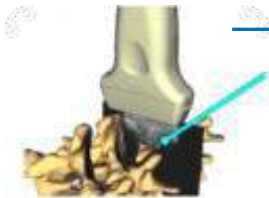


# Landmark registration

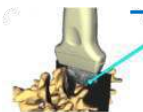
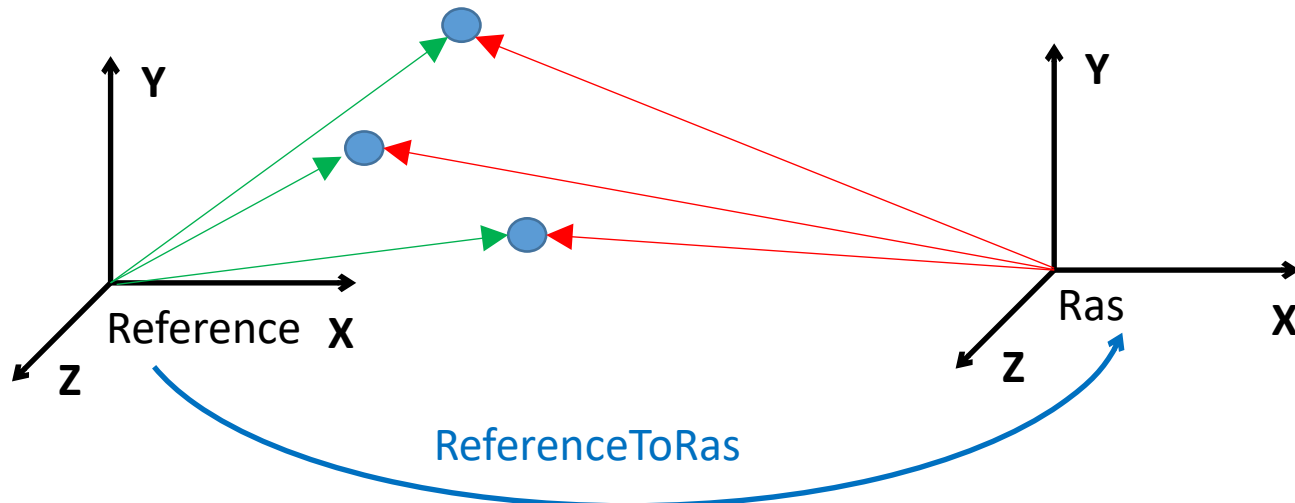


---

*SlicerIGT Tutorial Series*

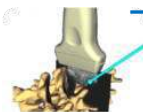
# Landmark registration

- Computes transformation between point pairs
- Points = landmarks = fiducials
- Computation is fast, non-iterative, optimal result
- Sensitive to outliers!
- **vtkLandmarkTransform** based on [Horn 1987]

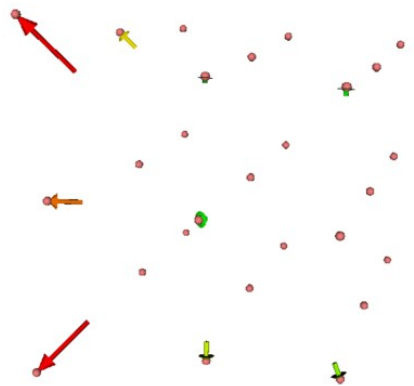


# Result transform type

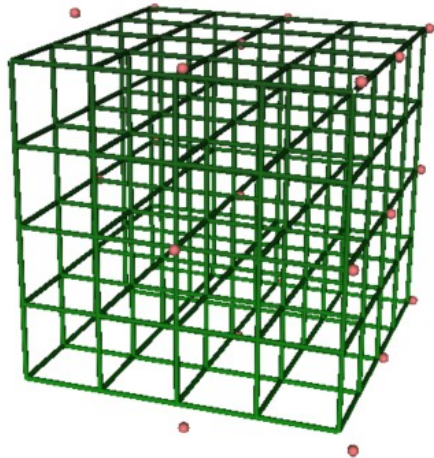
- Rigid
  - Translation + Rotation
  - Commonly used, because objects don't change size
- Similarity
  - Translation + Rotation + Scaling
  - Used when changing units, e.g. pixels to millimeters
- Warping
  - Splines, etc.
  - Used to model soft tissue deformations



Fiducial displacement:

