13th EUROPEAN CONFERENCE ON NON-DESTRUCTIVE TESTING
LISBON – PORTUGAL, 3 – 7 JULY 2023

Virtual encoder: a two-dimension visual odometer for NDT

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Some ultrasound inspection routines require mechanical sweeping of the transducer

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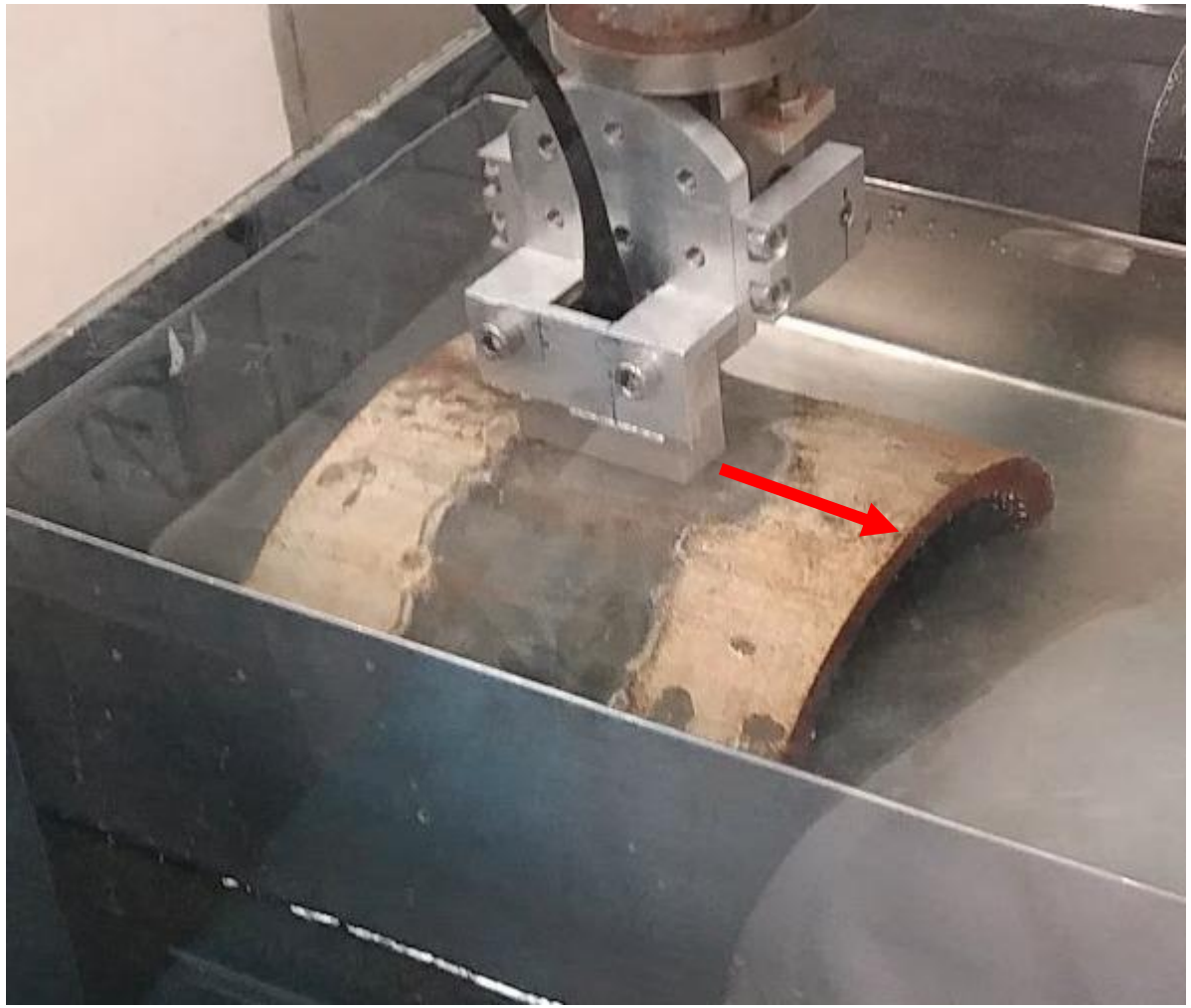

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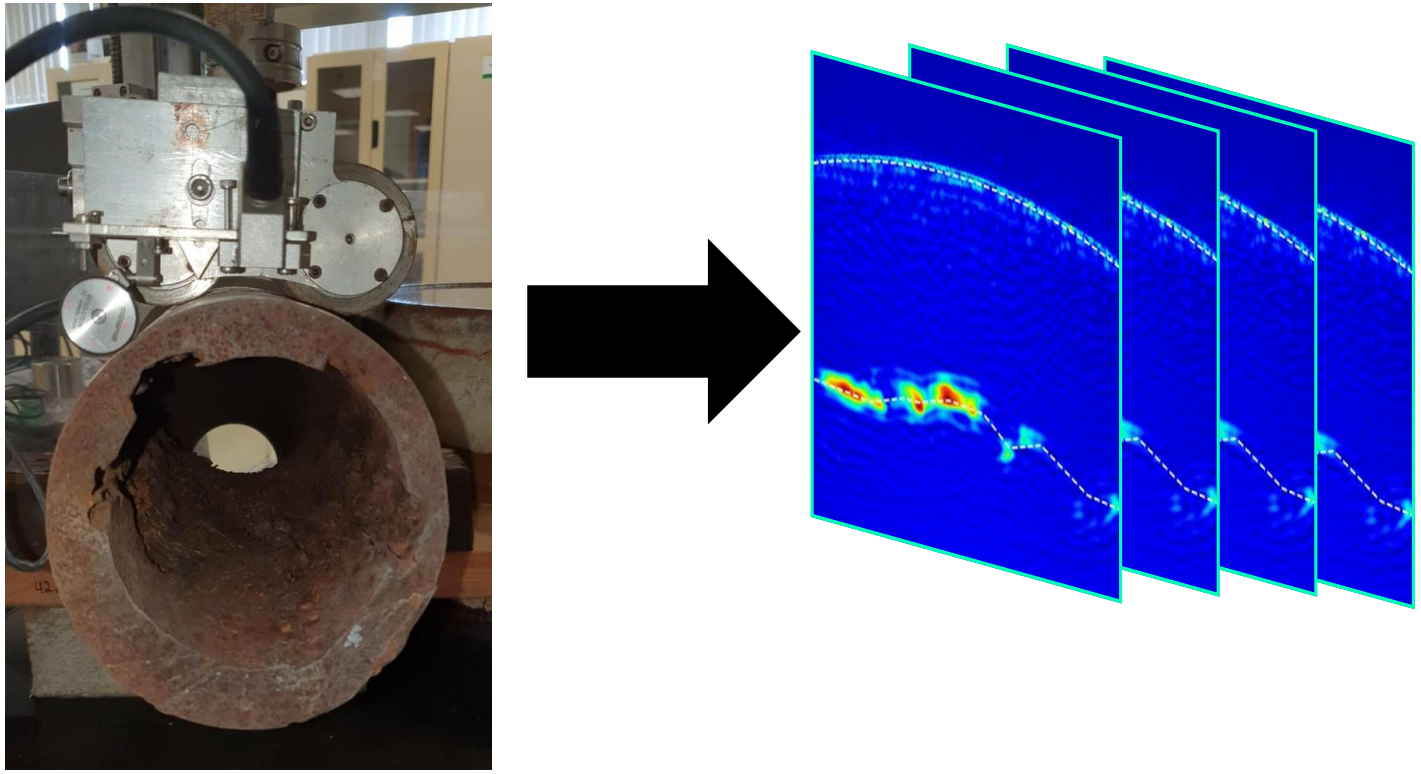

