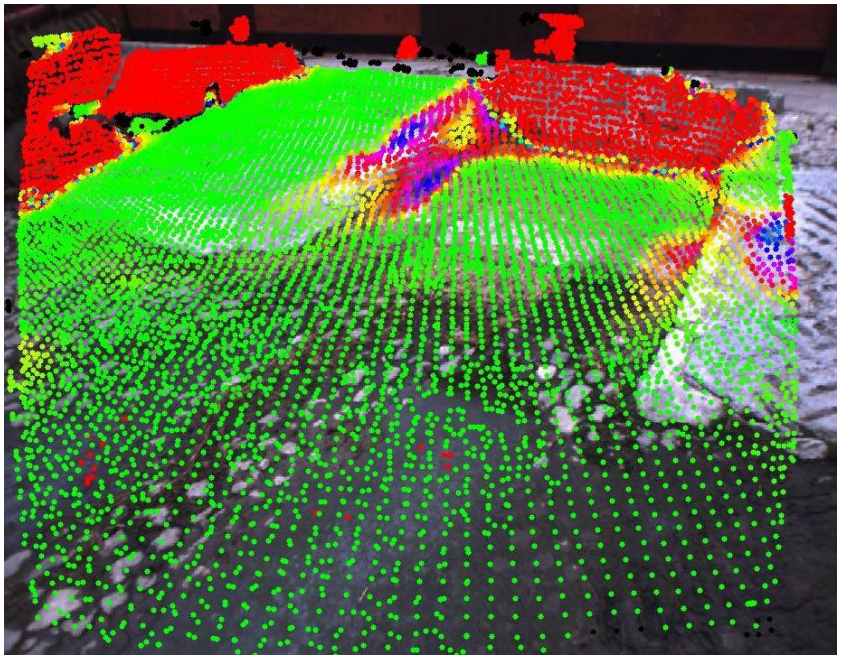
The computational time has been measured on low-performance computer:
Eee-pc Asus 1215N – Intel Atom CPU 1.8 GHz
OS Ubuntu 12.04

Obstacles Detection

Positive Obstacles: Every object, cause of potential collision, should be correctly interpreted



