Large Deformation Atlas Registration

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May 16, 2012

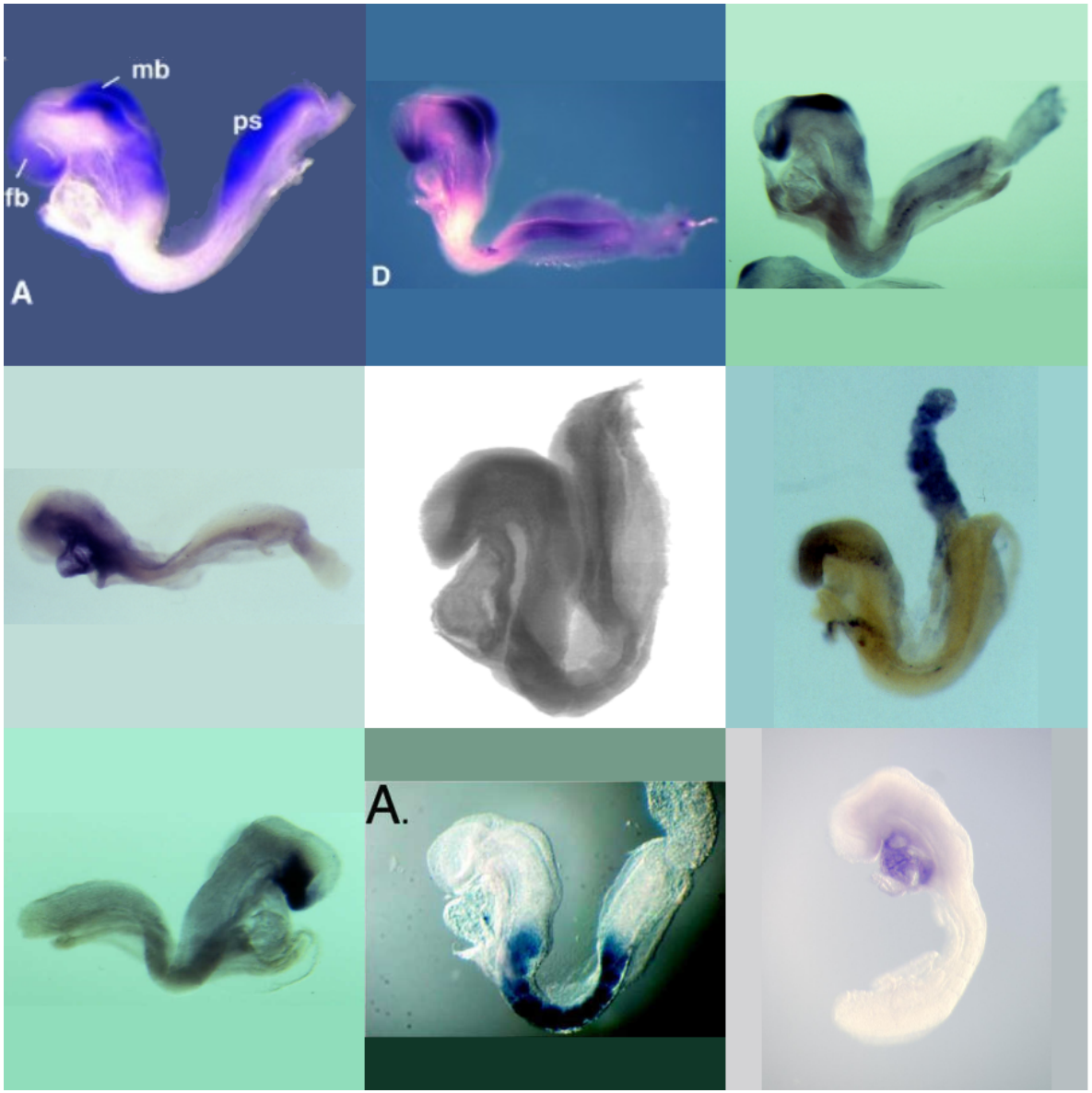
Introduction 1/3

Spatial atlases

$$atlas \leftarrow \{model\}_M + \{assay\}_A \, , A \gg M$$

Large deformations are a severe challenge

Introduction 2/3: Selection from an Assay



Introduction 3/3: Possible Approaches

Fluid models

Articulated models

Radial Basis Functions

Constrained Distance Transforms

Constrained Distance Transforms (*CDT*)

