Tool Localization – Demonstration Application

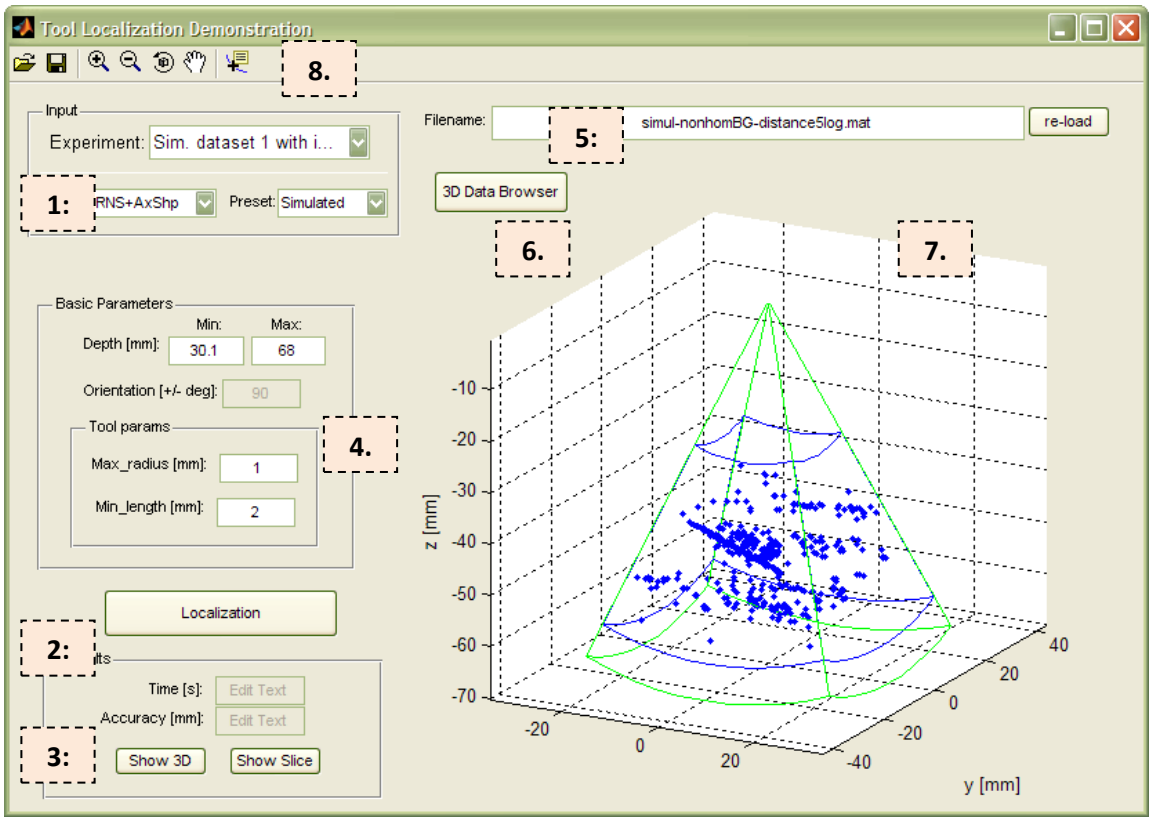
(December 2009, Created by Marian Uhercik, CREATIS in Lyon, CMP in Prague)

This is documentation for demonstration application for surgical tool localization in 3D Ultrasound (US) Images. It contains: (1) a description of application window and (2) a simple tutorial which shows how to use it.

The tool localization method is based on model fitting using RANSAC (RNS) and two models of tool in 3D US have been proposed (RNS+AxShp, RNS+IntDstr) in [1]; new model which used line filtering is described in [2]. The models IntDstr and LineFilter were learned on training data, while the model AxShp does not use any learning. Note that the method RNS+LineFilter is also reading line-filtered data from the file computed in pre-processing.