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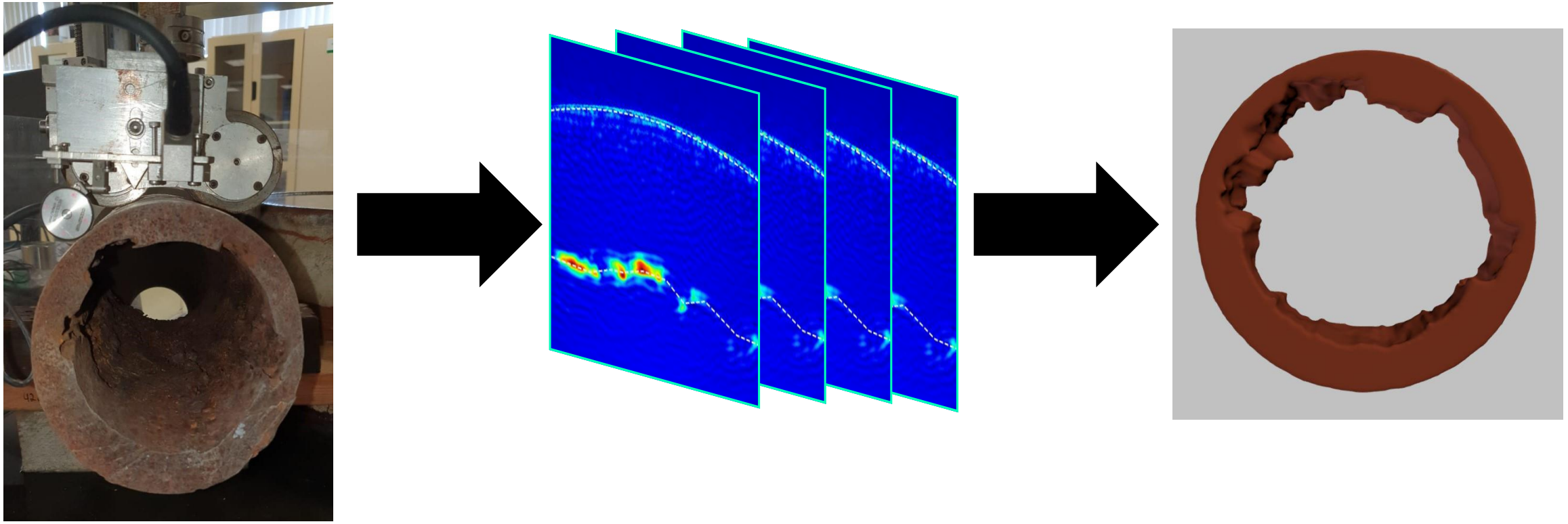
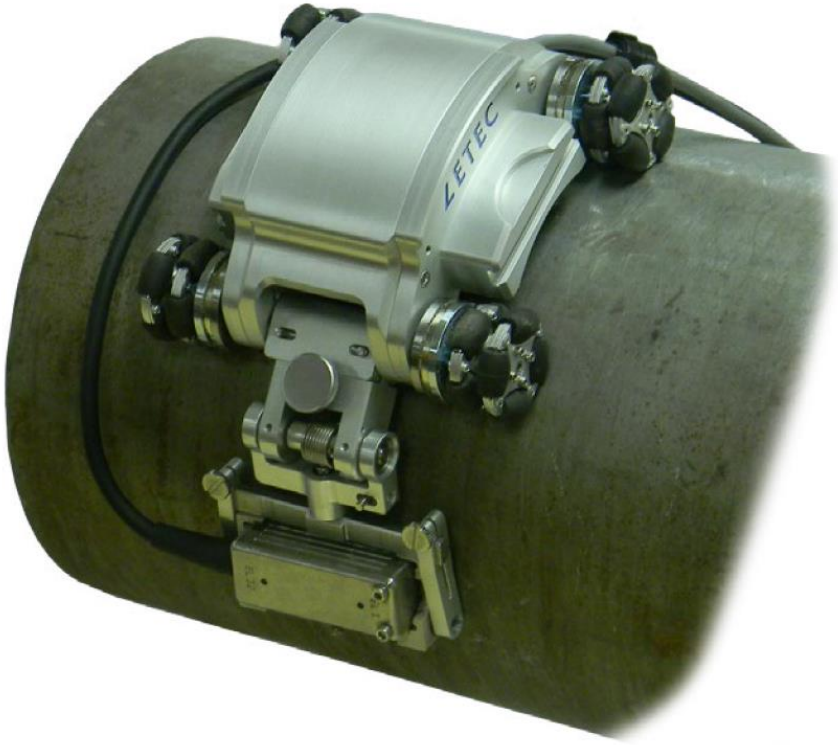
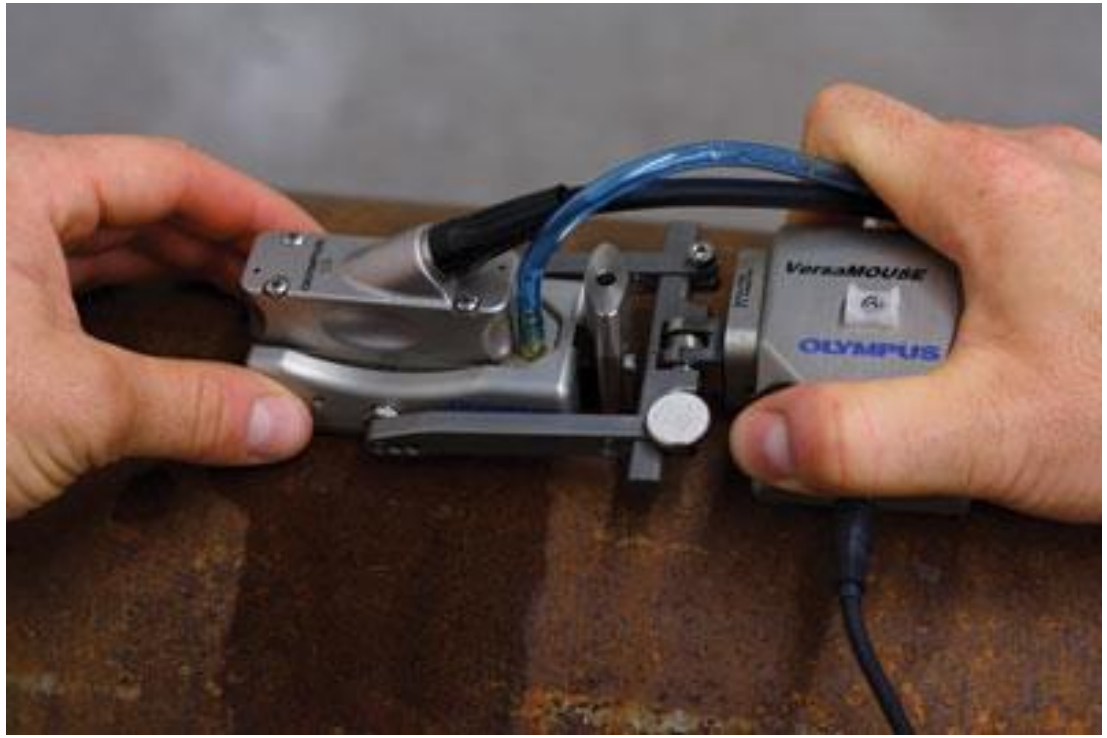


For 2-D displacements, the use of wheel encoders results in large and complicated schemes

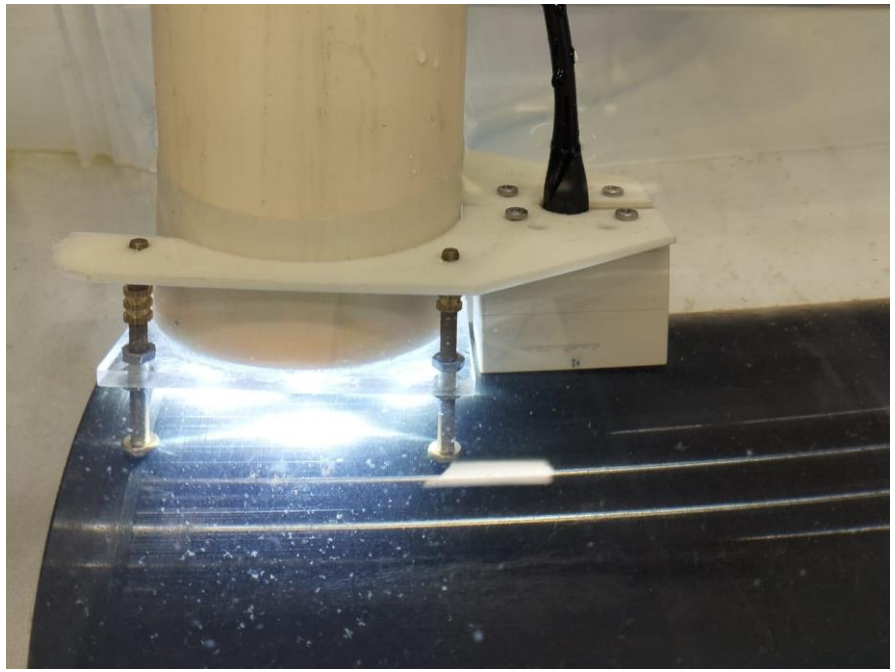


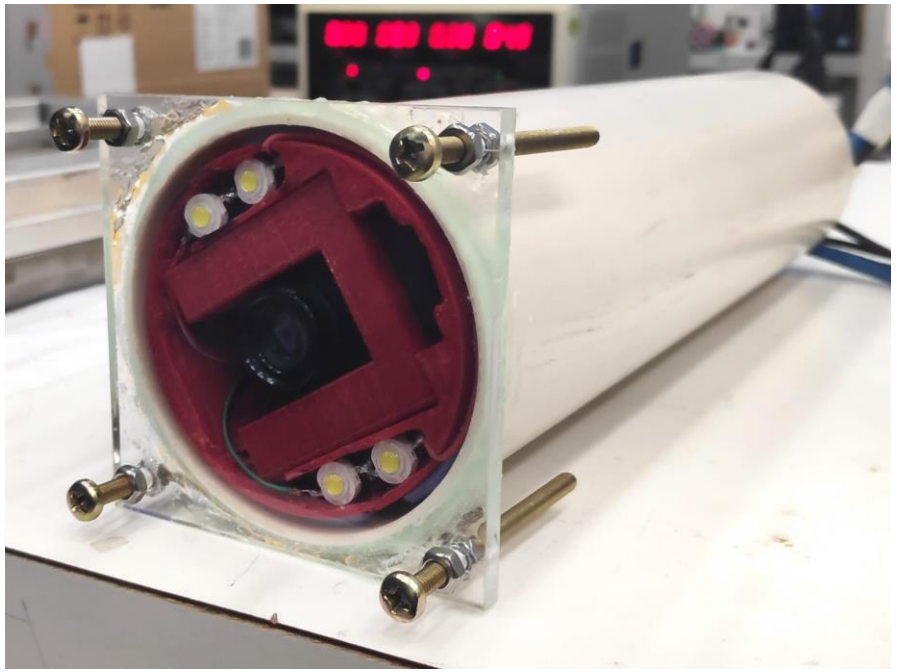


Left image: ZETEC NDT Sweeper from www.zetec.com
Right image: VersaMOUSE from https://www.olympus-ims.com/en/versamouse/