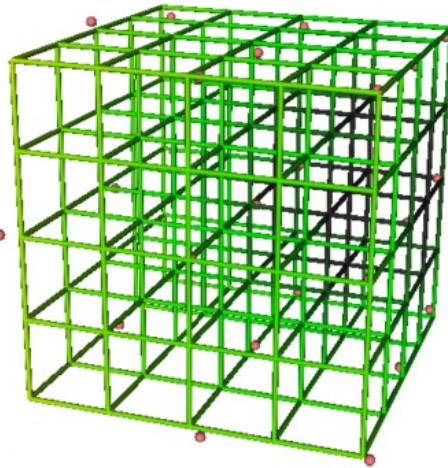


Rigid



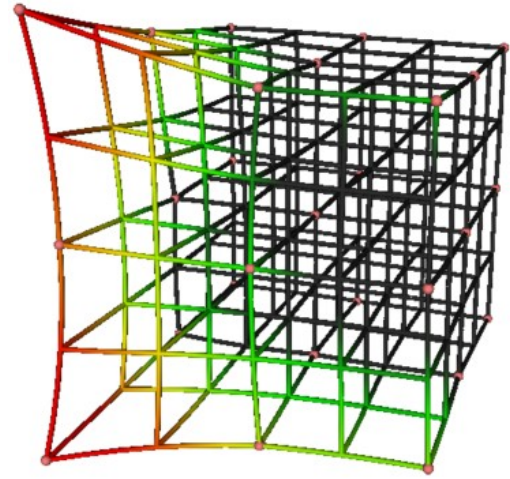
RMSE = 4.8

Similarity



RMSE = 4.2

Warping



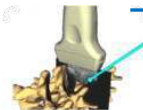
RMSE = 0.0



# Load example data

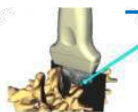
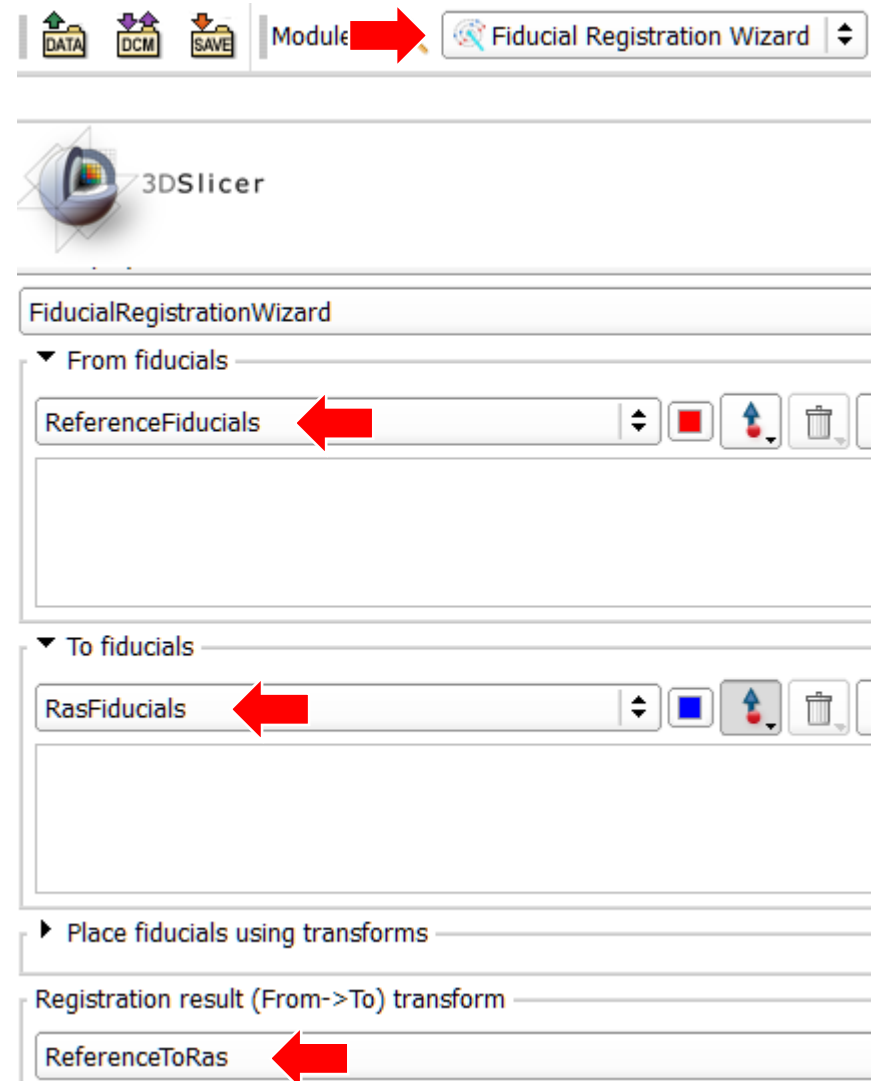
- Load scene:  
**SlicerIGT-Data/Skull\_GroundTruthLandmarks.mrb**
- Load additional transform:  
**SlicerIGT-Data/Skull\_StylusTipToStylus.h5**
- Create needle model
- Set up stylus transform hierarchy in **Data** module:

```
Image_Reference
├─ StylusToReference
│   └─ Skull_StylusTipToStylus
│       └─ NeedleModel
└─ SequenceBrowser
```