1. Application window

The screenshot of the main window:

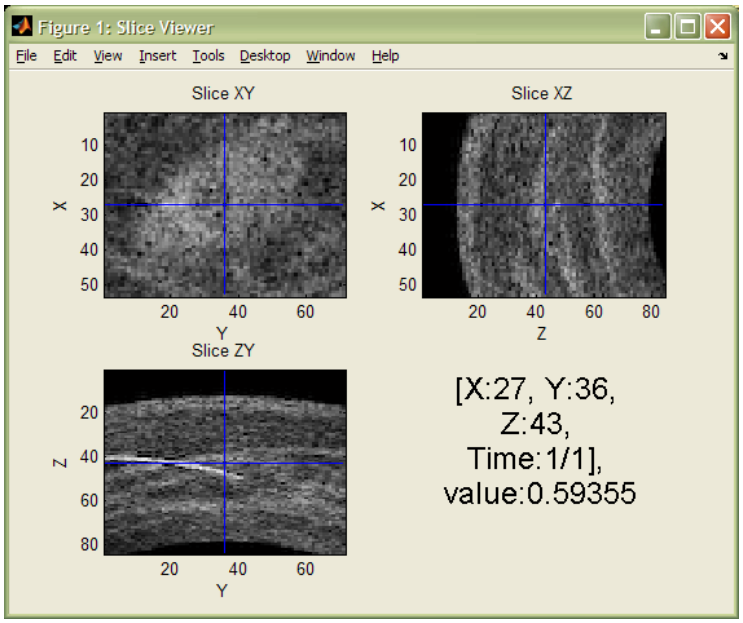


There are several controls:

1. **'Input' panel** – contains list of available experiments, methods and presets.

    - In ‘Experiment’ menu, you can choose pre-set experiment, which sets all other parameters, including filename, method, preset, depth range and tool parameters. When choosing any item, the data is loaded from the file and 3D view is shown.
    - ‘Method’ menu contains three available methods: RNS+AxShp, RNS+IntDstr, RNS+LineFilter. They were explained briefly explained above.
    - ‘Preset’ menu contains learned models for IntDstr and LineFilter model.
2. **‘Localization’ button** – starts localization algorithm with current parameters. The estimated tool axis is shown in the 3D view as a red line and the incident slice containing the tool is drawn in a new figure.
3. **‘Results’ panel** – contains elapsed time, and the axis accuracy compared to the ground truth.
    - Buttons ‘Show 3D’ and ‘Show Slice’ can refresh the result of localization.
4. **‘Basic Parameters’** panel
    - Depth [mm] – adjusts the region of interest (ROI) of input 3D data by setting the depth range: the minimum and the maximum depth in millimeters.
    - Tool parameters for axis estimation (should not be changed normally, it is recommended to use default values):
        - Maximal radius of the axis – it is an upper boundary, and should be close to the appearance radius of the tool.
        - Minimal length of the axis – the axis smaller than this length is rejected.
5. **Filename with ‘re-load’** button – shows the current filename with 3D US data. You can click on ‘re-load’ button to refresh the dataset and reset the parameters from file.
6. **‘3D Data Browser’ button** – this opens a tool which can be use to “browse” 3D data (SliceBrowser). You will see three perpendicular planes with a pointer, you can adjust the pointer interactively (a screenshot is shown below). Note that this tool just shows 3D matrix without conversion of data to proper Cartesian geometry.
7. **3D view of data** – contains a 3D view of thresholded data with the volume boundary shown as green wireframe. The blue wireframe shows the current ROI with voxels of intensity higher than specified threshold shown as blue points. Note that when localization algorithm is finished, this view changes to ROI only and the tool axis is shown as red line.
8. **Toolbar** – this contains tools for file storage and the 3D view interactions.
    - Load/Save button – save dataset together with chosen parameters.
    - Zoom In/Out, Rotate 3D view, Pan view, 3D data cursor.

A screenshot of 3D SliceBrowser:

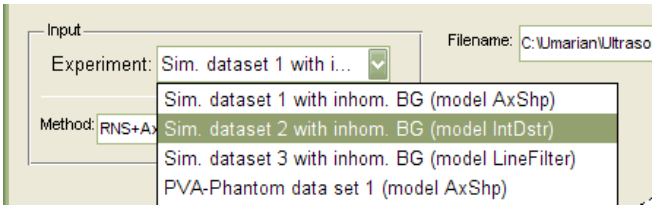


2. Tutorial for using demonstration application

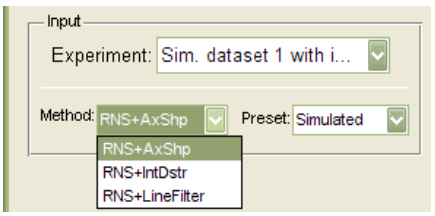
This is an example of simple procedure for demonstration of tool localization in 3D US:

1. Select an experiment from menu in the 'Input' panel. You have many types of experiments:
    a. Simulated data (4 experiments with different position of the tool).
    b. Tissue mimicking phantom data of PVA Cryogel with tungsten electrode.
    c. Breast biopsy data with a thick needle from GE (3 datasets).
    d. Breast biopsy data with a thin needle from GE. One dataset with two optional ROIs:
        i. Small ROI which can be tested with RNS+AxShp/IntDstr.
        ii. Large ROI which works only with RNS+LineFilter.
2. (Optional) Choose localization method (RNS+AxShp/IntDstr/LineFilter).
3. (Optional) Adjust parameters, e.g. depth range and tool parameters.
4. Push 'Localization' button and wait a second.
5. See the result in the 3D view and the slice incident with the tool is shown.

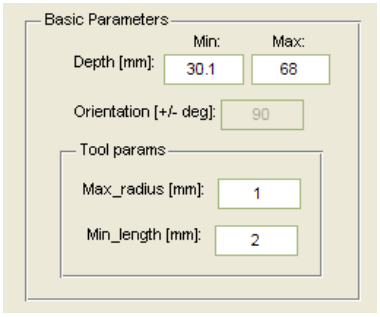
Step 1:



Step 2:



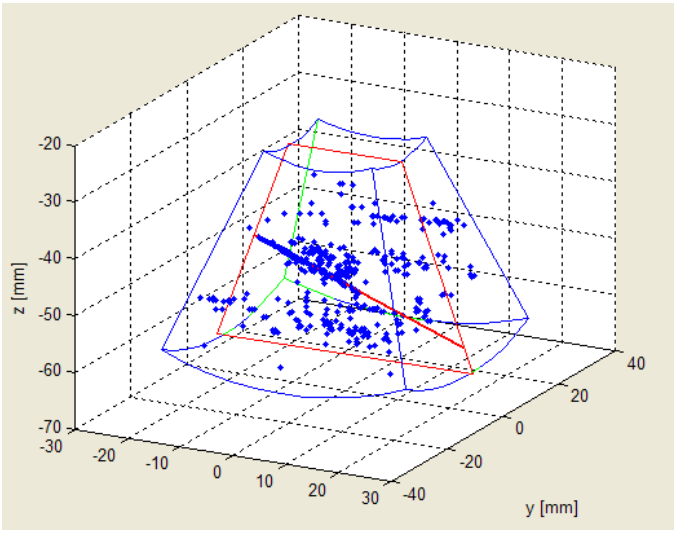
(optional)

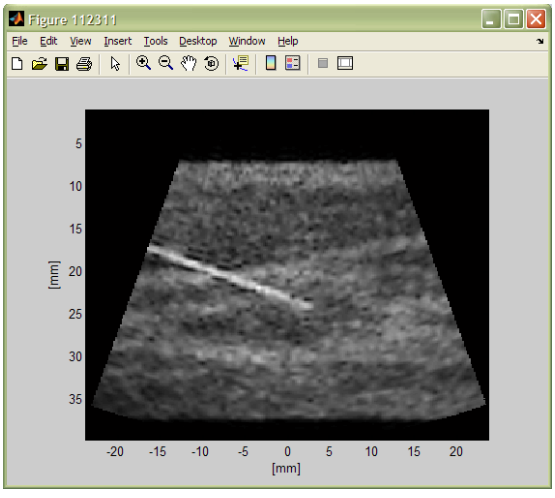
Step 3: 

(optional)

Step 4: 

Step 5:

The result is shown in 3D view: 

And also in separate figure: 

References:

[1] Marián Uherčík, Jan Kybic, Hervé Liebgott, Christian Cachard: Model Fitting using RANSAC for Surgical Tool Localization in 3D Ultrasound Images, Submitted to IEEE Transactions on Biomedical

Engineering (BME) [Available online as technical report: ftp://cmp.felk.cvut.cz/pub/cmp/articles/uhercik/Uhercik-TR-2009-11.pdf]

[2] Marián Uherčík, Jan Kybic, Christian Cachard, Hervé Liebgott: Line filtering for detection of microtools in 3D ultrasound data, 2009 IEEE International Ultrasonics Symposium (IUS), In print, September 2009 in Roma [Available online: http://cmp.felk.cvut.cz/~uhercik/Uhercik2009IUS.pdf]