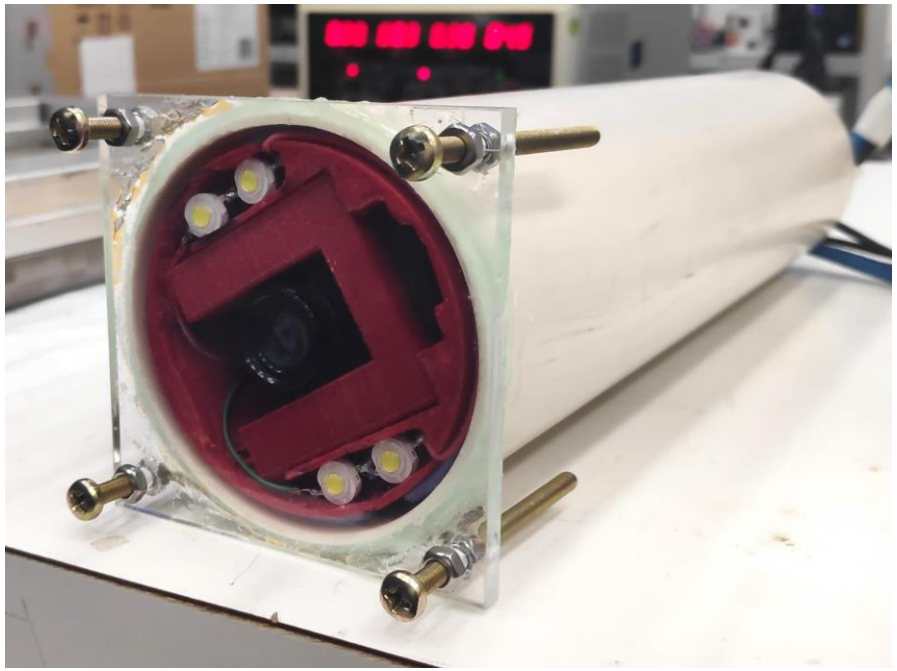
Proposed solution

We are proposing a solution, based on visual odometry, capable of computing the transducer 2-D displacement





A watertight vessel was used to allow underwater inspections



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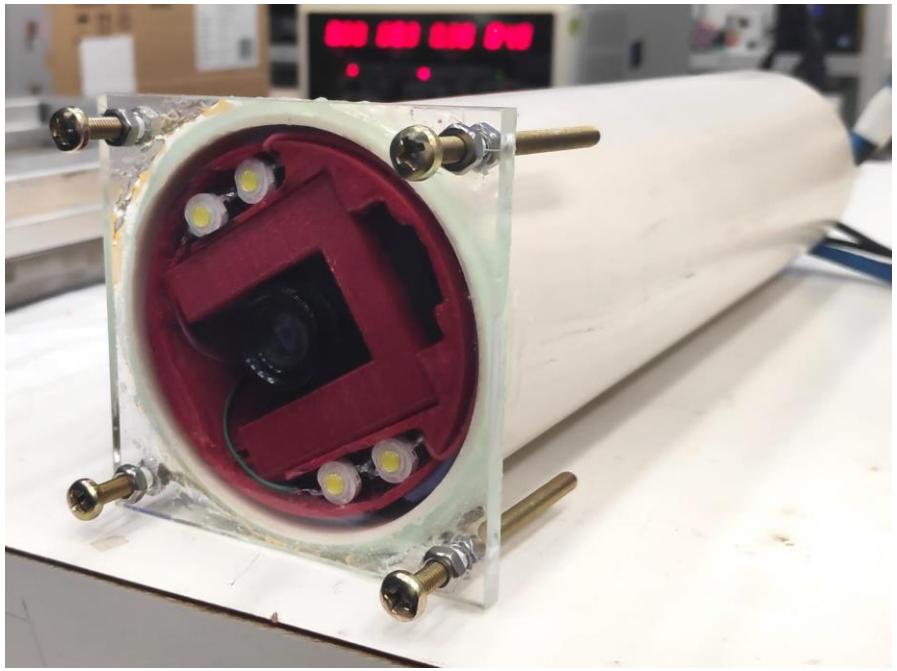

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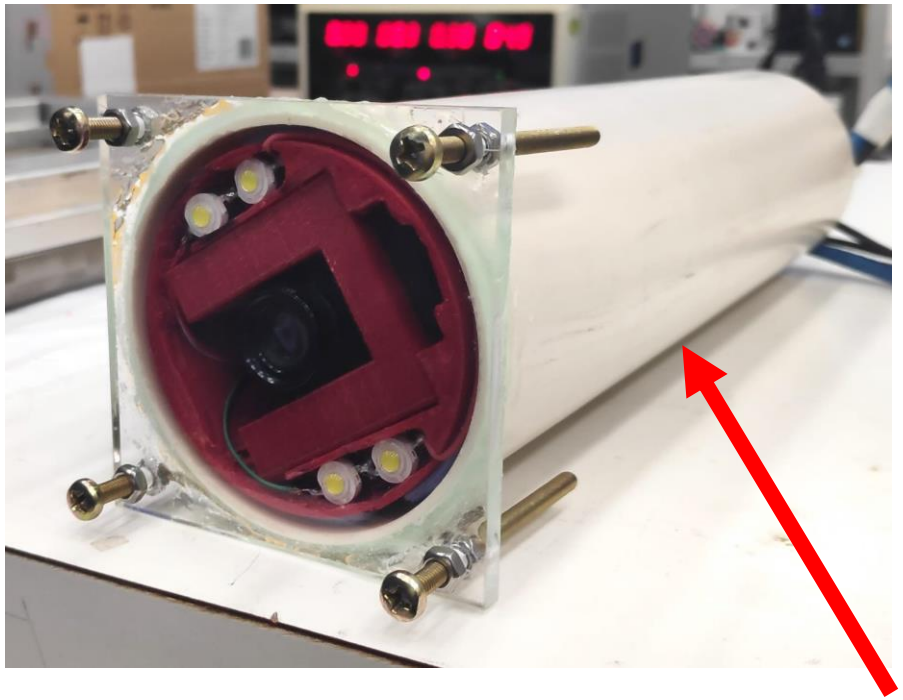
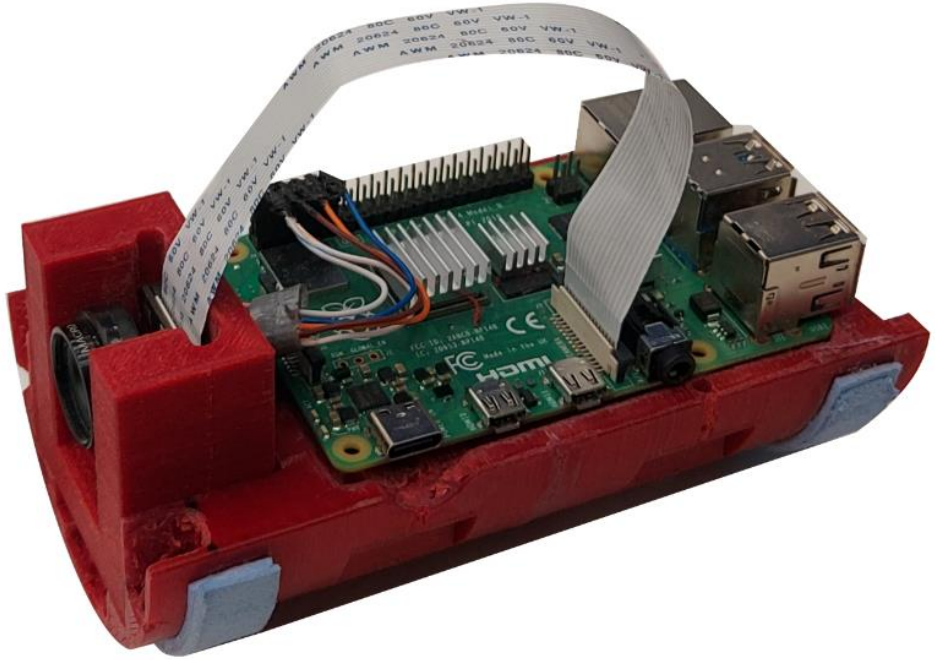
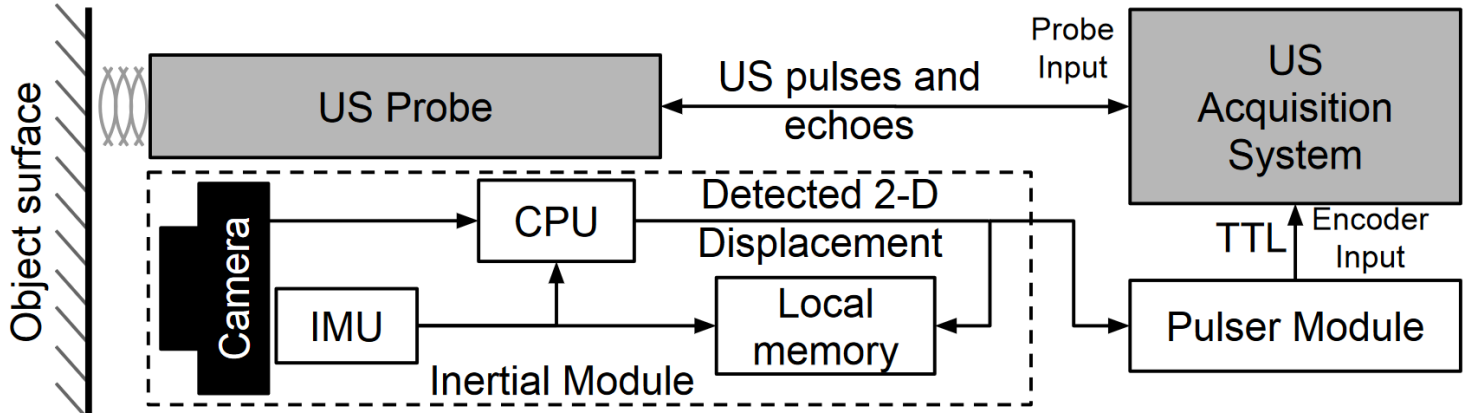