- RBFs.
- Distance Transforms
- Conforming Meshes
- Object resampling
- ANSI C implementation within Woolz

$$O_s(\mathbf{x})$$

$$O_t(\mathbf{u})$$

$$\Delta\mathbf{u} = \mathbf{u} - \mathbf{x}$$

$$\Delta\mathbf{u} = \mathbf{P}(\mathbf{x}) + \sum_{i=1}^{i=N} b(r_i)\lambda_{\mathbf{i}}$$

$$b_{IMQ}(r) = \frac{1}{\sqrt{r^2 + \delta^2}}$$

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$$
\begin{aligned}
O_s(\mathbf{x}) & \\
O_t(\mathbf{u}) & \\
\Delta\mathbf{u} &= \mathbf{u} - \mathbf{x} \\
\Delta\mathbf{u} &= \mathbf{P}(\mathbf{x}) + \sum_{i=1}^{i=N} b(r_i)\lambda_{\mathbf{i}} \\
b_{IMQ}(r) &= \frac{1}{\sqrt{r^2 + \delta^2}}
\end{aligned}
$$

RBFs are typically expensive to compute and invert

Conforming mesh framework

Constrained Distance Transforms (*CDT*)

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Geodesic Distance Transforms

Fast Marching algorithm

Conforming mesh framework

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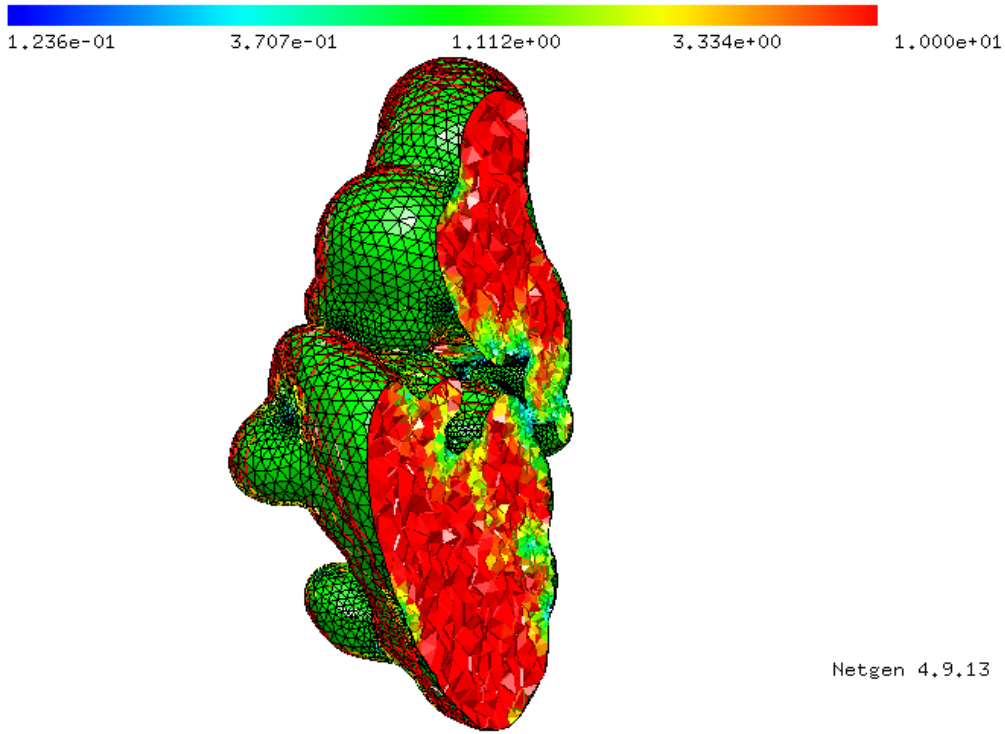

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Computing conforming meshes - a complex problem

Simple implementation in Woolz

External mesh generators (eg Netgen)

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Conforming mesh framework

Constrained Distance Transforms (*CDT*)

