Encountered Haptic Augmented Reality Interface for Remote Examination

E. Ruffaldi, A. Filippeschi, F. Brizzi, J. M. Jacinto, C. A. Avizzano
{e.ruffaldi, fi.brizzi}@sssup.it

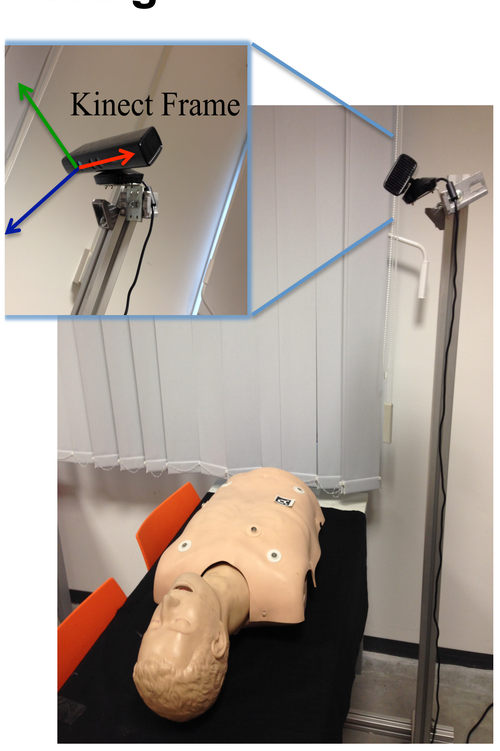
ISTITUTO DI TECNOLOGIE DELLA COMUNICAZIONE, DELL'INFORMAZIONE E DELLA PERCEZIONE
Scuola Superiore Sant'Anna

We present a 3D user interface for immersive remote tele-operated **palpation examination** and training. We combine 3D representation of the remote environment with encountered **haptic feedback** and **augmented reality** aiming at high transparency and naturalness of interaction.

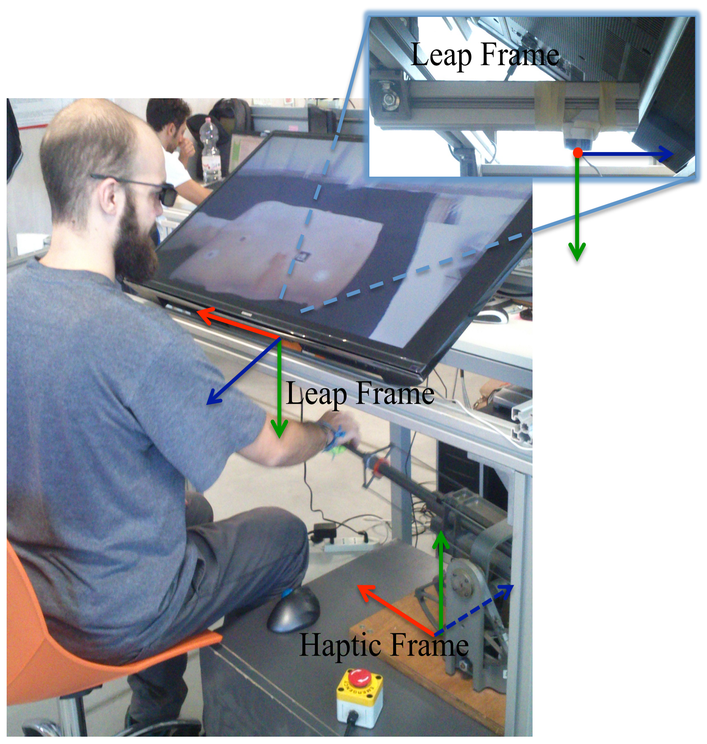
Context and Goal:

- The increasing number of examinations required in the developed countries is leading to a lack of specialized doctors in many hospitals.
- Research in tele-medicine has evolved from simple videoconferencing to tele-operation of robots [1].
- Virtual and Augmented Reality have been employed together with haptics for training purposes [2].
- This work contributes to the fields in the adoption of an encountered haptic approach for remote palpation combined with an Augmented Reality (AR) paradigm for visual feedback.