Similar dimensions of a pressure vessel used by PETROBAS in submarine inspections

System architecture



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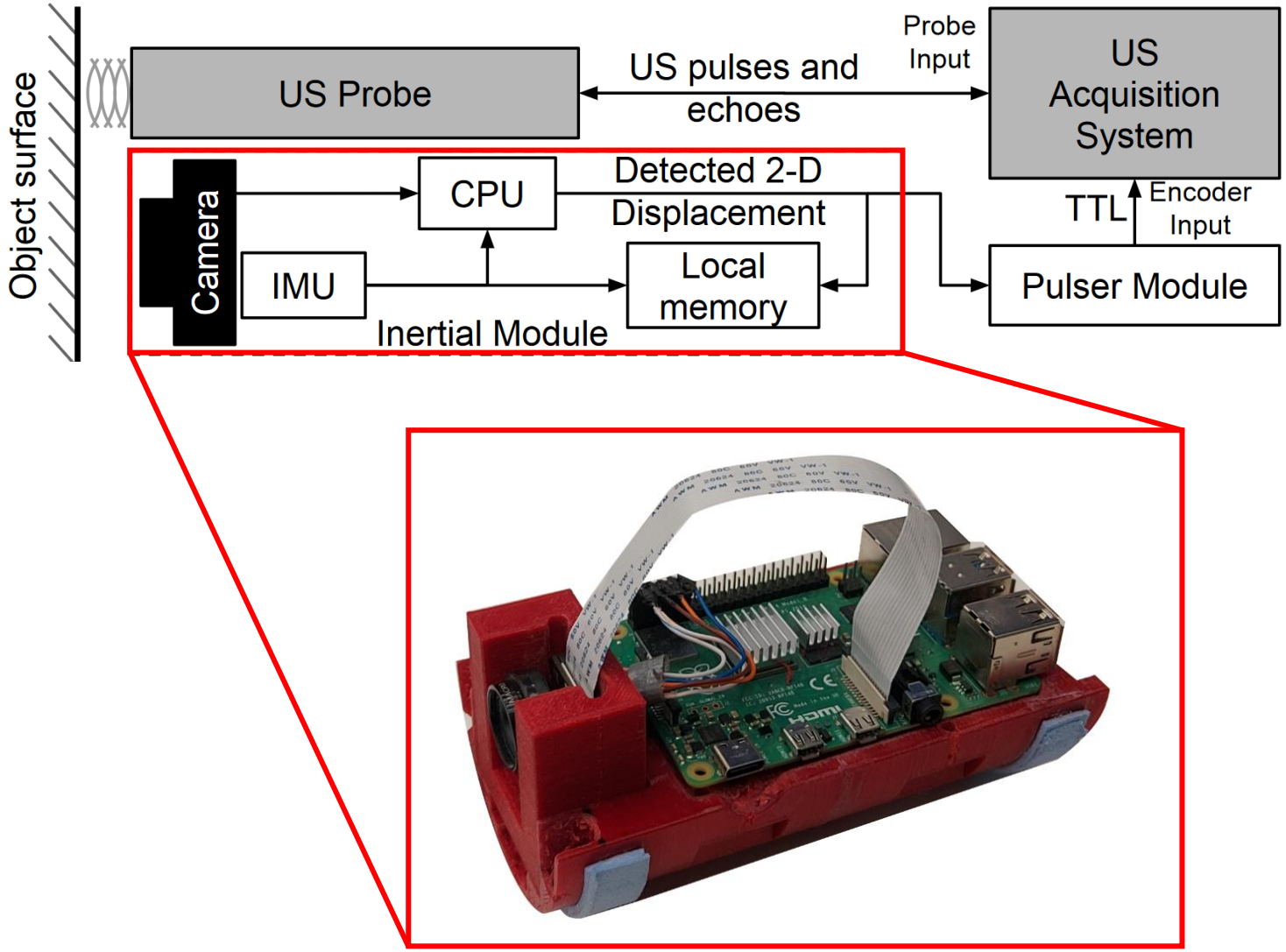
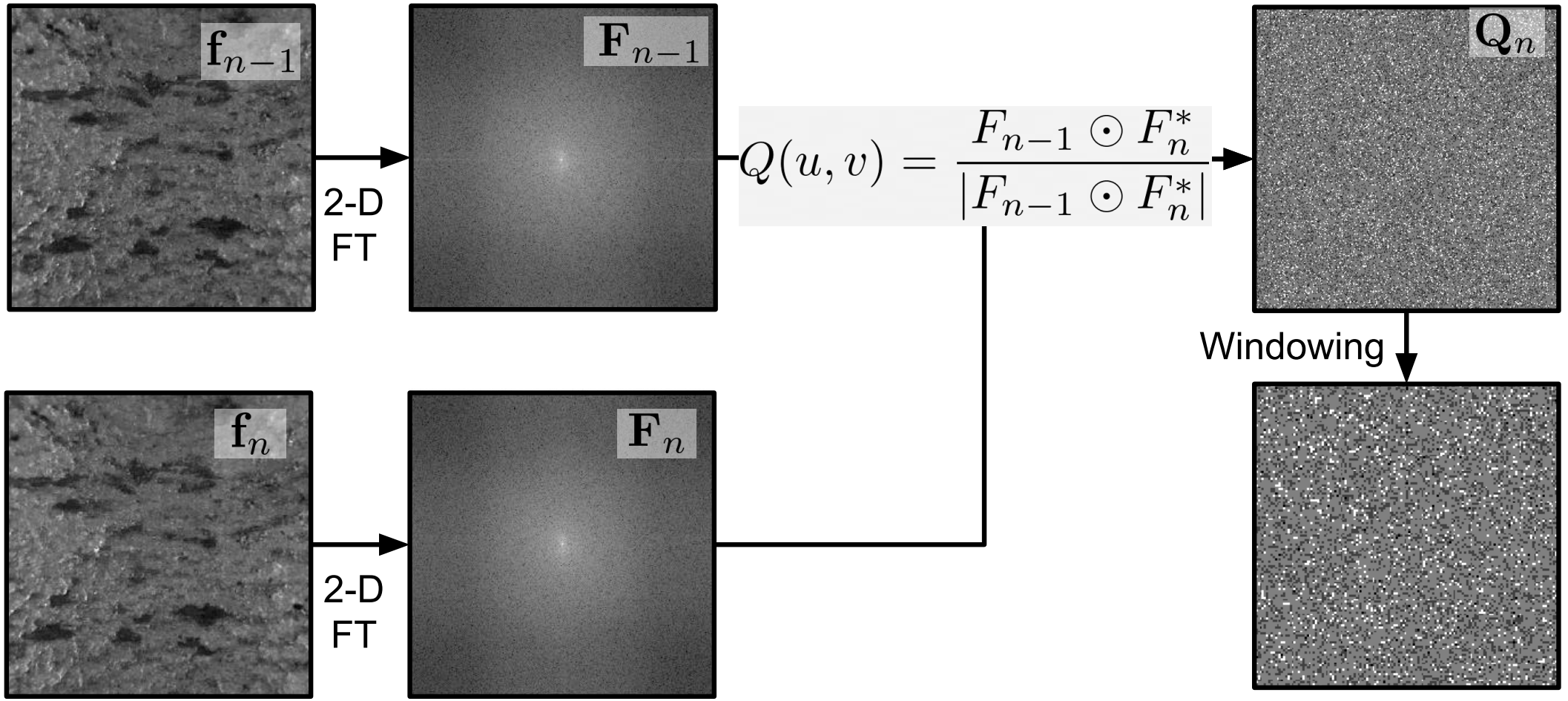


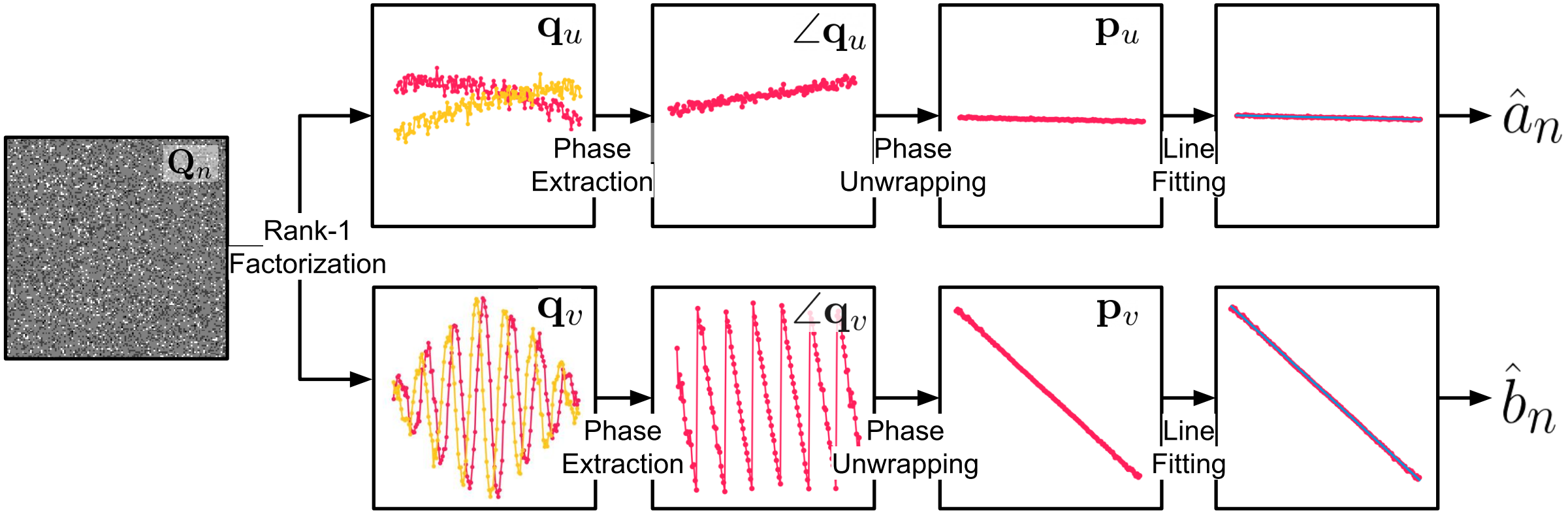
The algorithm

For each pair of frames, the cross-power spectrum is computed



[WS Hoge, "A subspace identification extension to the phase correlation method [MRI application]", IEEE transactions on medical imaging, 22(2), pp 277–280], 2003

