ROS-Based 3D On-Line Monitoring for LMD Robotized Cells

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Motivation and Innovative Character

Laser Metal Deposition (LMD)

- Promising additive manufacturing technique.
  - Parts are built up layer by layer directly from a 3D CAD model.
- For repair and direct fabrication of pieces.
- Near-net-shape (close to the final shape).
- Manufacturing of large metallic parts.
  - The material is directly deposited on the previous surface.

LMD Issues

- Thermal heating accumulation produces geometrical distortions.
- Distortions rise in poor dimensional accuracy and defects.
- Traditional off-line process (with constant parameters) becomes unsuccessful.

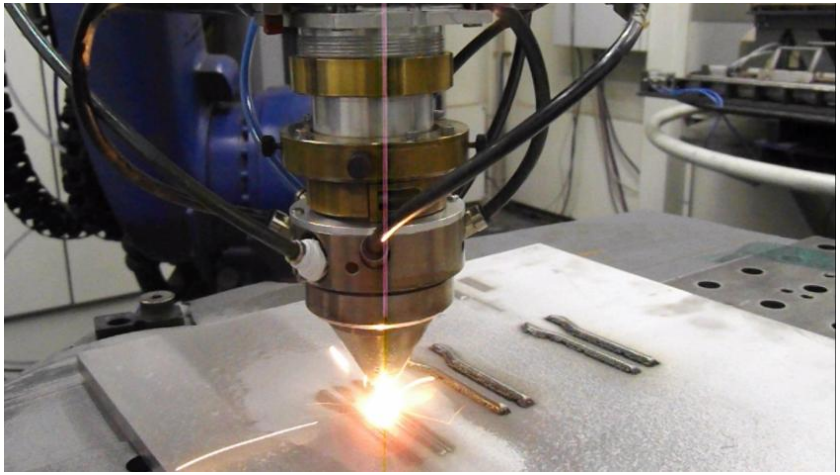
Motivation and Innovative Character

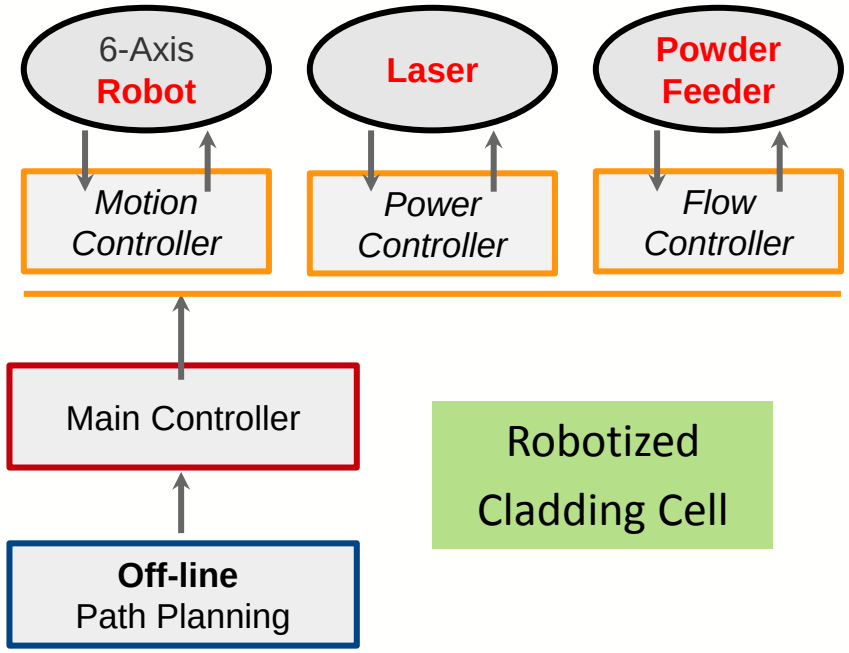
Motivation

- There are a lot of industrial robotized laser cells.
- Empower robotized laser cells for effective AM.

Innovation

- Retrofit current industrial facilities.
- Apply state of the art robotic software solutions.