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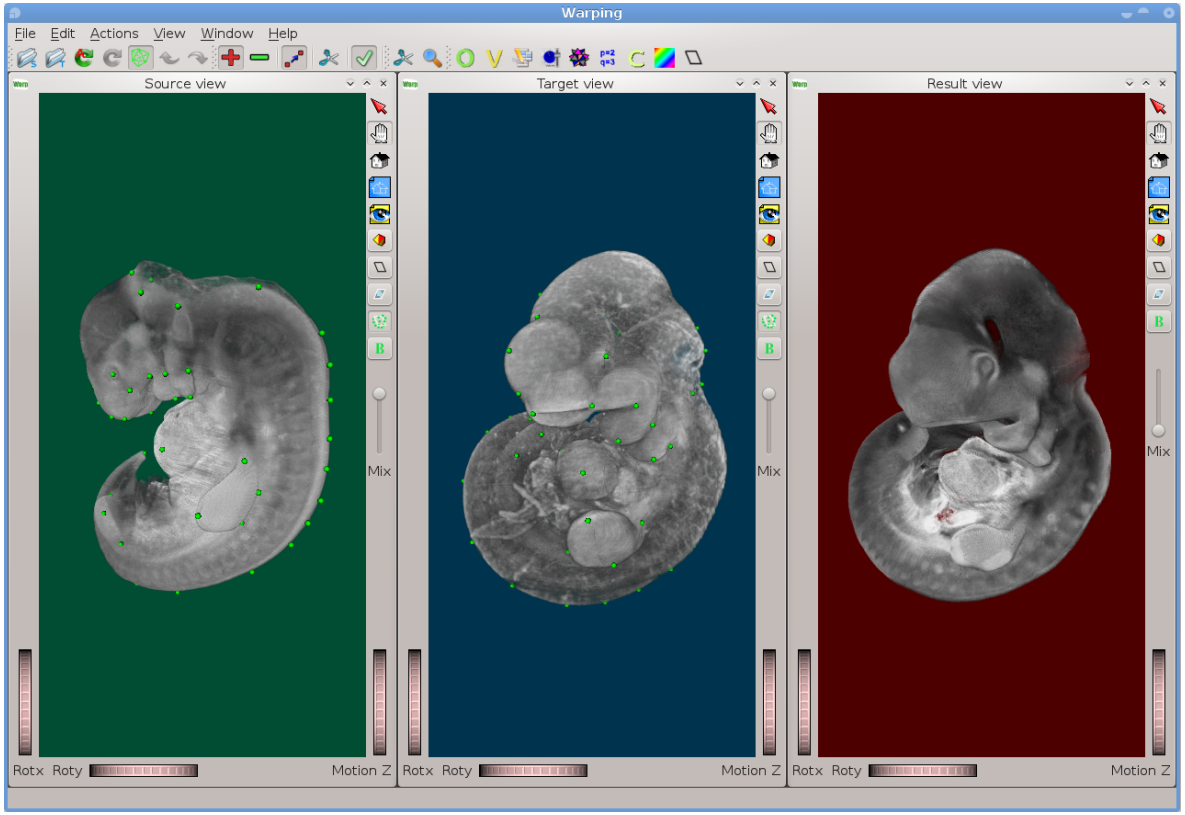
```
  struct _WlzTextProperty       *text;
} WlzProperty;

/************************************************************************
* The Woolz objects.
************************************************************************/
/*!
* \struct       _WlzCoreObject
* \ingroup      WlzType
* \brief        The core Woolz object type which can be used to determine
*               the type of a Woolz object.
*               Typedef: ::WlzCoreObject.
*/
typedef struct _WlzCoreObject
{
  WlzObjectType type;                   /*!< The Woolz object type. */
  int           linkcount;              /*!< The link count: A counter
                                             for the number of references to
                                             the object, which should only be
                                             accessed through WlzUnlink(),
                                             WlzAssignObject() and
                                             WlzFreeObj(). */
} WlzCoreObject;

/*!
* \struct       WlzObject
* \ingroup      WlzType
* \brief        The Woolz object.
*               Typedef: ::WlzObject.
*/
typedef struct _WlzObject
{
  WlzObjectType      type;              /*!< From WlzCoreObject. */
  int                linkcount;         /*!< From WlzCoreObject. */
  WlzDomain          domain;            /*!< The objects domain: It's
                                             spatial extent or
                                             geometric properties. */
  WlzValues          values;            /*! The values defined within
                                             the object's domain. */
  WlzPropertyList    *plist;            /*! A list of the object's
                                             properties. */
  struct _WlzObject  *assoc;            /*! An object which is
                                             assosciated with this object. */
} WlzObject;

/*!
```