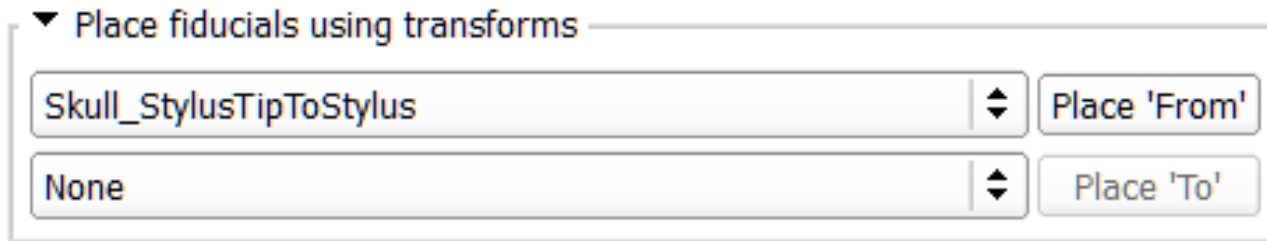
# Create input and output nodes

- Select **IGT / Fiducial Registration Wizard** module
- Create *From* fiducials and name the list "**ReferenceFiducials**"
- Create *To* fiducials and name the list "**RasFiducials**"
- Create *result transform* as "**ReferenceToRas**"

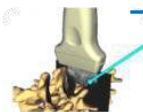


# Set up stylus as input

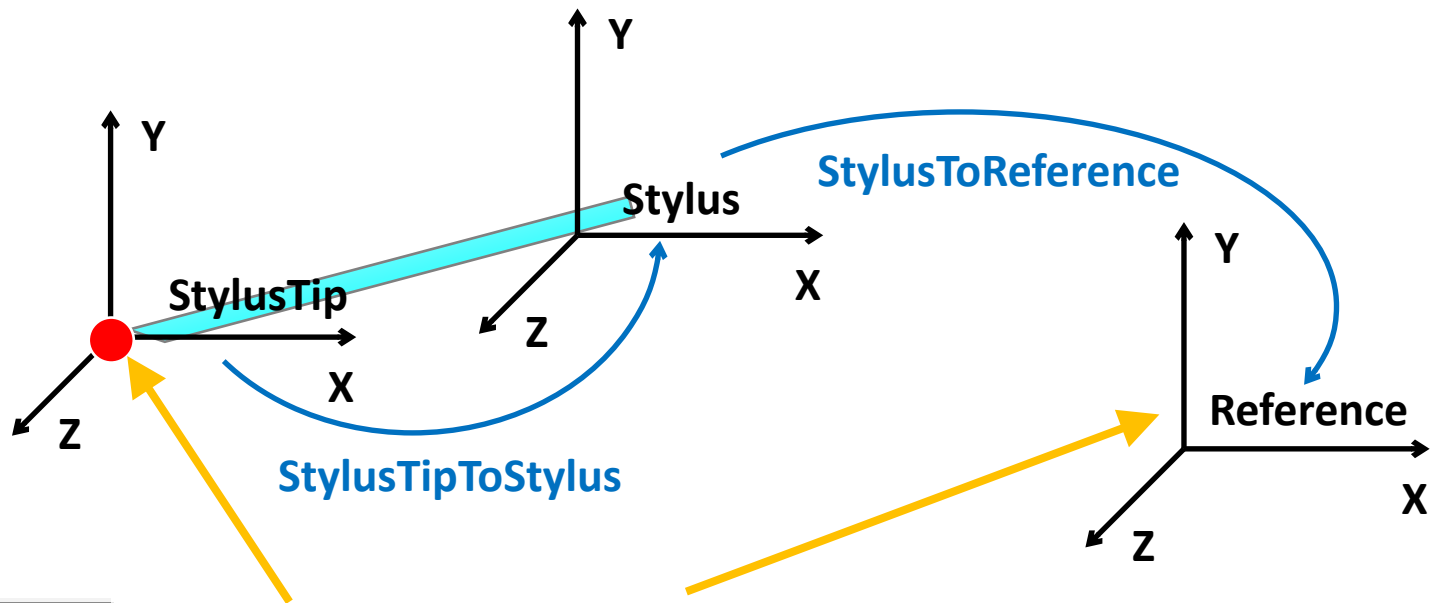
- Expand **Place fiducials using transforms** group
- Select **Skull\_StylusTipToStylus** to place *From* fiducials