Design



Patient Site



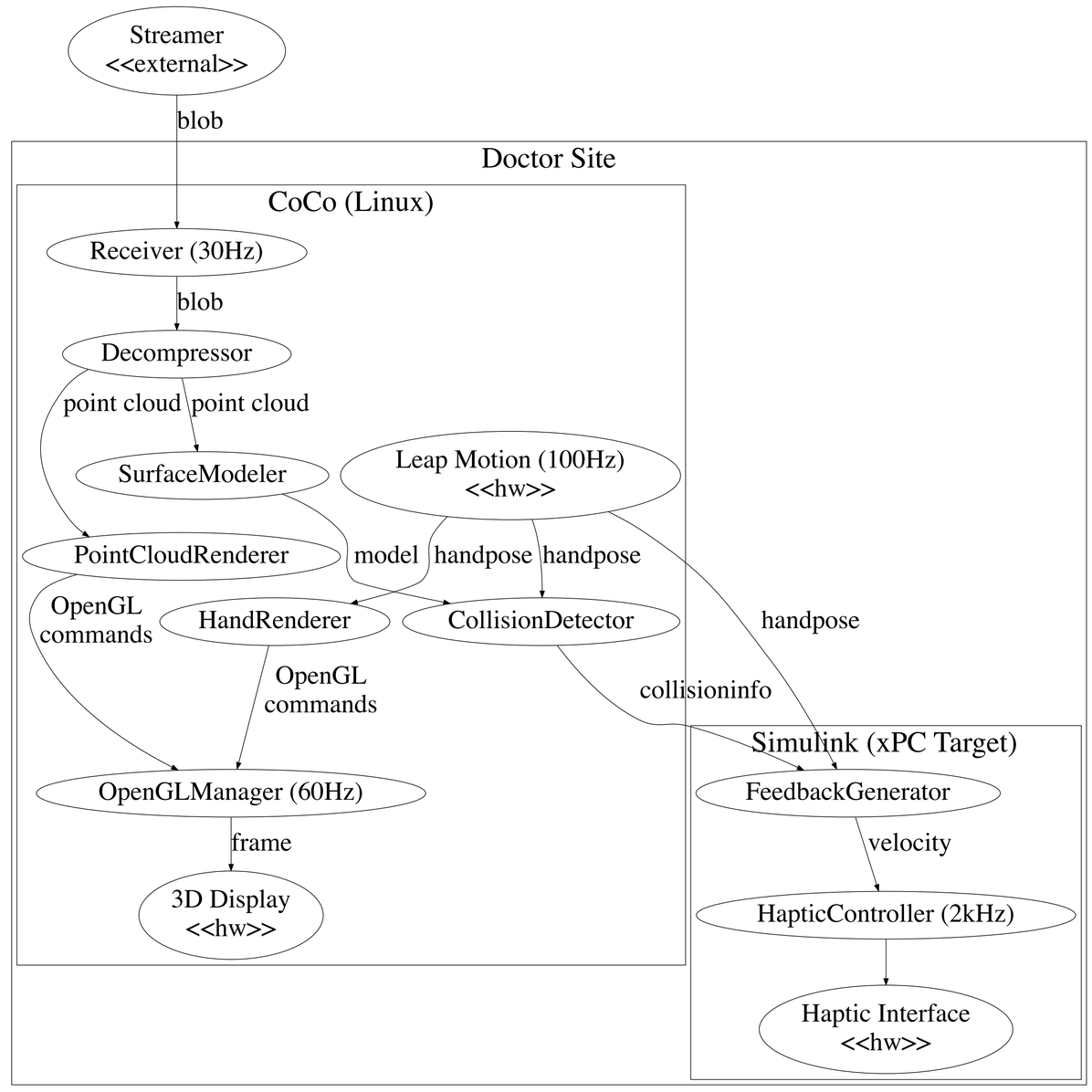
Doctor Site

- **Patient Site:** Kinect camera acquires the scene from above and the video is streamed over the network.
- **Doctor Site:** The doctor looks down to the patient through a large 3D screen and interacts with the patient scene with its hand which is tracked with a **Leap Motion** and mapped in the remote scene to provide **collision information** with the mannequin. These information are sent to the haptic interface (HI) (placed below the screen) for the **haptic feedback**. The visual feedback is augmented by a virtual hand showing the movement of the user in the remote scene.

Two states for the haptic device:

- **No contact:** the hand is not in contact with the remote surface and it's followed by the HI so that, as soon as the hand collides with the surface, it encounters the interface.
- **Contact:** the user receives a haptic feedback in the vertical direction, based on the indentation of the hand on the belly surface.

System Architecture with Data Flows



A new framework for high-performance AR/VR Compact Components (**CoCo**): core library + AR + application components.

Core:

- Synchronization and communication of multi-thread tasks plus execution profile.
- Creation of periodic or triggered tasks.
- Low overhead thanks to the features of the *C++11* standard.

Components:

- All of the components run in parallel.
- Connected in a graph structure allowing to pick the best buffering policy between the ports exposed by each one.

Calibration

Several **coordinate systems** are involved in the application as shown in figure on the left. A **calibration procedure** is executed to align all the frames.

- Leap Motion frame to Kinect frame (RGB marker)
- Haptic Interface frame to Leap Motion frame

Conclusion

We have presented an interaction paradigm that combines encountered haptics with AR display.

- We investigated the precision of the exploration for the identification of abnormal tissues in the virtual model.
- The virtual stiffness model combines a single surface stiffness value with the embedding of a virtual tumor at a given depth with the proposed task of identifying the location of the virtual tumor while exploring the remote body.

Acknowledgements

REMEDI project (grant 610902) of European Commission

[1] P. Arbeille et al. Use of a robotic arm to perform remote abdominal telesonography. *American Journal of Roentgenology*, 188(4):W317– W322, 2007
[2] T. R. Coles et al. Integrating haptics with augmented reality in a femoral palpation and needle insertion training simulation. *Haptics, IEEE Transactions on*, 4(3):199–209, 2011