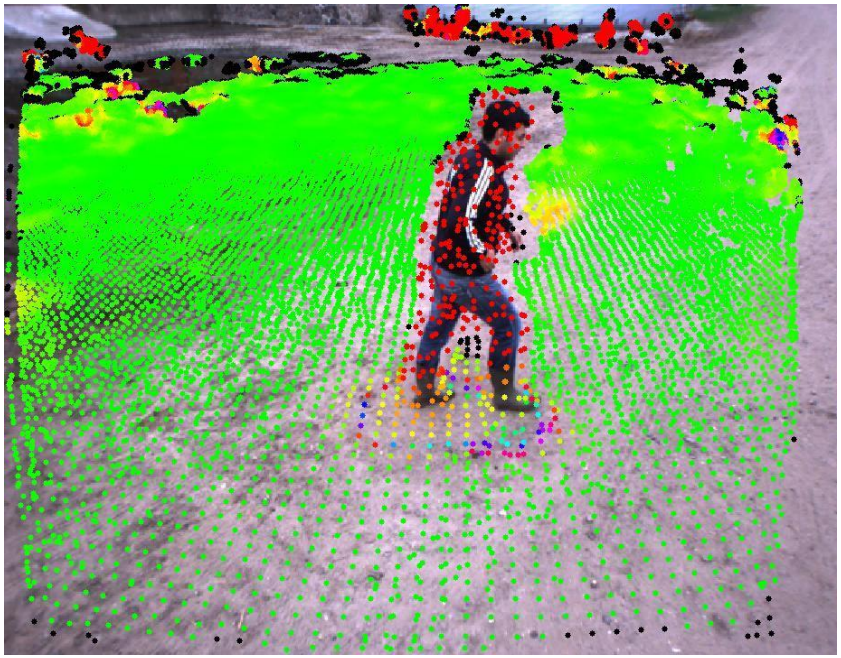
Positive Objects



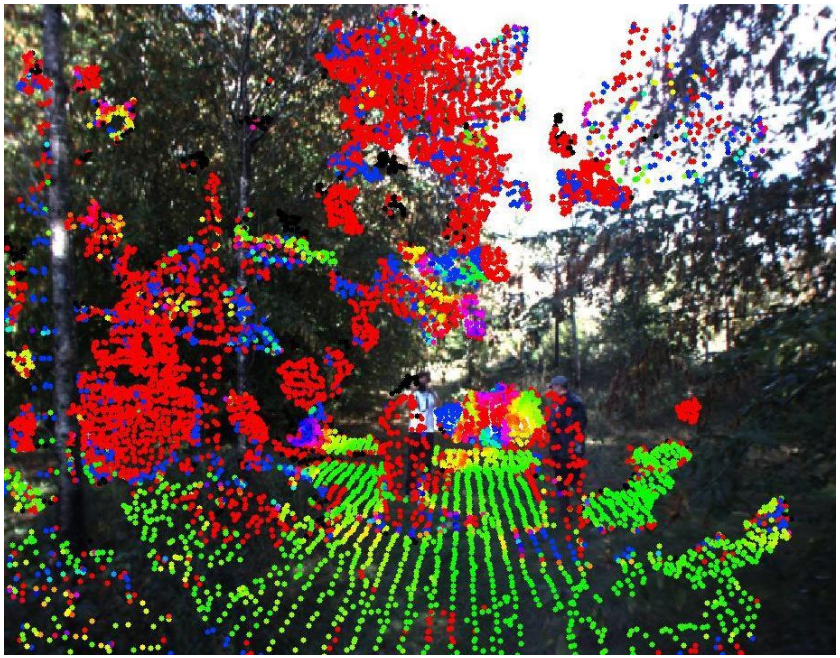
Ramp

Obstacles Detection

Dynamic Obstacles: The vehicle should always preserve the safety of humans interpreted as dynamic object



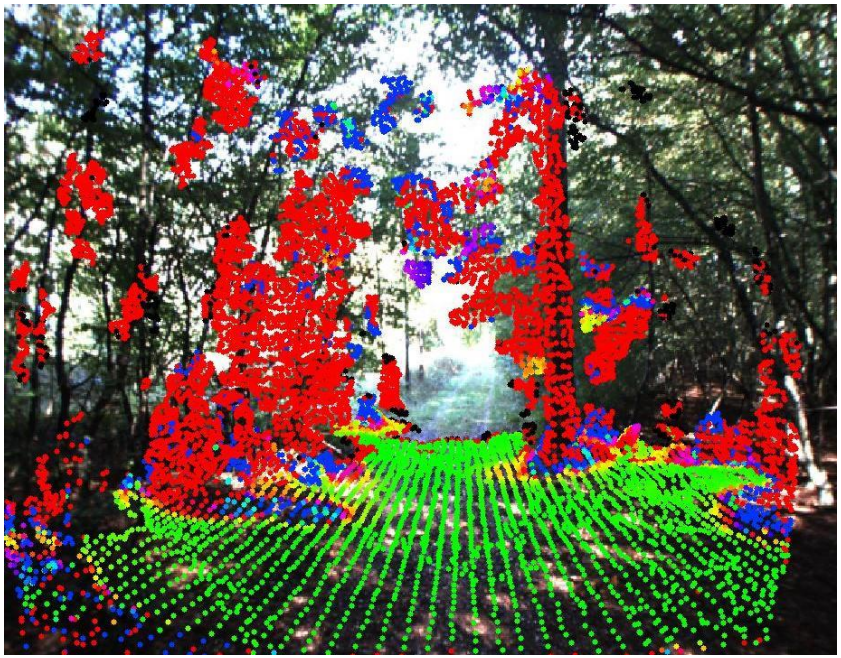
Single Human Operator



Multiple Human Operators

Obstacles Detection

Difficult Scenarios: Woodlands, high grass and waterholes should be correctly detected in order to preserve the vehicle safety.

