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Co-Located Haptic Interaction for Virtual USG Exploration

E. Ruffaldi, F. Brizzi, **A. Filippeschi**, C.A. Avizzano

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Outline

- Introduction
- Objectives
- System description
- Calibration for co-location
- Interaction modalities
- Results and conclusions

Introduction

Ultrasonography (USG) is an important diagnostics procedure that allows identifying different types of pathologies or structural alterations.

Allowing doctors to perform **remote examinations** may help with the **shortage** of specialists that occurs in developed countries

Haptic and **visual** feedback are crucial for this kind of examination

Only a few systems allow for remote USG examination, we develop a new one within the EU **ReMeDi project**

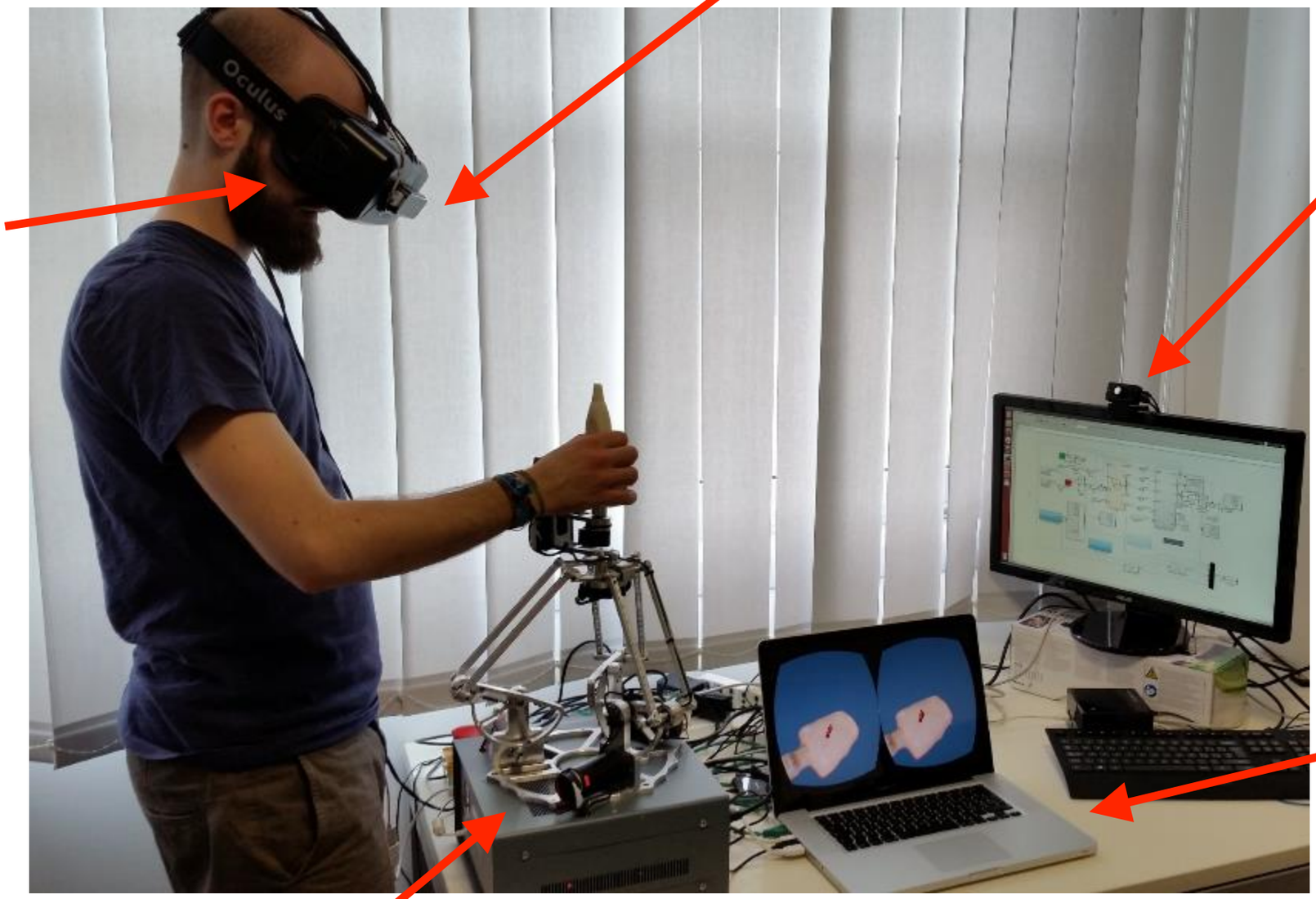
Objectives

- System suitable for virtual and remote USG examination:
  - Haptic feedback
  - 3D Augmented Reality Environment
  - Co-location of haptic and visual feedback
  - Easy navigation
  - Simple calibration procedure