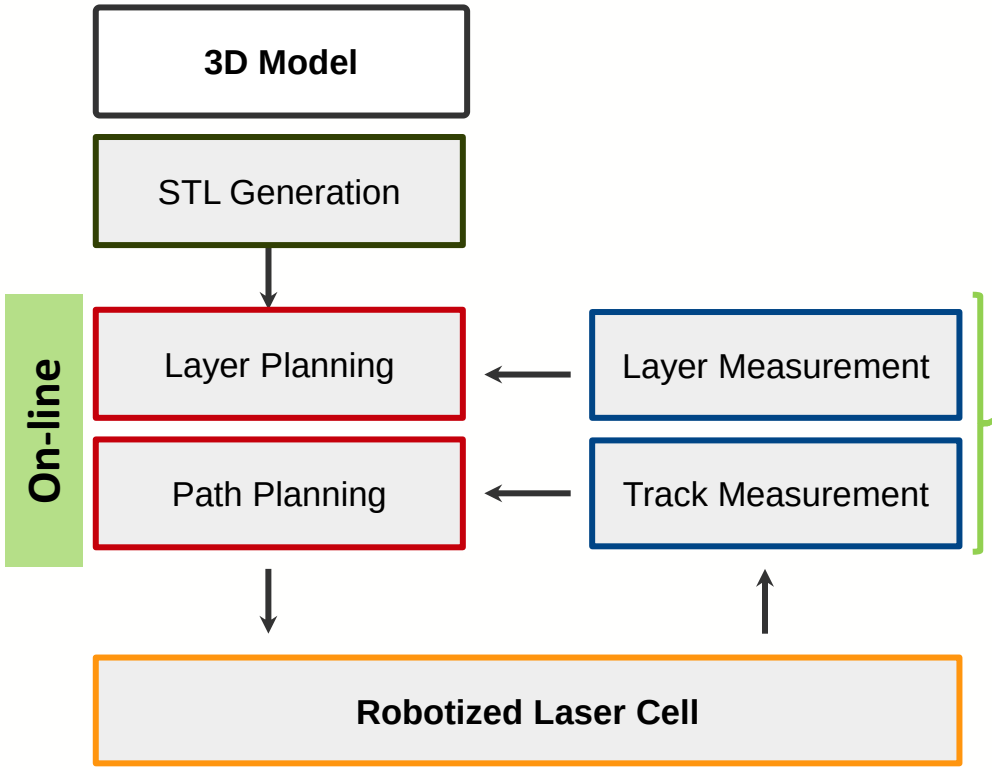


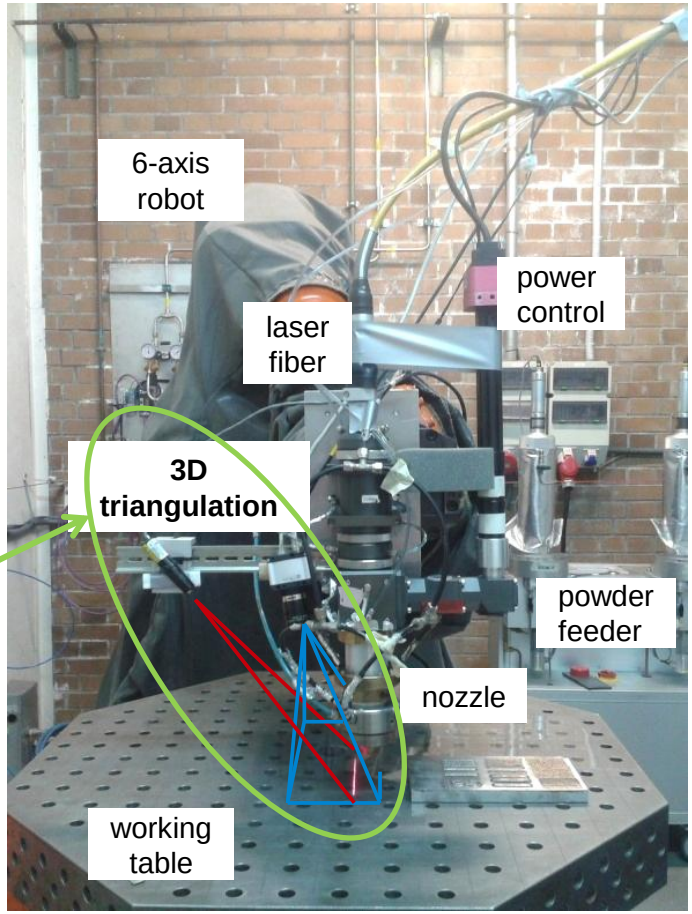


Proposed Solution

LMD geometrical control

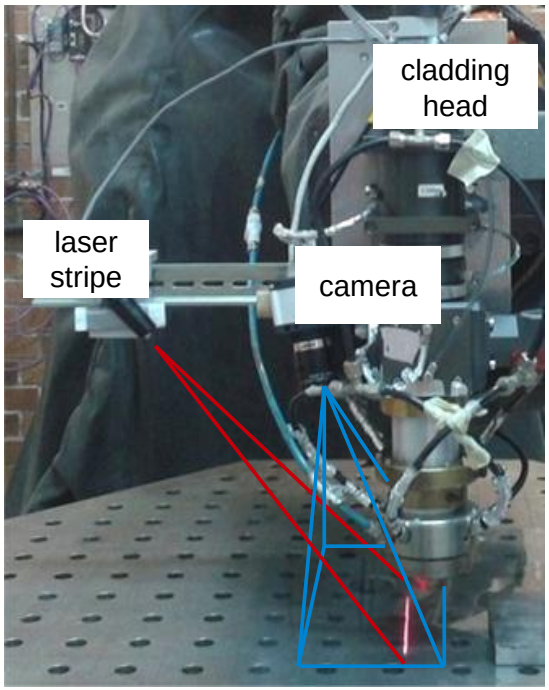
- On-line geometrical monitoring.
- Adaptive path planning.