https://github.com/ma-tech/Woolz

A GUI for Interactive CDT: WlzWarp

Qt, Coin, Simvoleon & Woolz



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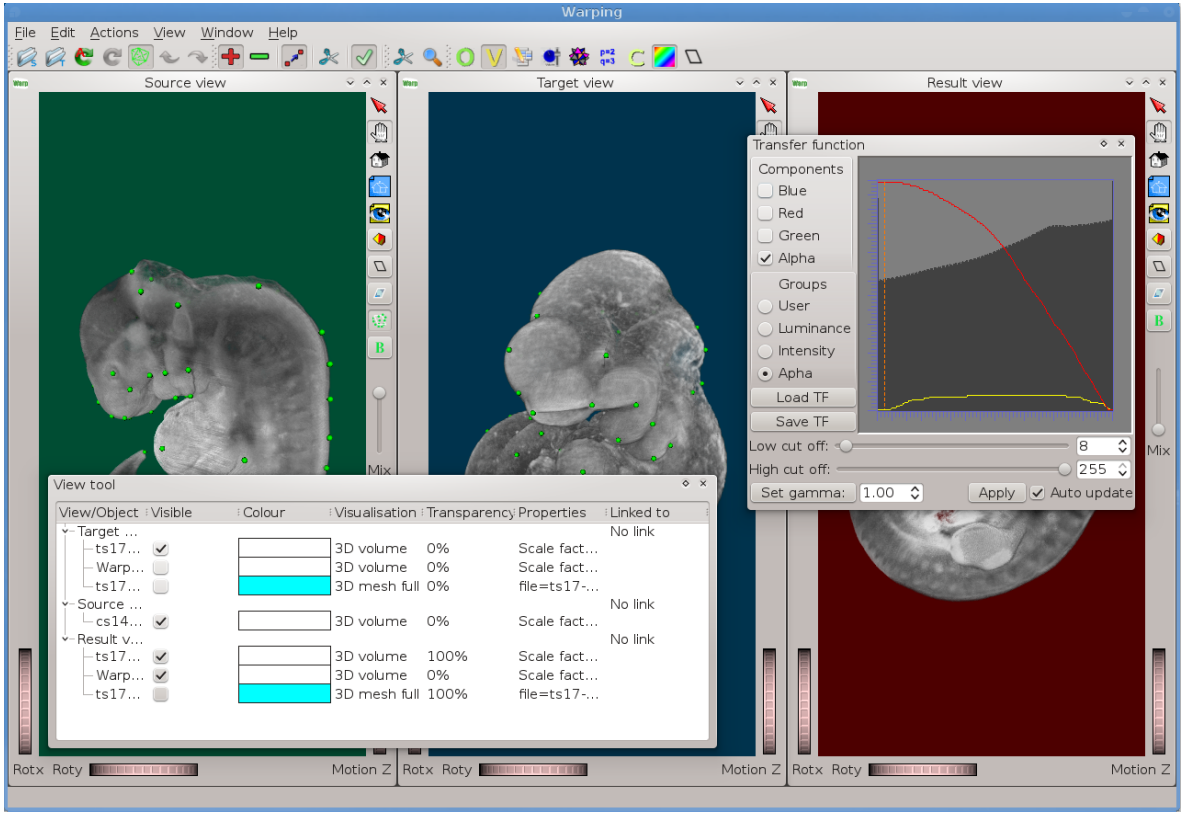