The displacement between the frames is proportional to the slope of the singular vectors q_u and q_v phase



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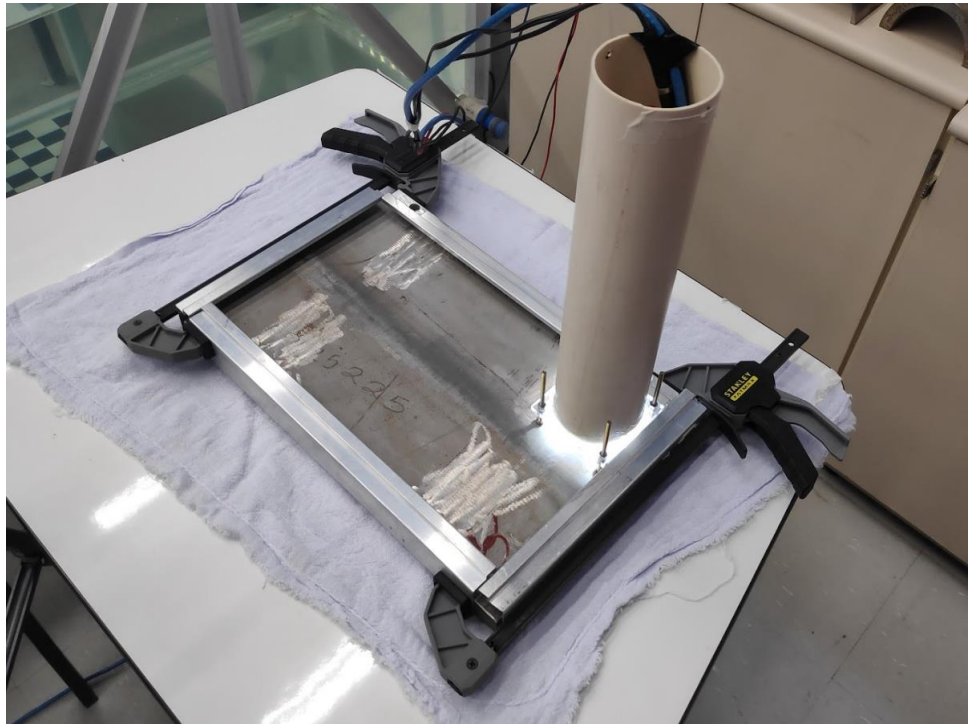
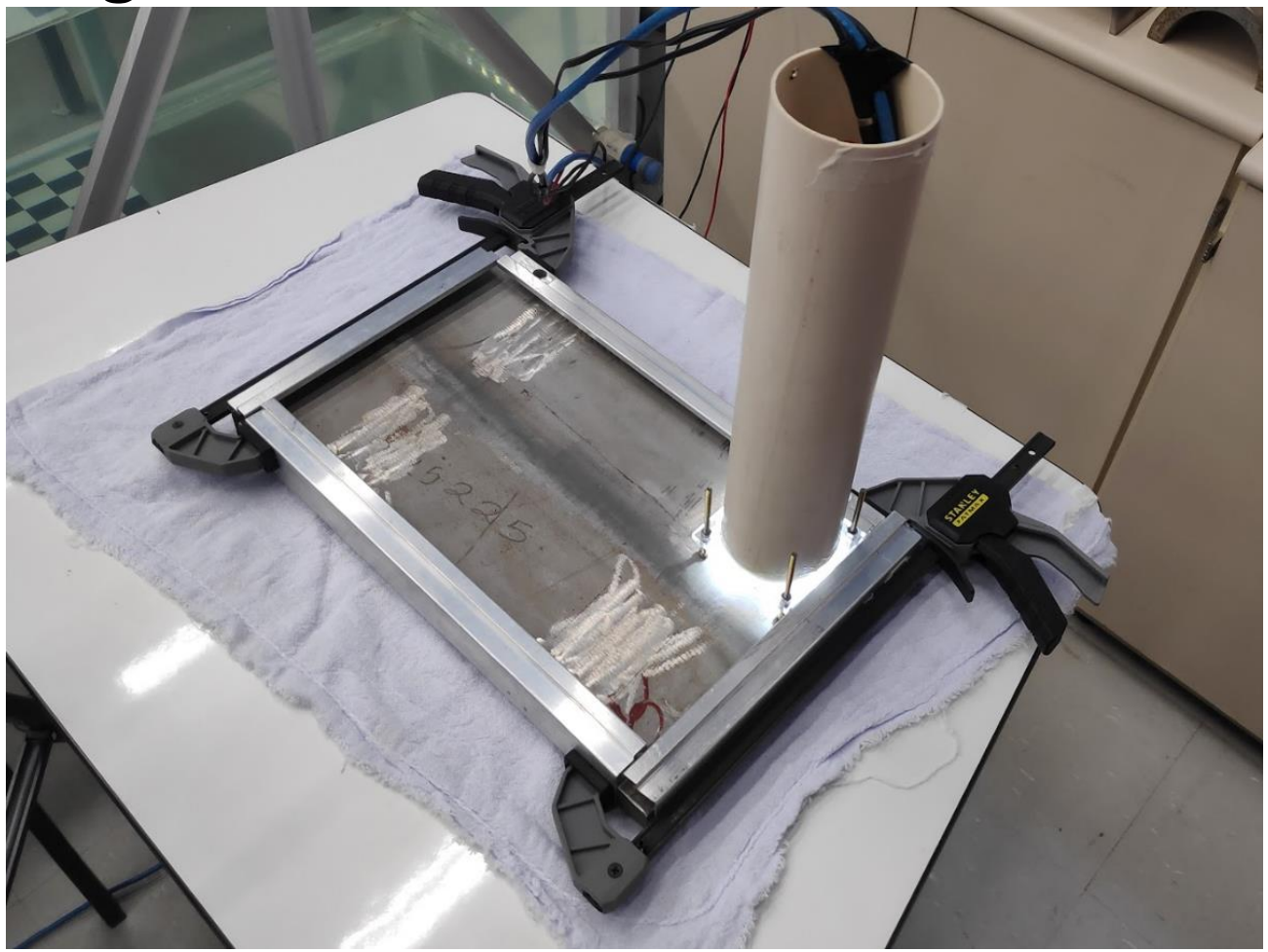
Experiments and Results

Two types of specimens were used: planar and cylindrical shaped



For each specimen shape, the inertial module was shifted in three different paths. One called“Single-X”