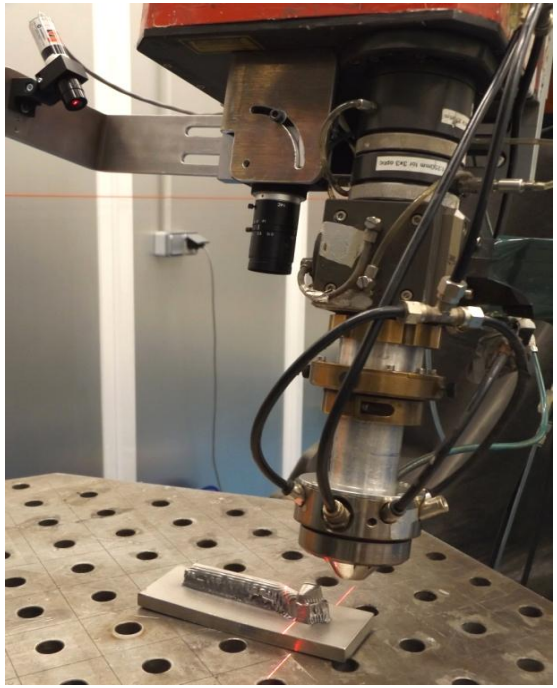




3D scanning setup

- Industrial CMOS camera.
- Industrial RED laser stripe.
- Fixture to attach the components to the laser cladding head.





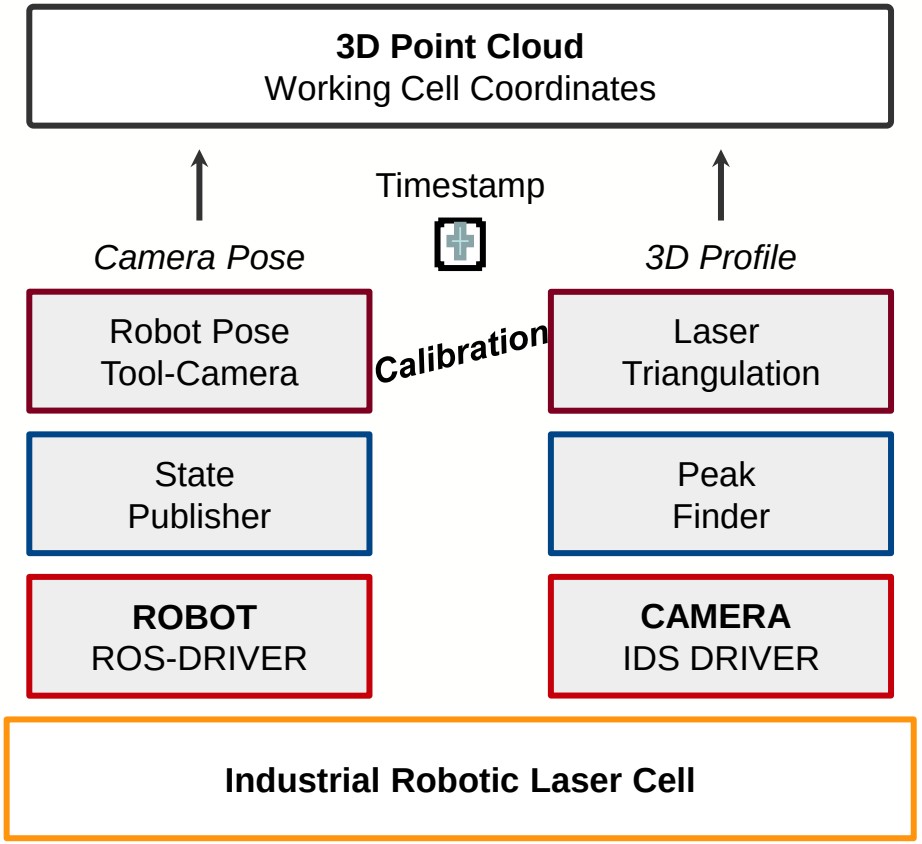
3D Geometrical Monitoring

3D Geometrical Monitoring

- 3D point cloud (geometric information)
  - On-line generation.
  - In robot coordinates.
  - Independently of the speed.
  - No movement restrictions.
  - Free orientation.

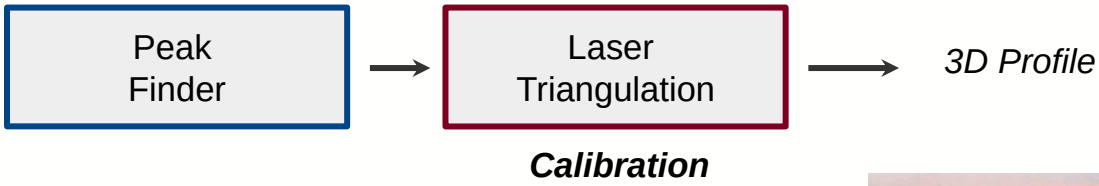
Monitoring main tasks

- Laser Stripe Detection
- Laser Triangulation
- Transformation to robot coordinates



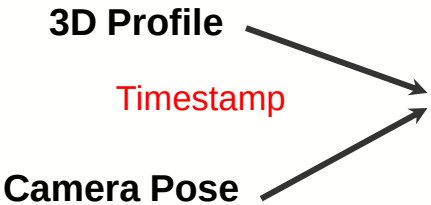
3D profile calculation

- Center Of Gravity method as peak finder.
- Point correspondence for 2D-to-3D mapping solution.