System

Leap Motion

Oculus Rift

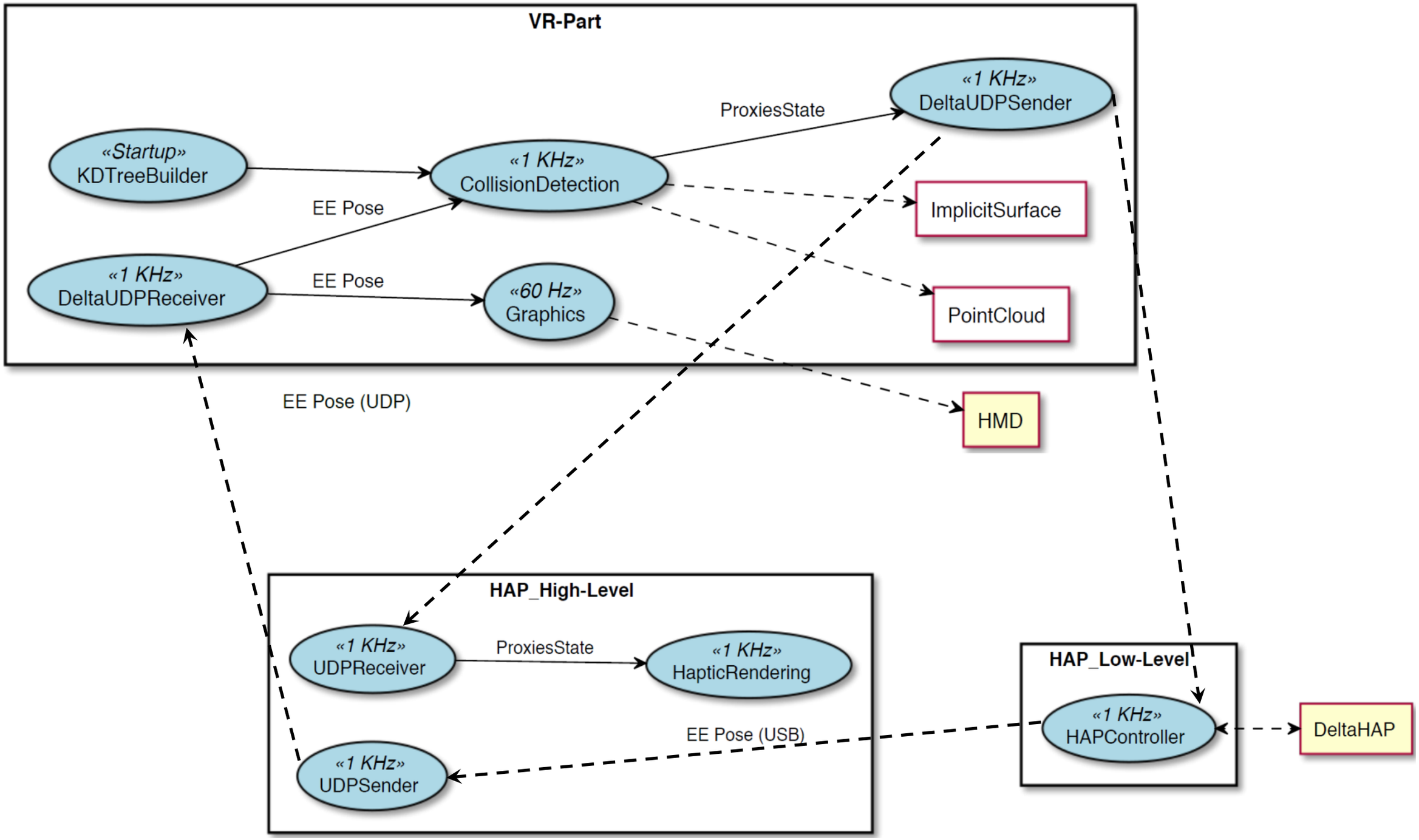


Tracking Camera

Host PC

Haptic Interface

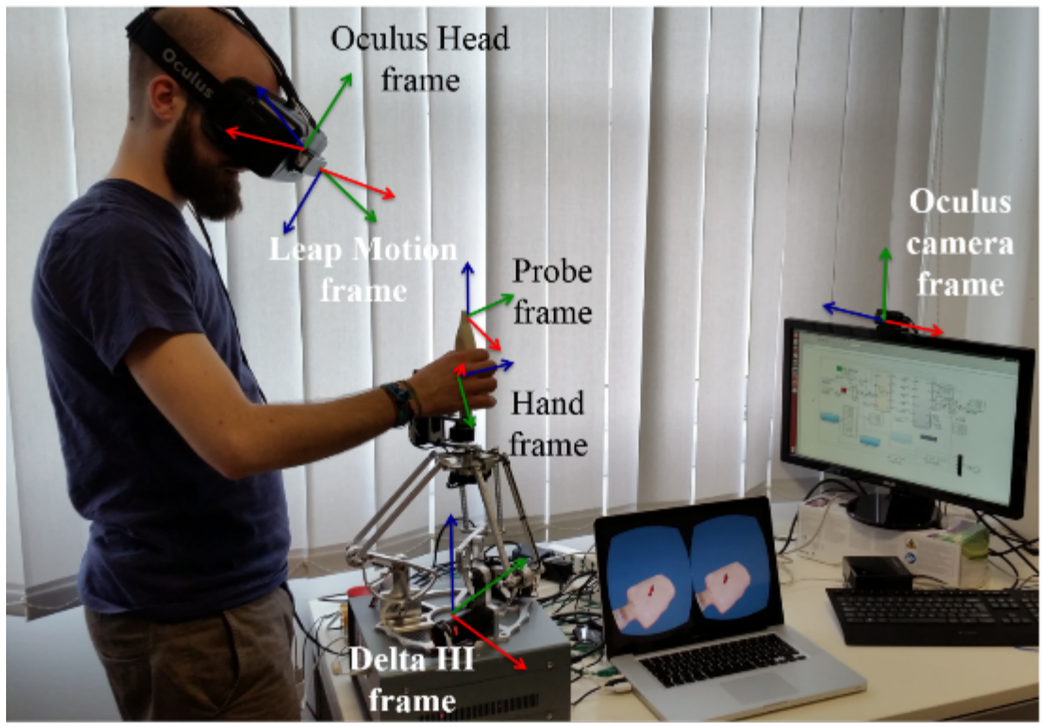
Software Architecture



Co-location

Rigid **transformations** between 7 reference systems are needed

- Haptic Interface base and USG end-effector
- Virtual geometry: comprising mannequin mesh and implicit surfaces
- HMD tracking camera origin and head pose
- Leap-Motion base (attached to the HMD) and hand pose.



