PLUS: An open-source toolkit for developing ultrasound-guided intervention systems

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Introduction

Context

Ultrasound-guided intervention systems require integration of many hardware and software components: ultrasound scanner, position tracking device, data processing algorithms, visualization software, etc., typically each with proprietary interfaces.

Purpose

- Provide a **free** and sharable **software platform:** PLUS (Public software Library for UltraSound).
- Facilitate rapid prototyping of ultrasound-guided intervention systems for translational clinical research.

Method

Software platform

- Development started from the SynchroGrab toolkit [1], fully reworked: fixed, improved, extended.
- Built on the NA-MIC Kit (VTK, ITK, CMake, …), fully in C++.
- Build system: CMake. Extensive automatic testing: CTest/CDash
- OS-independent, but most devices require Windows.
- Supports building of standalone applications or can be connected to 3D Slicer (Fig. 1).
- Persistent storage in MetaIO image files (using custom frame fields to store tracking information for each image frame).
- All configuration settings are specified in a single XML file.

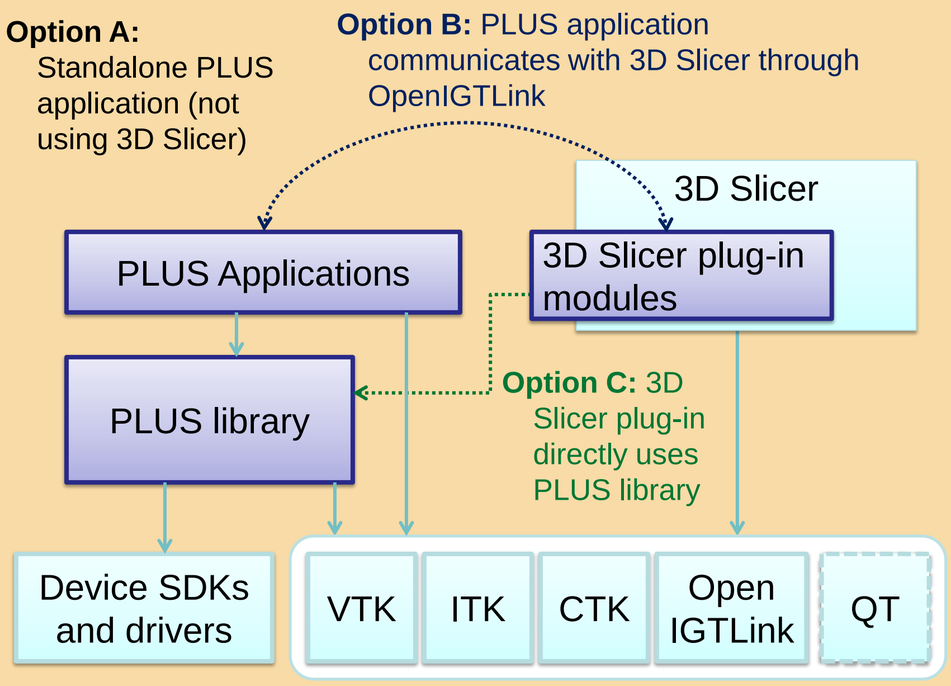

Figure 1: Relationship of PLUS library and application to 3D Slicer other software libraries

Supported devices

Tracking devices

- Optical trackers
  - NDI Certus
- Electro-magnetic trackers
  - Ascension 3DG (standalone or integrated into Ultrasonix SonixGPS system)
- Brachytherapy steppers
  - CIVCO EXII
  - CMS Accuseed DS
  - Burdette Medical Systems

Ultrasound imaging devices

- Ultrasonix: B-mode and RF image acquisition
- Other: B-mode image acquisition through ImagingControl USB framegrabber

Features

Calibration

- Spatial calibration: Compute the transform between the ultrasound image plane coordinate system (IMAGE) and the coordinate system of the marker that is attached to the transducer (PROBE) – Fig. 2. Fully automatic. Uses a double-N calibration phantom [2]. The calibration phantom can be reproduced by a 3D printer.
- Temporal calibration: Determines the time latency difference between the image and tracking data acquisition. Fully automatic, based on change detection. Accurate tracking data is computed for each image frame by interpolation.