Point cloud reconstruction

- ROS-based
  - Tf library (interpolation)

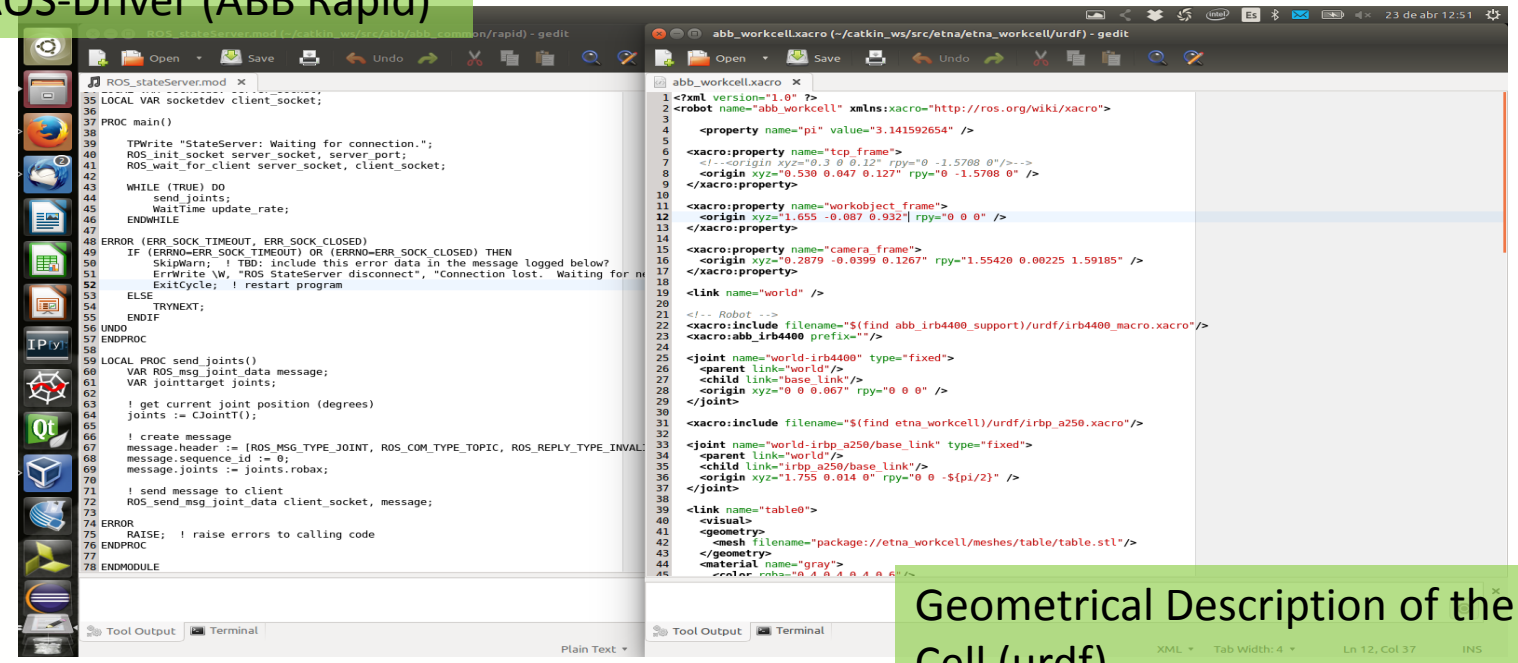


ROS-Industrial components

ROBOT
ROS-DRIVER → State Publisher → Robot Pose Tool-Camera → *Instantaneous Camera Pose*

Calibration + urdf

ROS-Driver (ABB Rapid)