Calibration of the HMD reference system with respect to the HI base

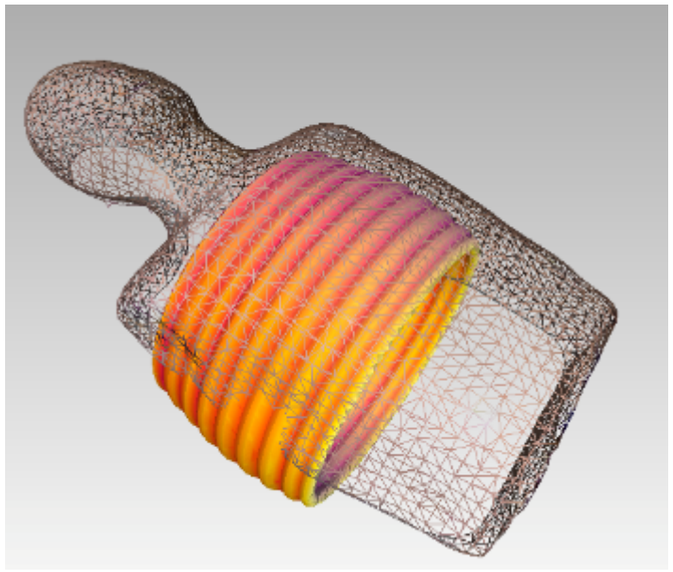
1.The USG probe is positioned in (0; 0; z0) and null rotation of the HI base frame.

2.The user's hand horizontally on top of the probe rotated so that it is aligned with the probe. In this way the transformation between the hand frame and the probe frame is fixed and known.

3.When the above steps are done a key is pressed on the keyboard and the system reads the poses of the hand and of the probe in their respective frames and computes the calibration matrix that allows to related the HI base frame with the HMD camera origin.

Interaction: haptic feedback

Outer layer: skin



Volume defined by a set of local potentials generated by the point-cloud surface point augmented by the normals.
At time step a KD-Tree is queried for the points and normals around the end-effector. These points are then combined to obtain an implicit surface.

Inner layer: ribs

The inner layer displays virtual ribs that have been modeled as implicit surfaces. These surfaces have been obtained by combining multiple tori functions by means of constructivesolid geometry semantics.