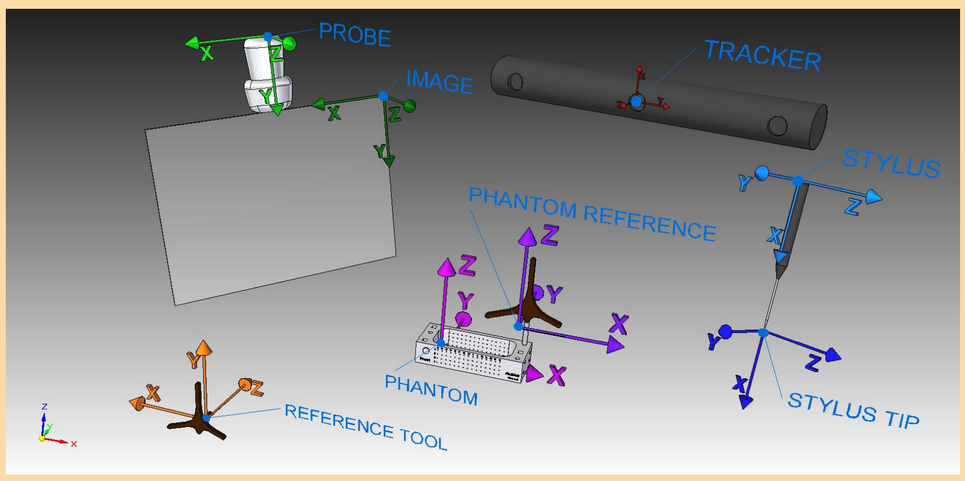

Figure 2: Coordinate systems used for the calibration

Example applications

- Tracked ultrasound capturing: Collects B-mode or RF ultrasound data and corresponding image plane position.
- Volume reconstruction: real-time, during image acquisition. Supports various interpolation and compounding methods.
- Real-time tracked ultrasound OpenIGTLink broadcasting allows application development in 3D Slicer. – Fig. 3.

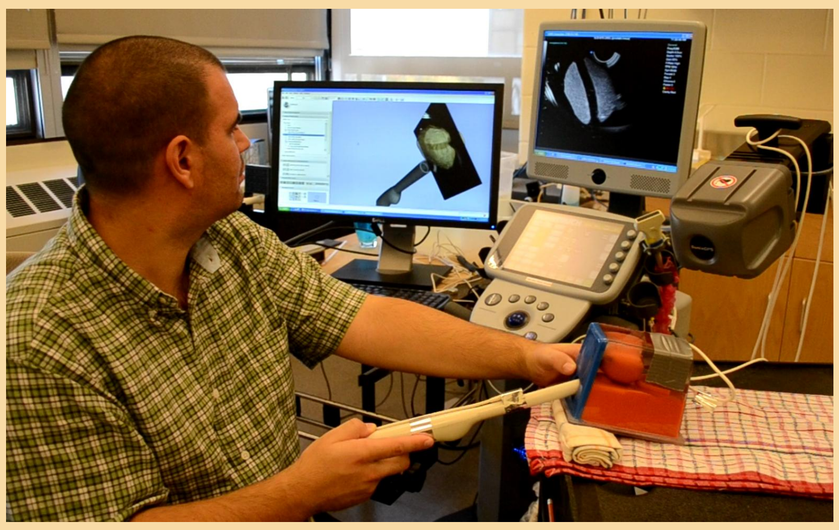

Figure 3: Tracked ultrasound for biopsy navigation with 3D Slicer

Conclusions

- The toolkit has a BSD-type license, which allows free usage and modification.
- Already being used/evaluated at Queen's University, University of British Columbia, and Robarts Research Institute.
- The toolkit will be publicly released in October 2011 at this website: **https://www.assembla.com/spaces/plus/**

References

[1] J. Boisvert, D. Gobbi, S. Vikal, R. N. Rohling, G. Fichtinger, P. Abolmaesumi (2008), "An Open-Source Solution for Interactive Acquisition, Processing and Transfer of Interventional Ultrasound Images" in The MIDAS Journal - Systems and Architectures for Computer Assisted Interventions (MICCAI 2008 Workshop), http://hdl.handle.net/10380/1459

[2] T. K. Chen, A. D. Thurston, R. E. Ellis & P. Abolmaesumi (2009), "A real-time freehand ultrasound calibration system with automatic accuracy feedback and control" in Ultrasound in medicine biology 35(1), pp. 79-93.

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