- When pressing **Place 'From'** or **Place 'To'** buttons, fiducials are created at the *origin* (0,0,0) of the *From* (first) coordinate system of the selected transform, transformed by the transform hierarchy.
- See explanation on next slide



# How *Place fiducials...* work

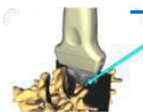


Place 'From' adds **this** point in **this** coordinate system to **this** list


because of this selection and this transform hierarchy

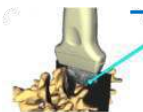
Skull\_StylusTipToStylus

```
Image_Reference  
[-] StylusToReference  
[-] Skull_StylusTipToStylus  
    NeedleModel  
    SequenceBrowser
```



# Populate the '*From*' and '*To*' lists

- Select **SequenceBrowser** node in the Sequence toolbar
- Drag the **time** slider to points where you see the stylus placed in skull landmarks in the video
- Rotate the 3D view so you see the same landmark point in the surface model
- Press the **Place 'From'** button to add a *From* fiducial
- Press the fiducial selector  button in the To list and click on surface model to place a *To* fiducial
- See next slide for illustration



# Adding first point pair

1.

2.

3.

4.

3DSlicer

Help & Acknowledgement

Display

FiducialRegistrationWizard

From fiducials

ReferenceFiducials

	Label	X	Y	Z
1	ReferenceFidu...	233.515	-32.536	-101.495

To fiducials

RasFiducials

	Label	X	Y	Z
1	RasFiducials-1	-78.455	121.076	102.100

Place fiducials using transforms

Skull\_StylusTipToStylus

Place 'From'

None

Place 'To'

time 2.054 s SequenceBrowser

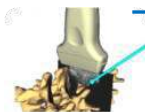
S: 0.000mm

B: Image\_Reference

R: 0.000mm

G: 0.000mm

RasFiduc...



# Adding second point pair

10.0fps 10.0fps 6.953 s SequenceBrowser

3DSlicer

Help & Acknowledgement

Display

FiducialRegistrationWizard

From fiducials

ReferenceFiducials

	Label	X	Y	Z
1	ReferenceFidu...	233.515	-32.536	-101.495
2	ReferenceFidu...	232.727	-35.717	-66.799

To fiducials

RasFiducials

	Label	X	Y	Z
1	RasFiducials-1	-78.455	121.070	102.100
2	RasFiducials-2	-84.098	145.771	78.746

Place fiducials using transforms

Skull\_StylusTipToStylus Place 'From'

None Place 'To'

B: Image\_Reference

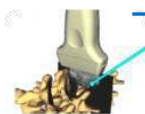
S: 0.000mm

R: 0.000mm

G

Fiducials-2

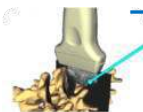
RasFiducials-2



# And so on for many point pairs...

... but how many?

- At least 3 point pairs are needed for registration
- More point will probably increase accuracy AND slightly increase the RMSE (root mean square error)
- Accuracy will increase because random errors cancel each other out
- RMSE will increase because of less overfitting
- RMSE is an unknown mix of precision and accuracy!



# When all point pairs are added

- It is a good idea to switch to **Manual update** from **Auto-update** to prevent errors when accidentally moving fiducials later in the scene
- Save the **ReferenceToRas** transform, or save the entire scene, in case you want to check the result later

Registration result (From->To) transform

ReferenceToRas

Result transform type:  Rigid  Similarity  Warping

Update

Status: Success! RMS Error: 0.98907

Auto-update

• Manual Update

▶ Preview transform