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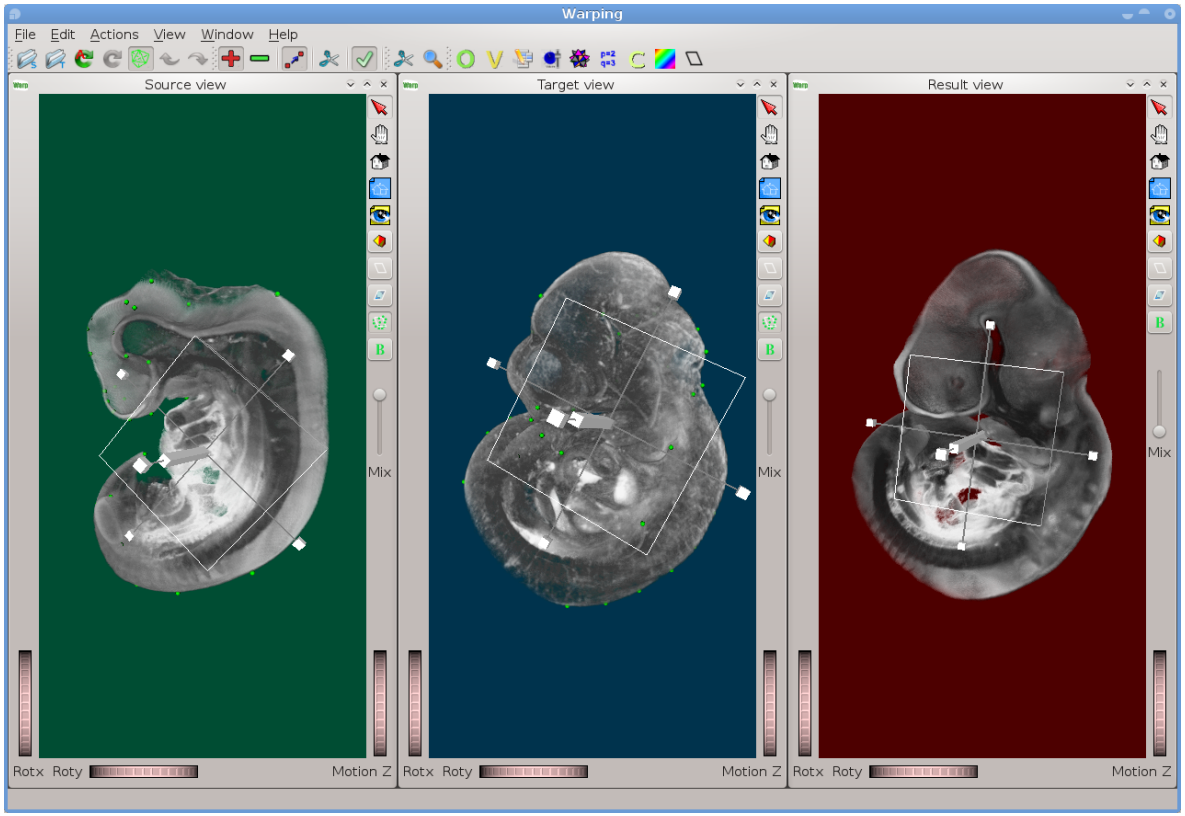

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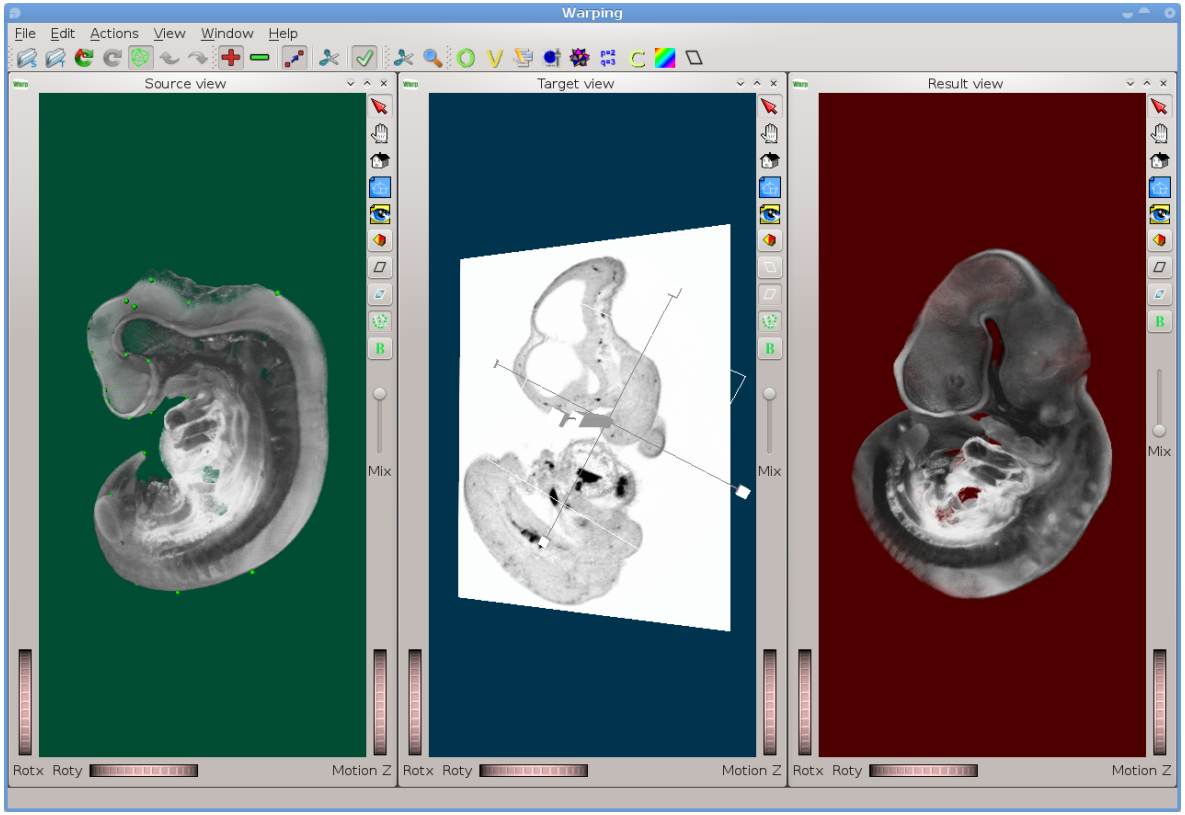