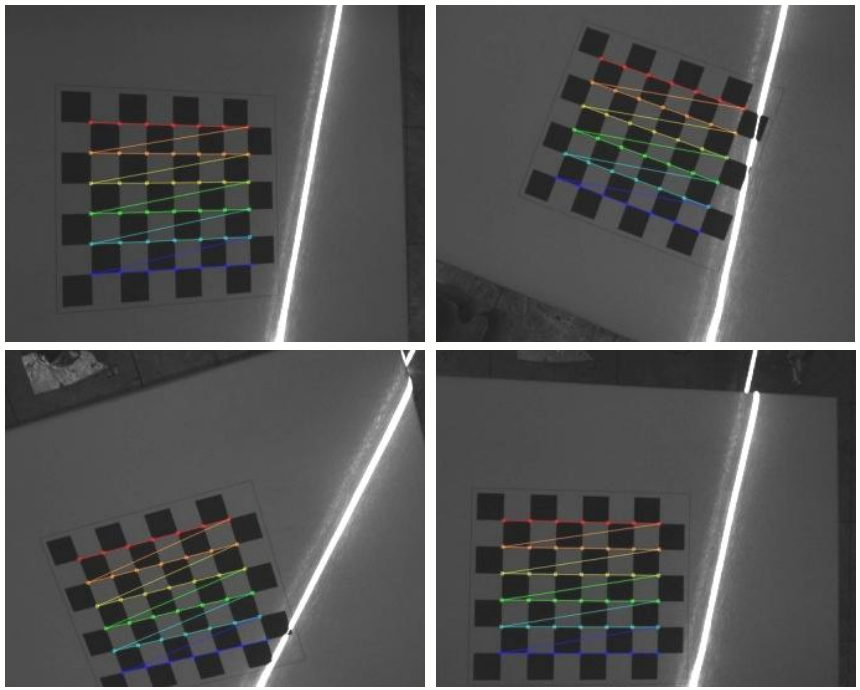


Geometrical Description of the Cell (urdf)

Self-Calibration

Calibration steps

- Camera calibration (OpenCV method)
- Laser stripe calibration
- Hand-eye calibration (Classical method Tsai-Lenz)



Laser stripe calibration steps

1. Checkerboard localization.
2. Laser stripe detection (RANSAC).
3. Laser plane estimation (RANSAC).
4. 2D-to-3D transformation matrix estimation.

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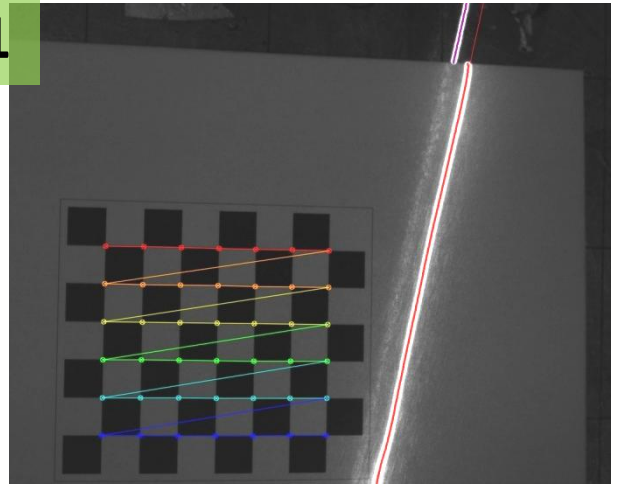

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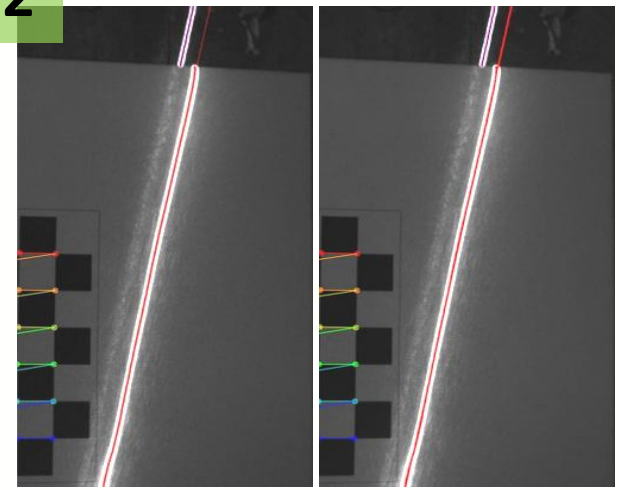