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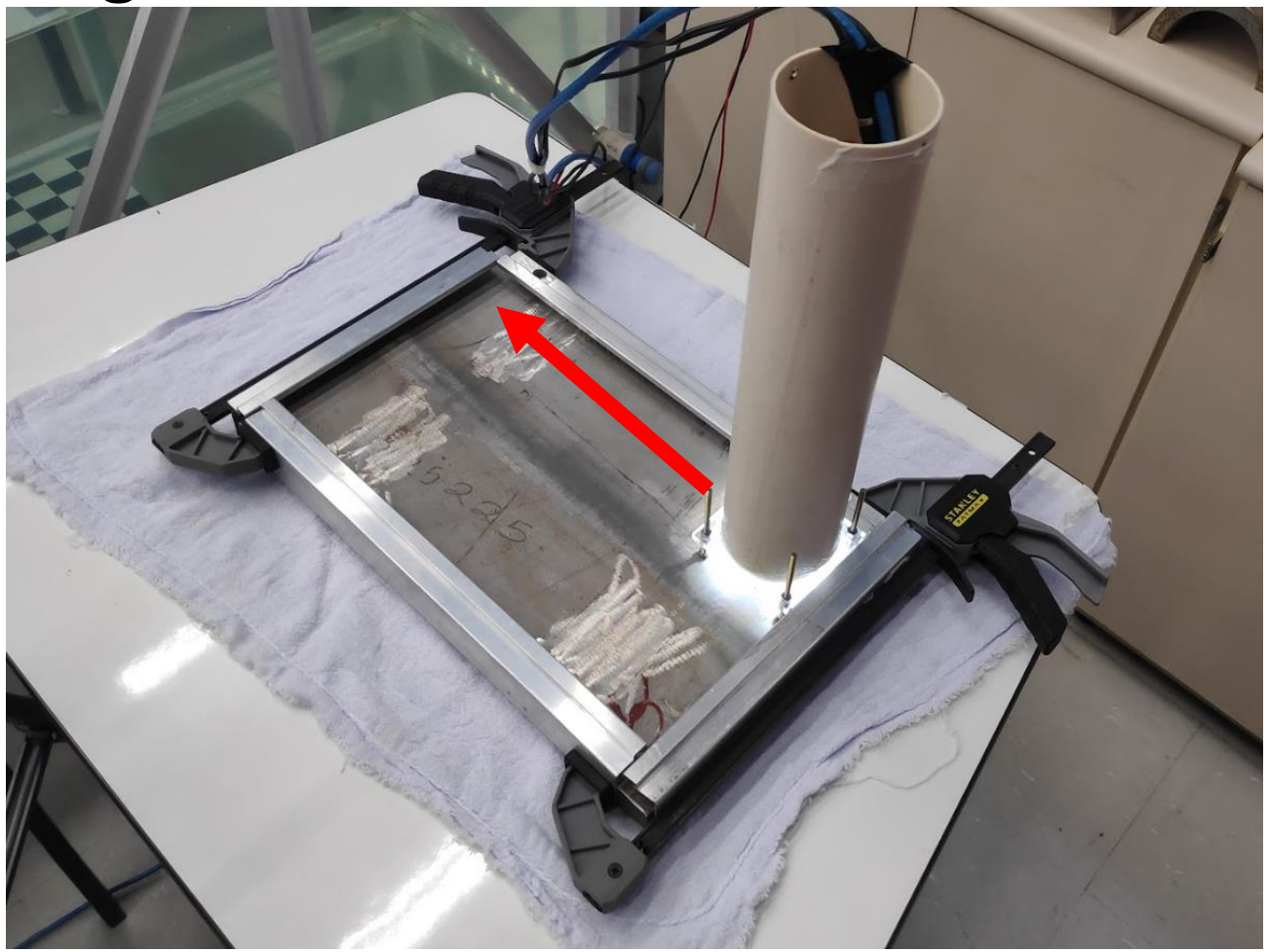
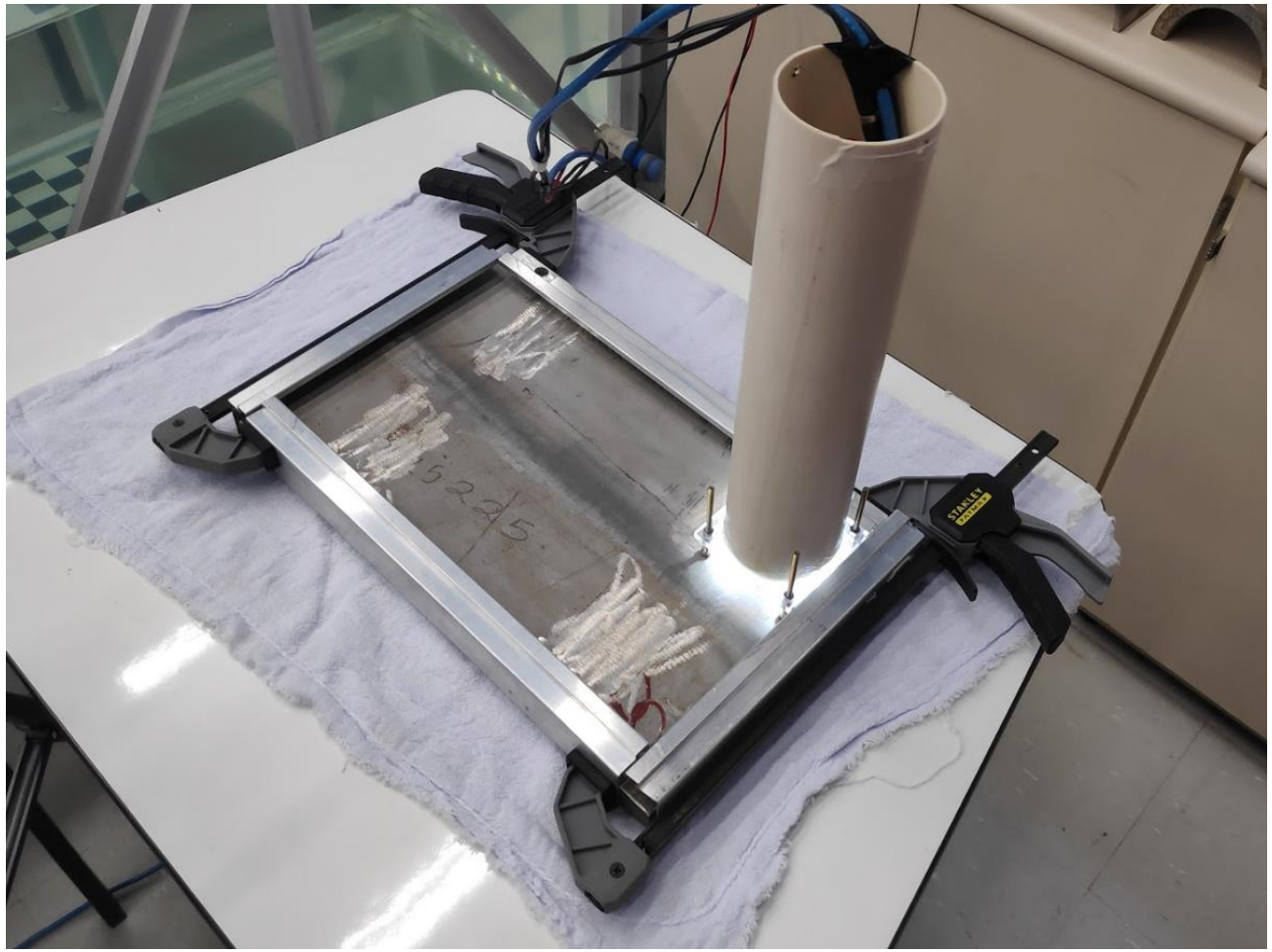


“Single-Y”