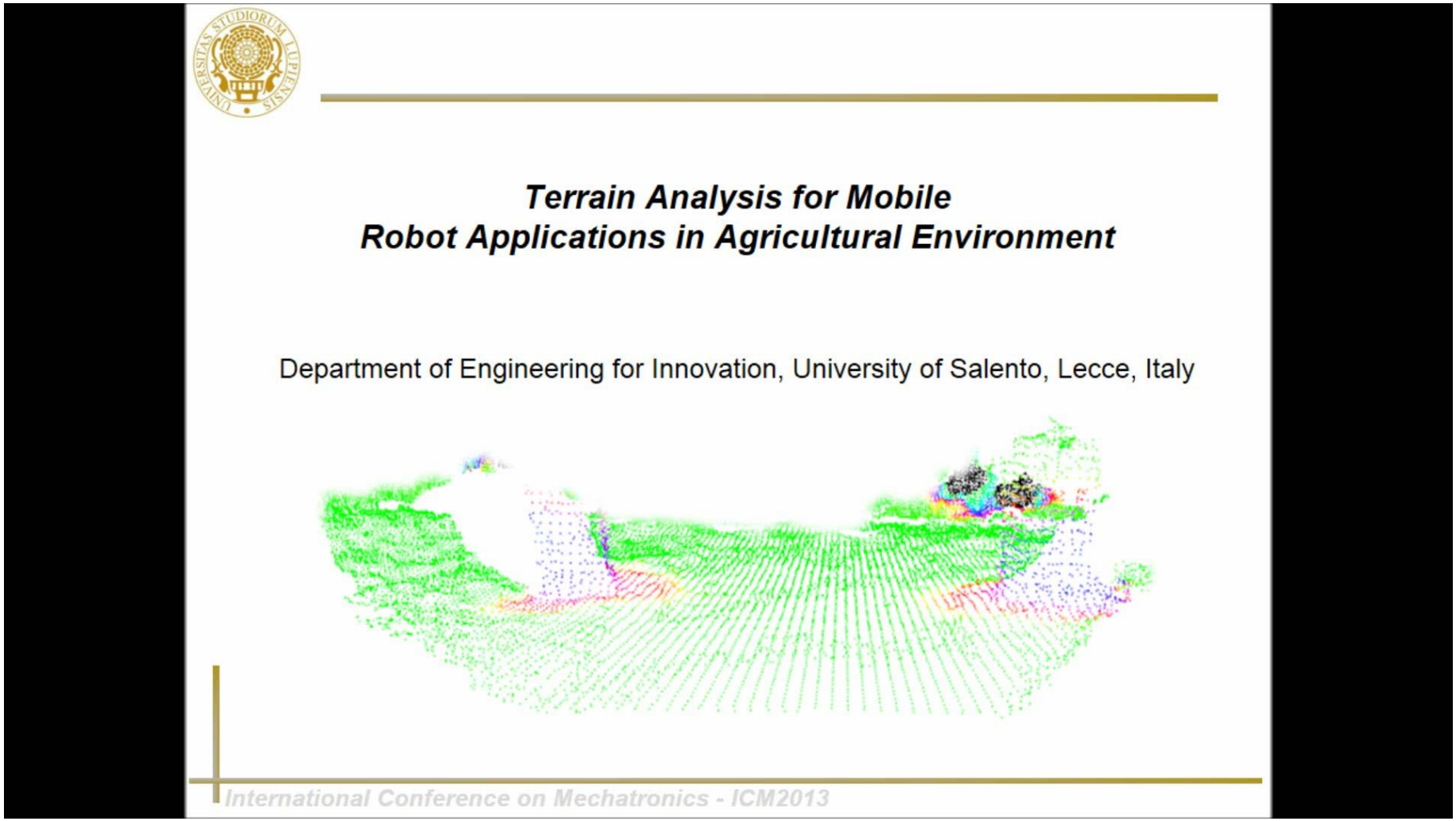


Woodland

High Grass

Experimental Application: Agricultural

Link on YouTube: https://www.youtube.com/watch?v=wjZxROMB3QE



Conclusion

Advanced perception system for mobile robotics can be enhanced using 3D points cloud processing. Possible tasks are:

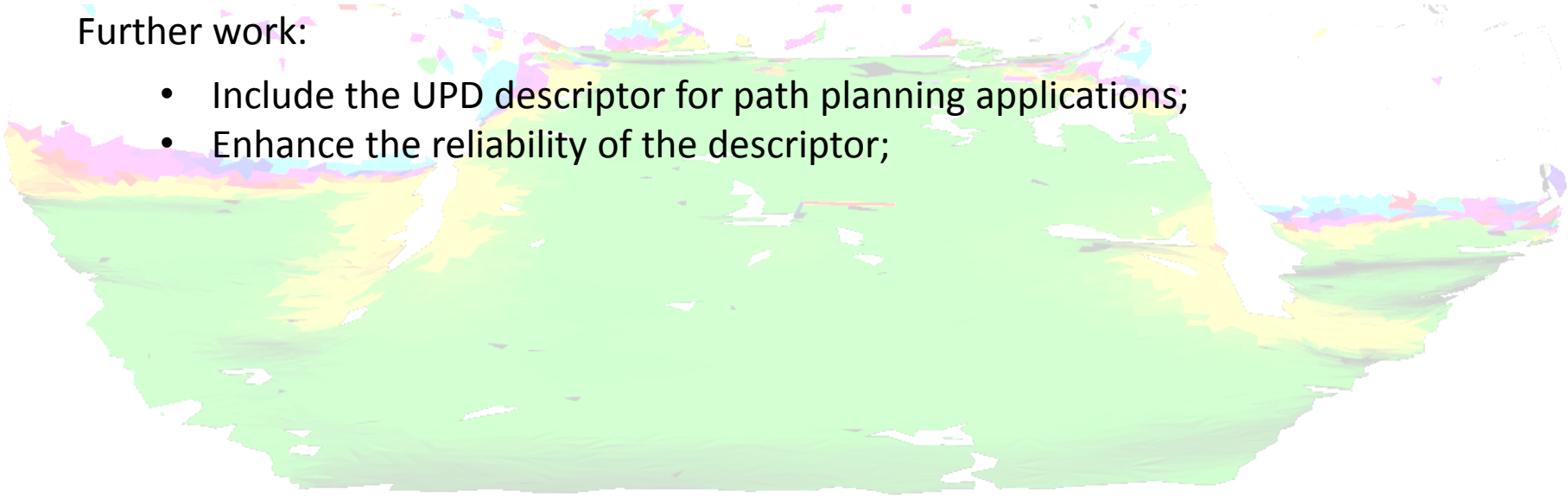
- Navigation and reconnaissance for autonomous driving
- Obstacle detection and recognition;

Specifically, by using UPD as a geometric descriptor, it is possible to:

- Enhance safe driving;
- Interpret outdoor scenes in challenging terrain;

Further work:

- Include the UPD descriptor for path planning applications;
- Enhance the reliability of the descriptor;



Any question ?

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