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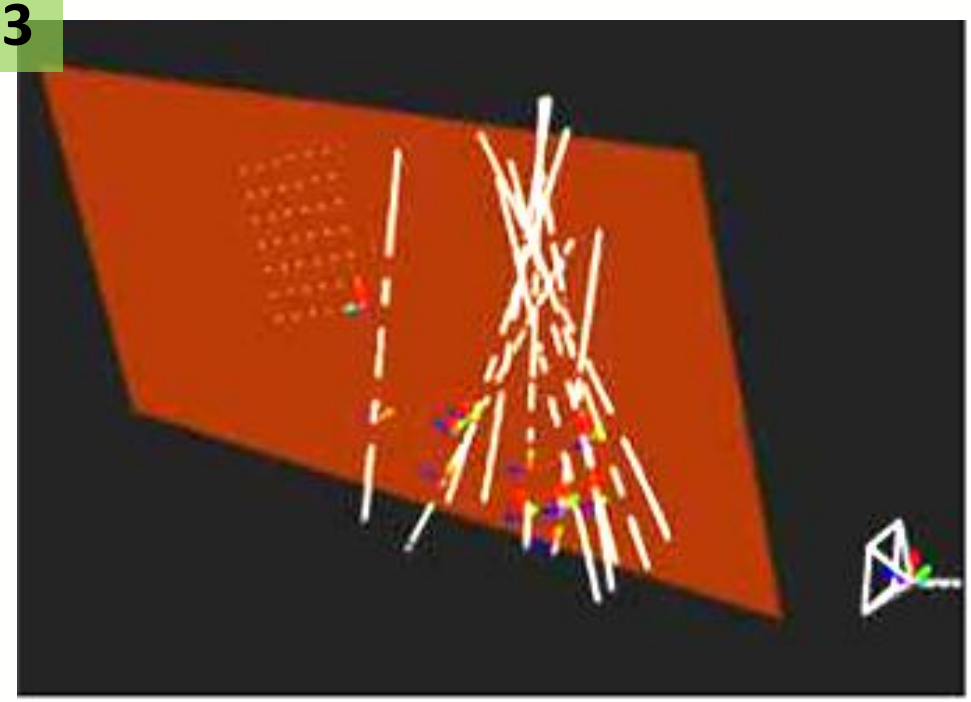
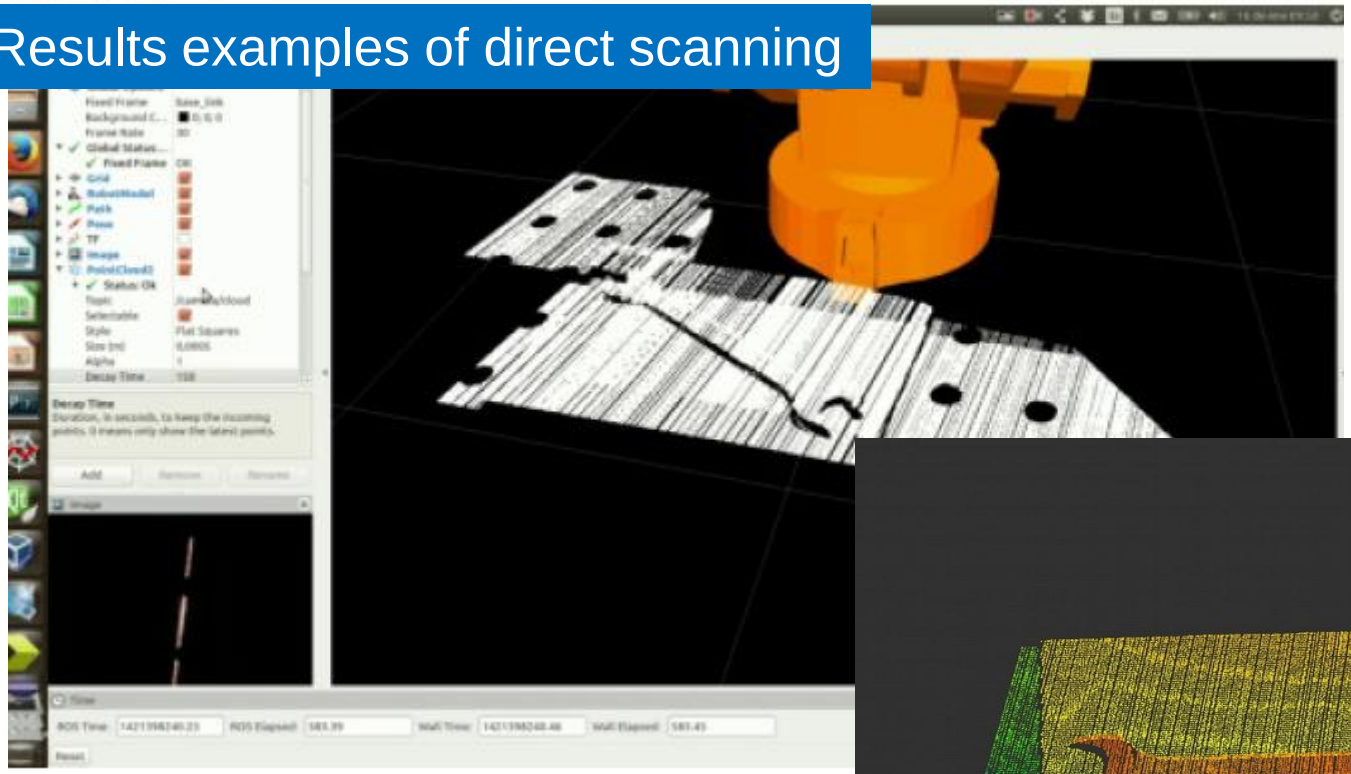