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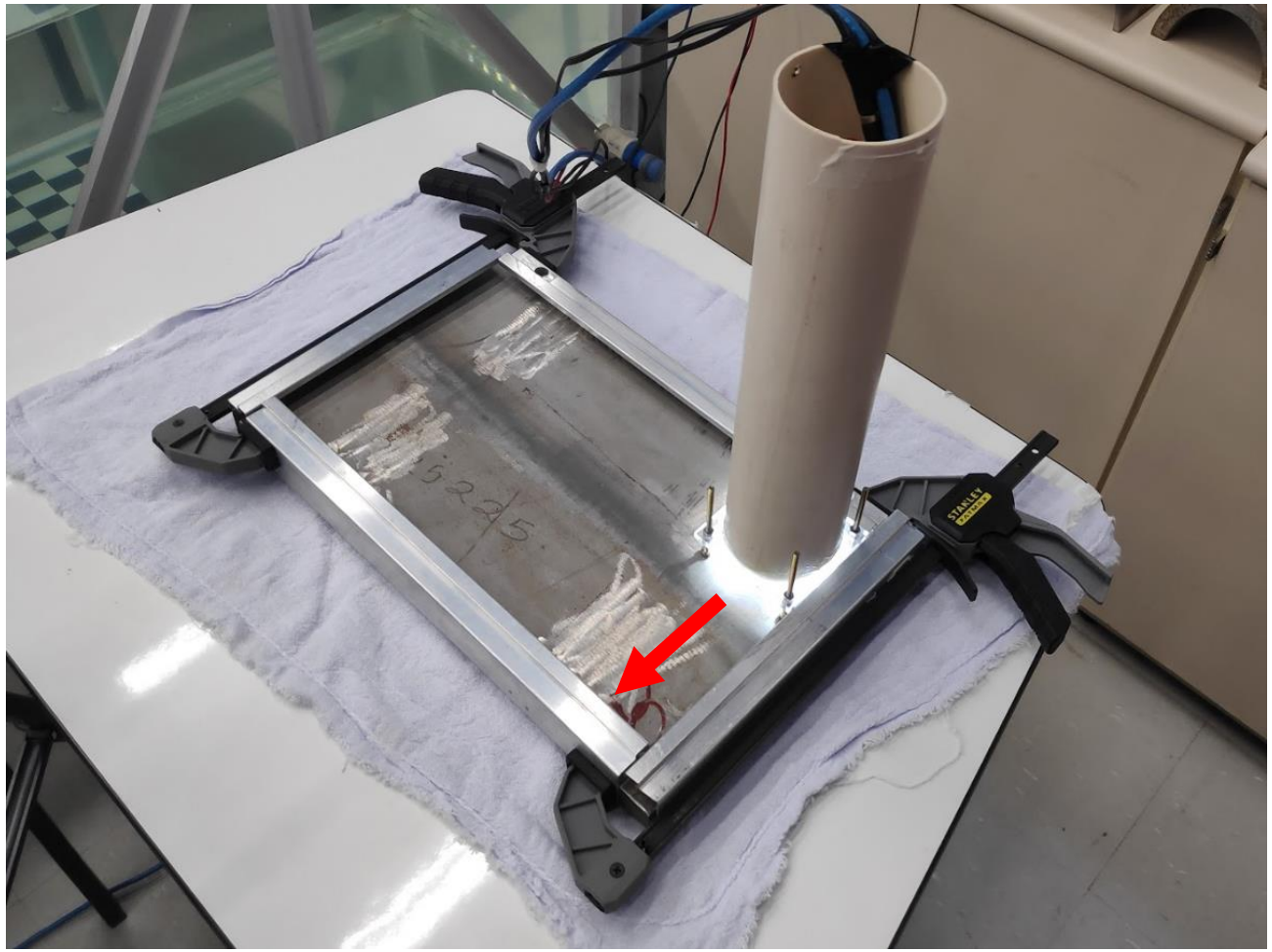
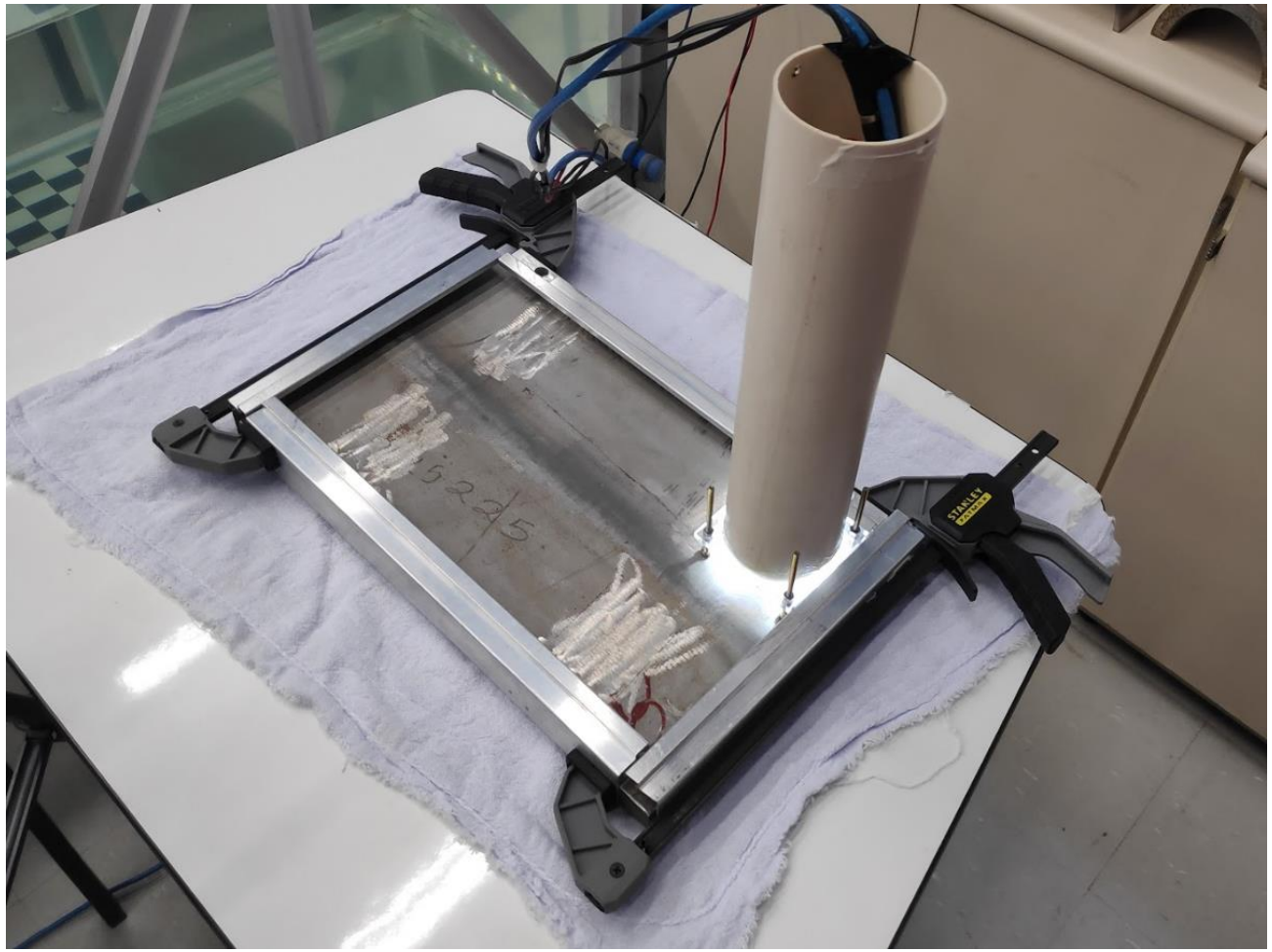


And “Closed-loop”



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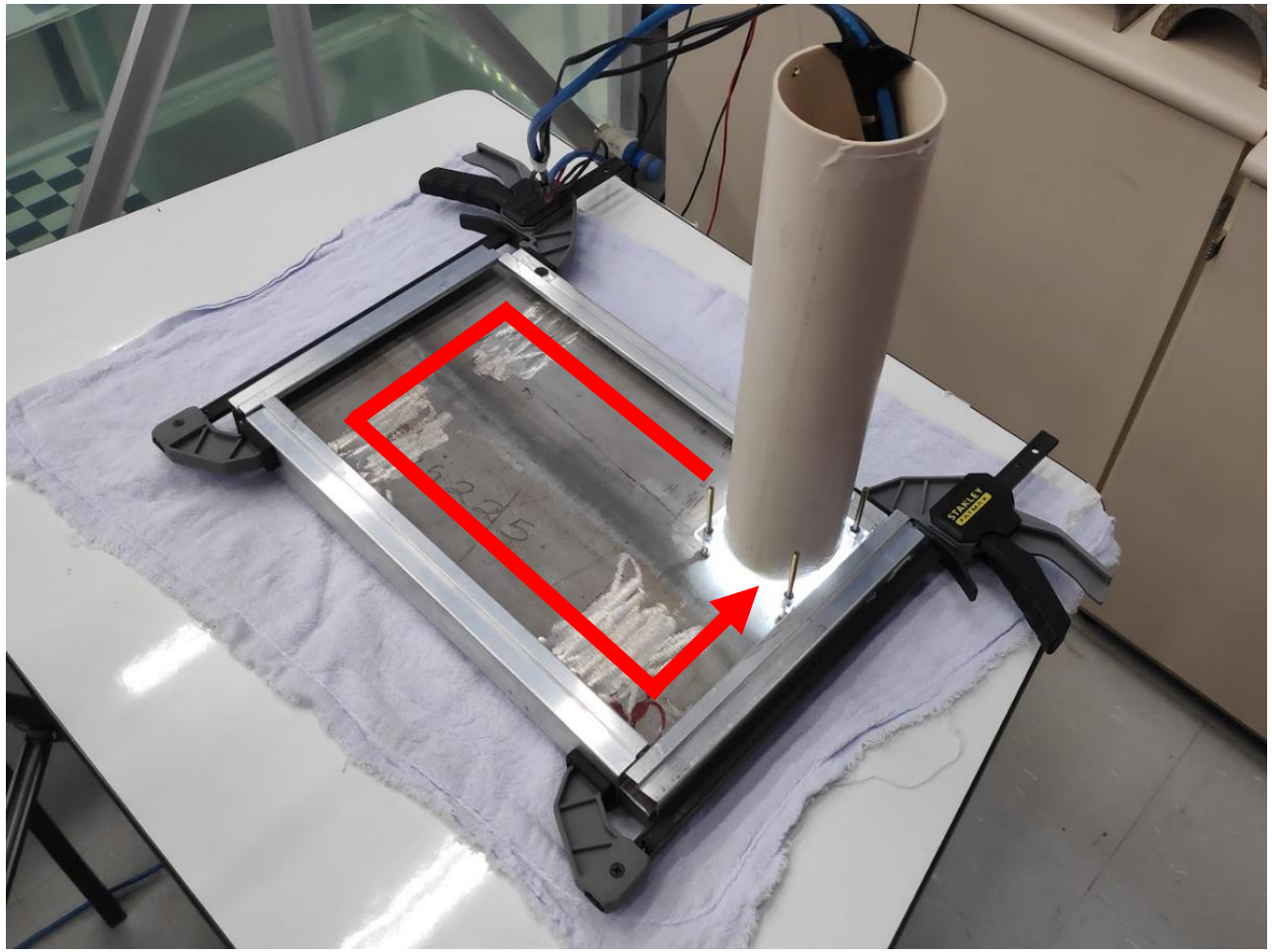
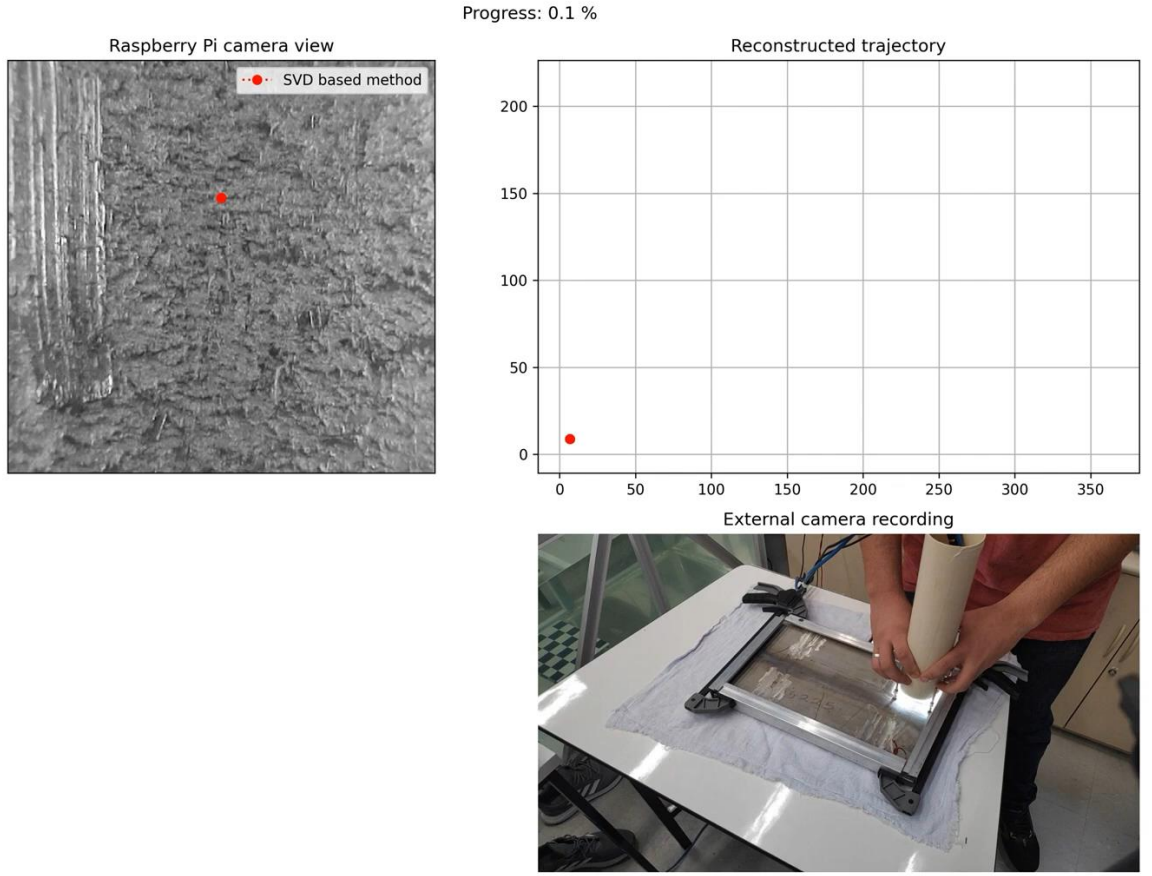