Implicit Surface Algorithm

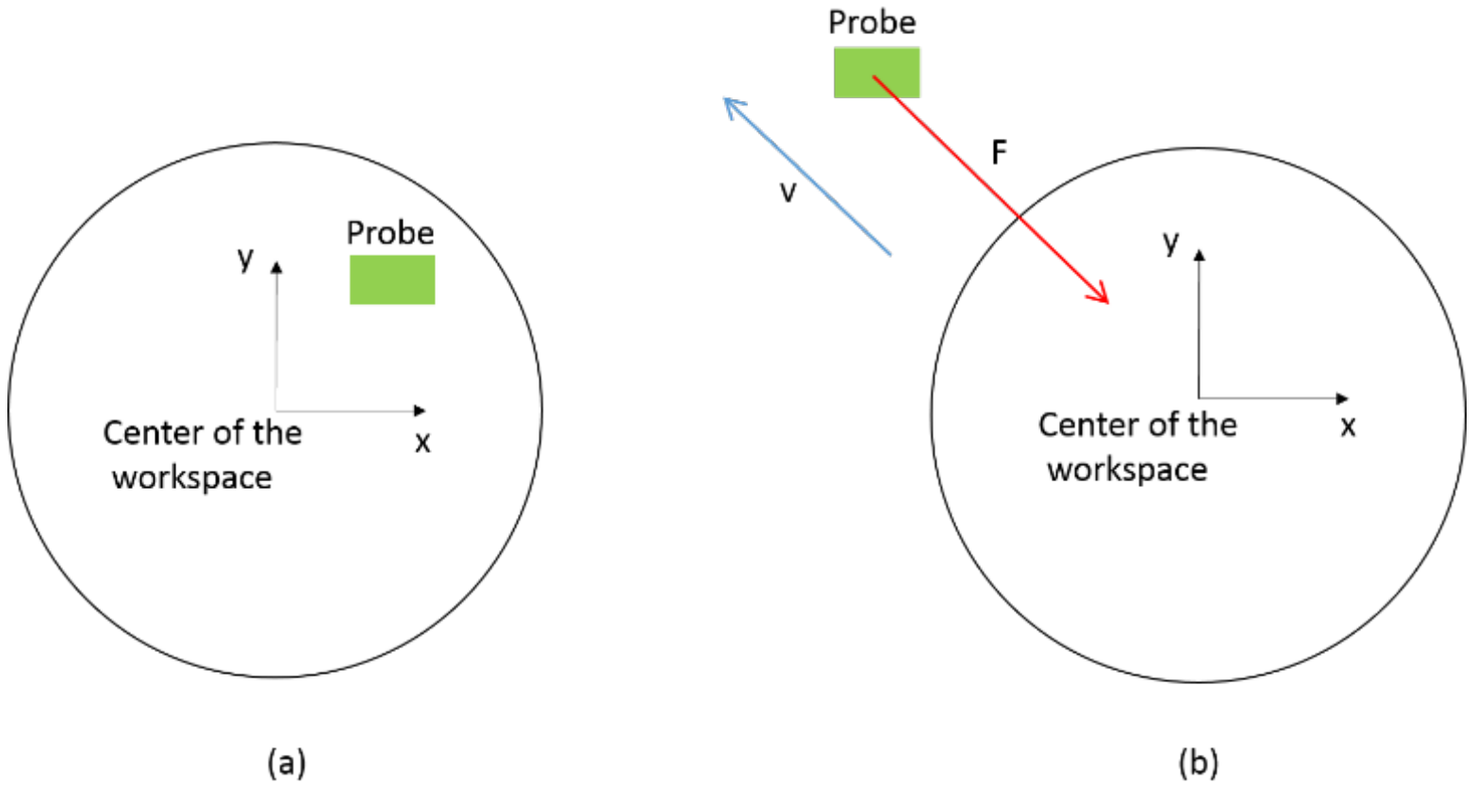
Sum of effects

Interaction: Indexing

The thorax and the abdomen of a person are **larger** than the workspace of the haptic device → **Indexing**

a) The probe is inside of the interaction window cylinder

b) The probe is outside of the interaction window cylinder: the image shifts and a recalling force is perceived