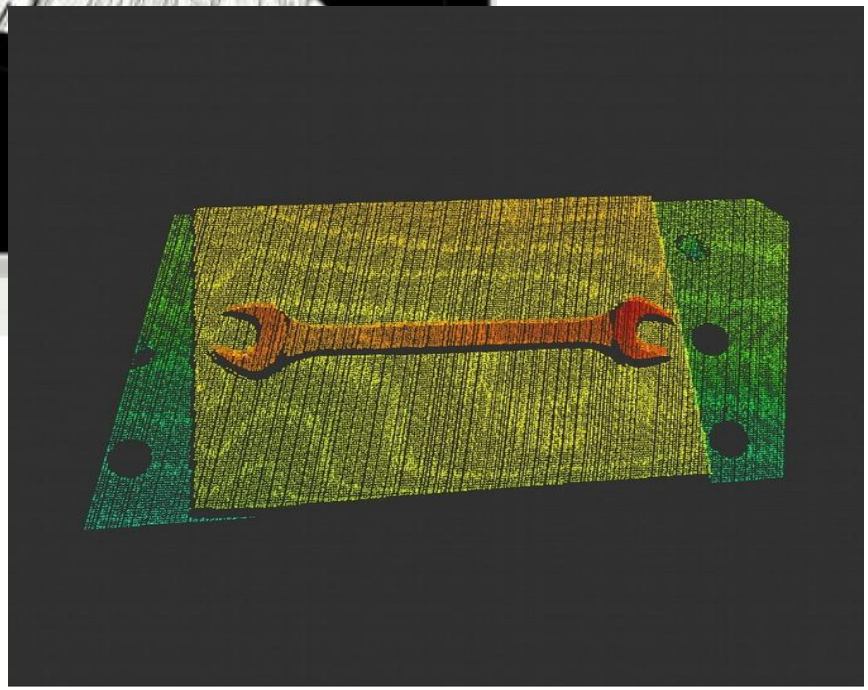
Experimental results

On-line scanning

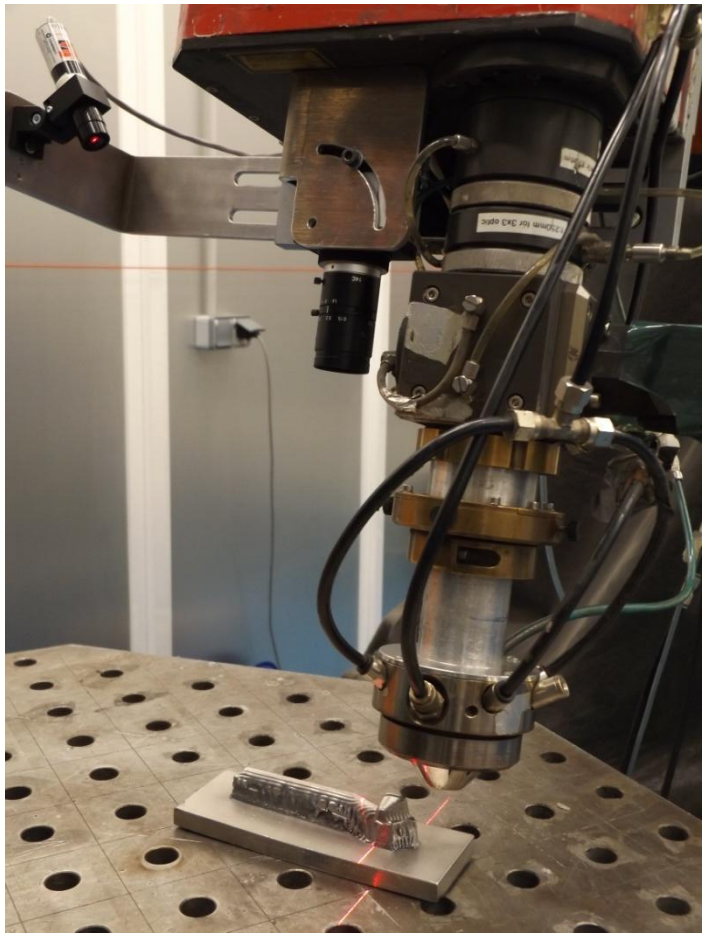
robscan.MP4

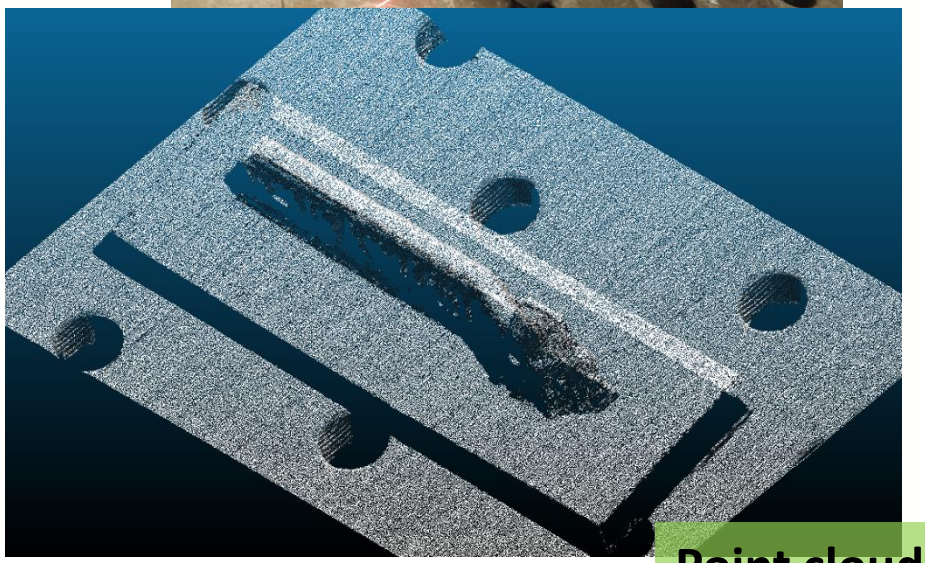
Results examples of direct scanning





Processing results





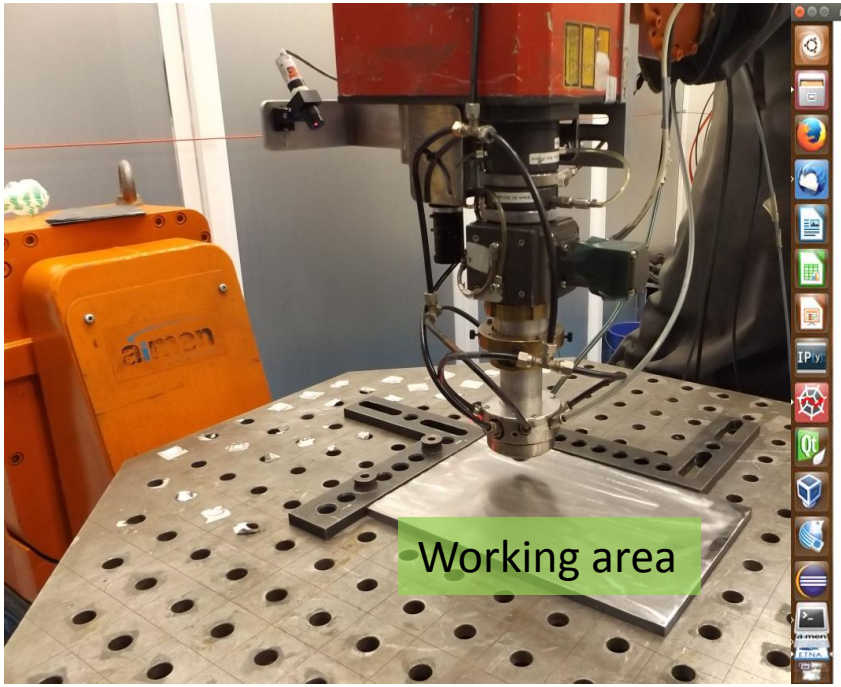
Point cloud

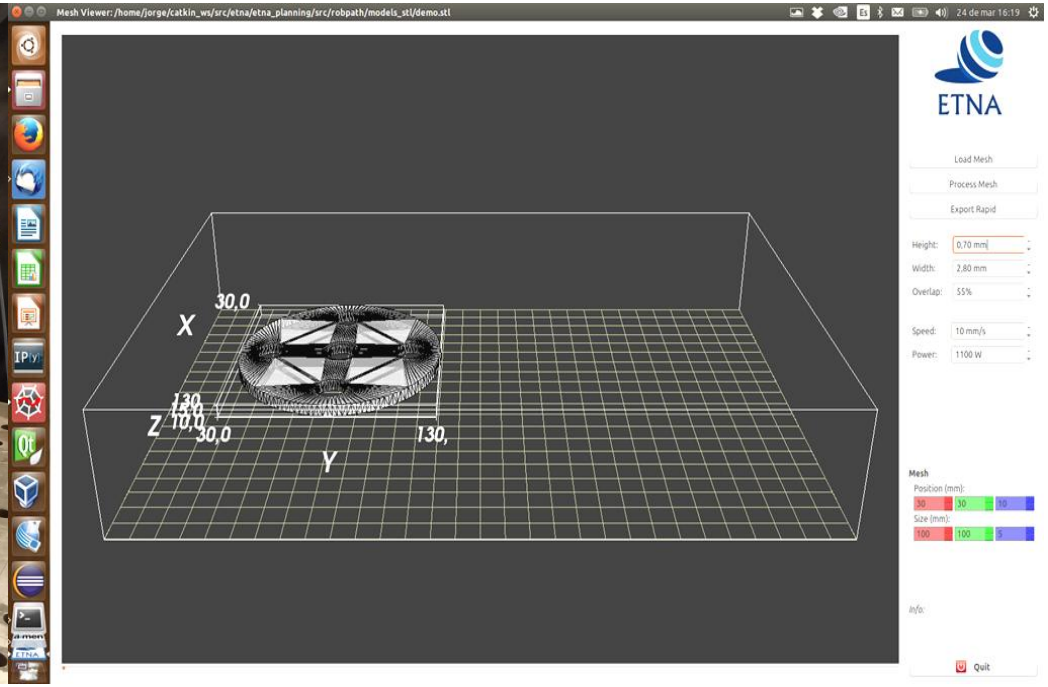
Conclusions and Future Work

Future work

- Complete the layer measurement module.
- Develop the on-line path planning system.
- Enable a full automatic LMD robotized cell.

LASHARE Project
http://www.lashare.eu/





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Thank you for your attention

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