Video of the closed-loop path in a dry environment and planar surface (standalone)



YouTube video available at https://github.com/thiagokalid/Virtual-Encoder-ECNDT-2023

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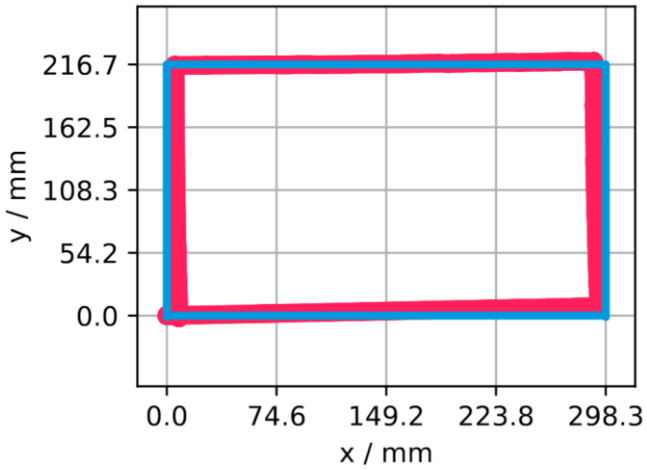

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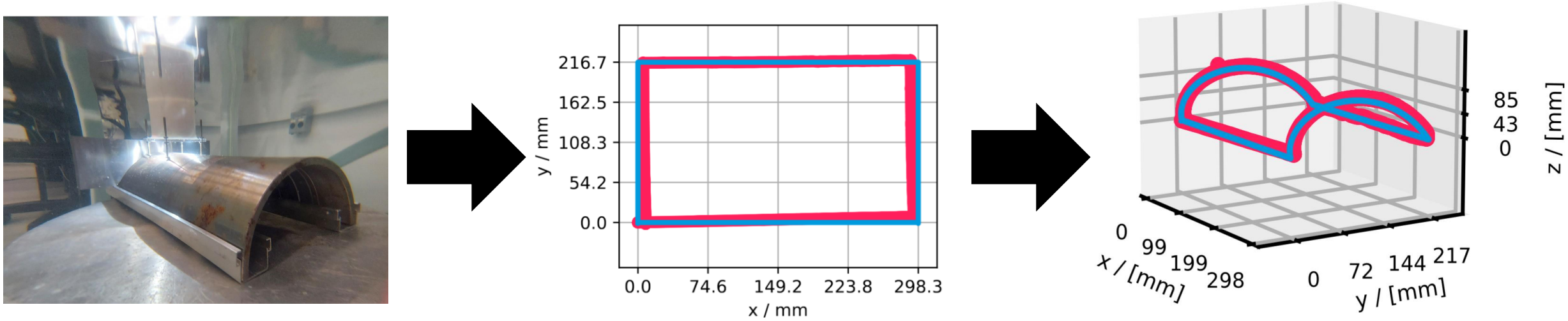
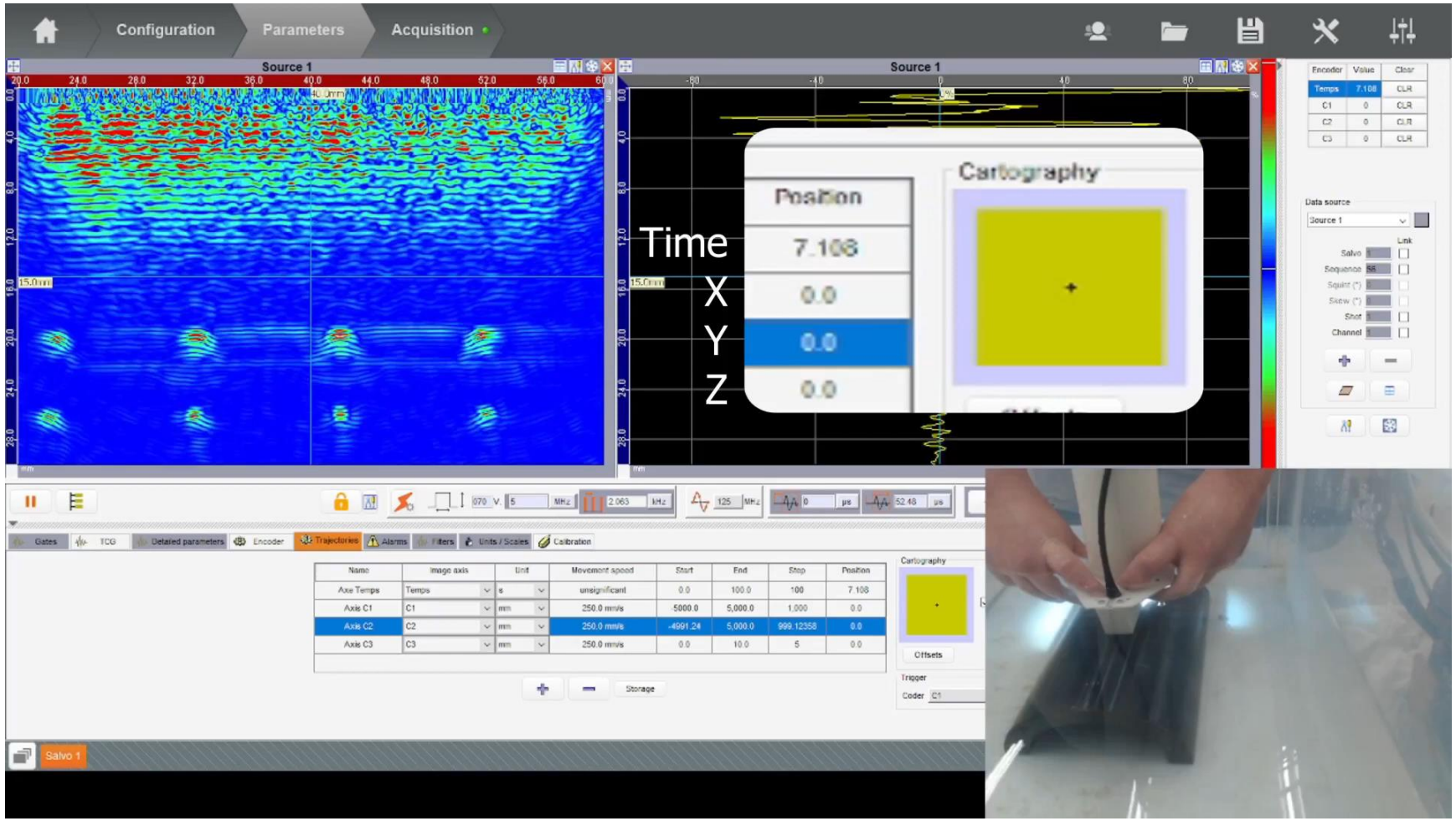


Integration with ultrasound acquisition system (M2M PANTHER by Eddyfi Technologies)



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Each experiment was done in a dry environment (contact) and underwater (immersion)

Table 1. Cumulative displacements, in millimeters, measured for the 2-D trajectories reconstructed from the data provided by the virtual encoder

Test type	Axis	Planar			Cylindrical		
		True	Contact	Immersion	True	Contact	Immersion
Single-x	x	358.0	358.9	357.8	298.3	299.4	293.0
	y	0.0	-4.7	-7.1	0.0	0.4	-8.4
Single-y	x	0.0	-2.6	-2.5	0.0	1.6	-0.3
	y	200.3	200.7	200.6	216.7	216.5	210.5
Closed loop	x	0.0	-3.4	-3.8	0.0	-1.6	8.2
	y	0.0	7.2	5.5	0.0	5.6	12.2

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- **Capable of computing 2-D displacement up to 20 FPS;**
- **Maximum error was 12.2 mm or 2.8 % of the traveled distance.**

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Thank you!

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All the source code and data is provided as additional material in
https://github.com/thiagokalid/Virtual-Encoder-ECNDT-2023.

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