Results

PERCRO Perceptual Robotics Laboratory

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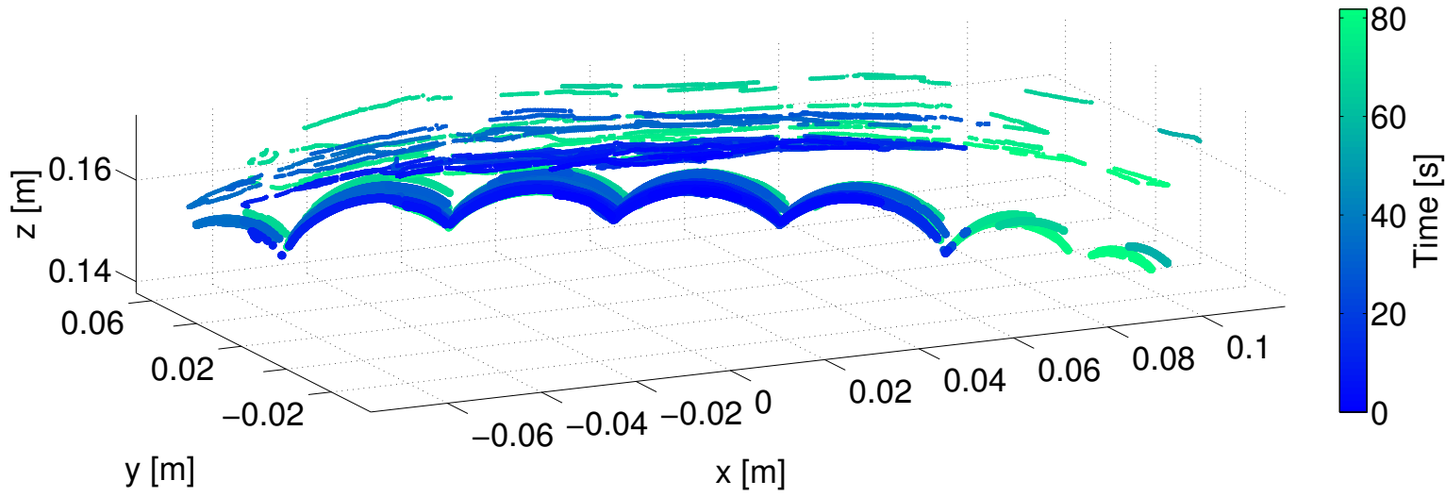
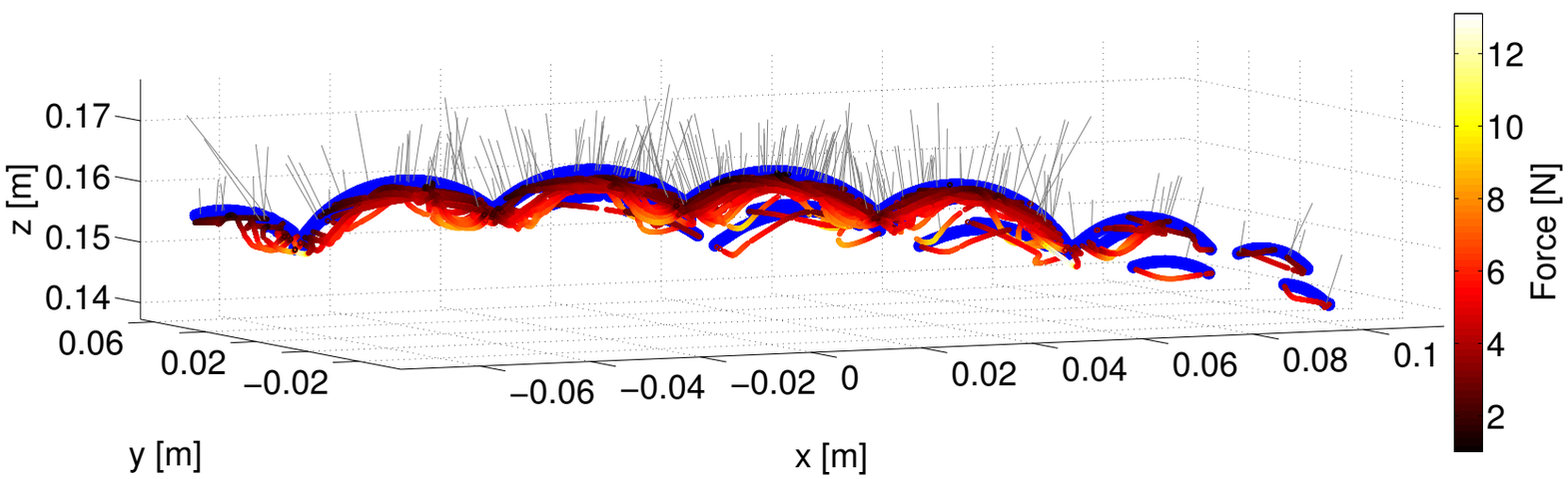
Results

Interaction over the two layers.
Proxies from the two layers are displayed with color corresponding to **time** in seconds.





Blue lines represent the position of the **proxy** on the ribs.
Red lines represent the **position** of the end-effector colored according to the **intensity of the force feedback**

Conclusion

A VR setup that has been designed for the virtual exploration and training in USG

- Suitable force rendering
- Suitable 3D AR Environment
- Easy navigation

Future steps

- Assessment of the effectiveness of the setup
- Improvements to support further layers with different stiffness values
- Generation a simulated USG image

thank you!

email: a.filippeschi@sssup.it