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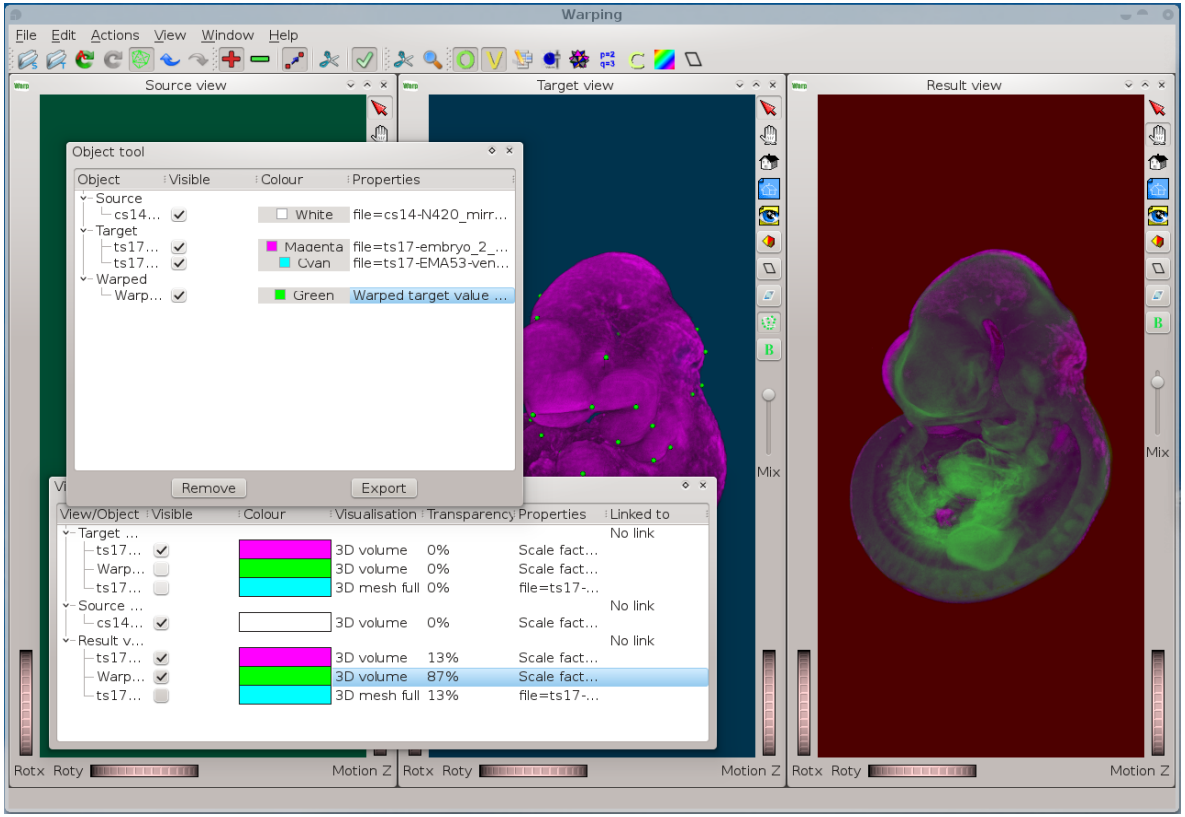
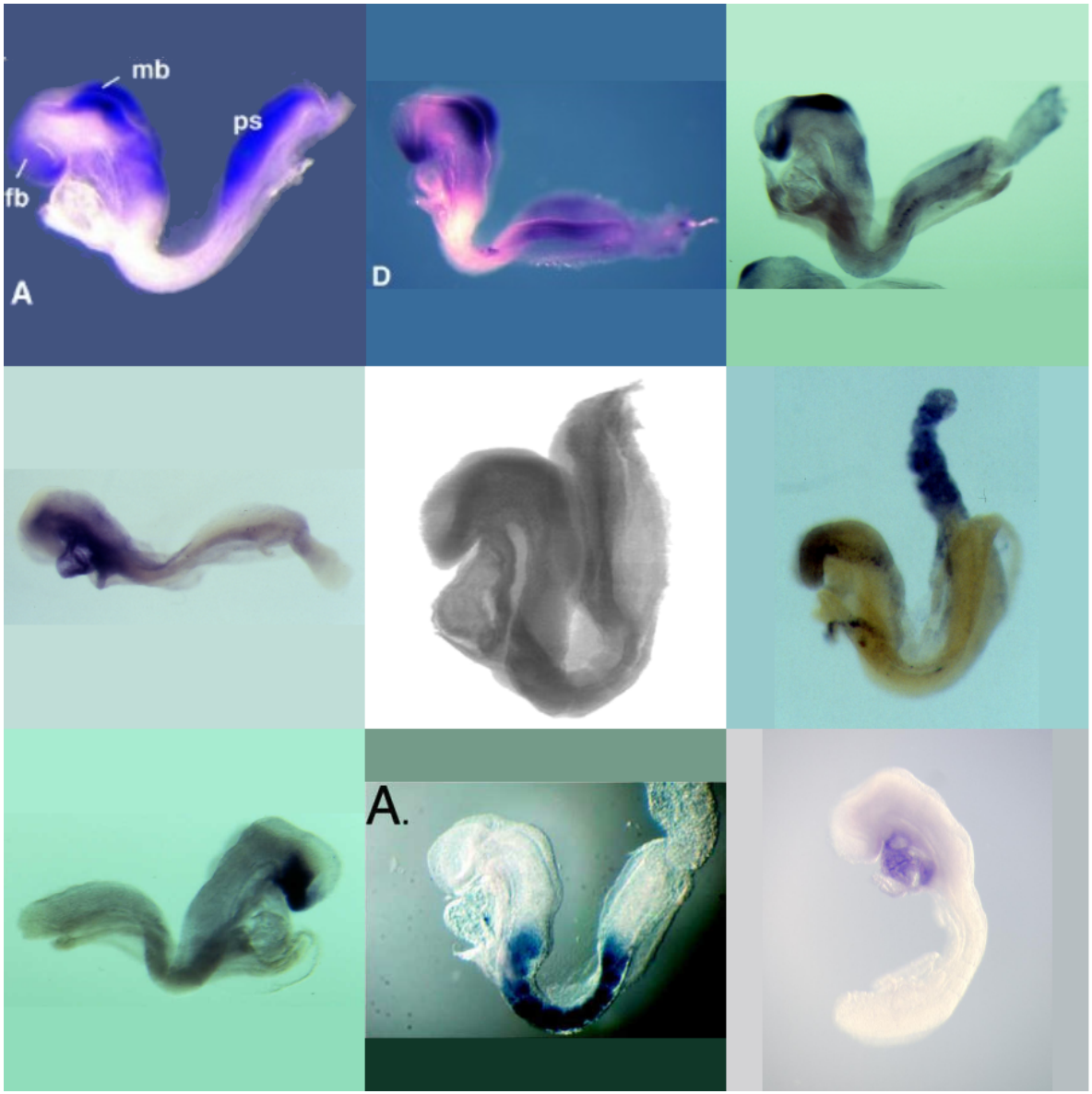
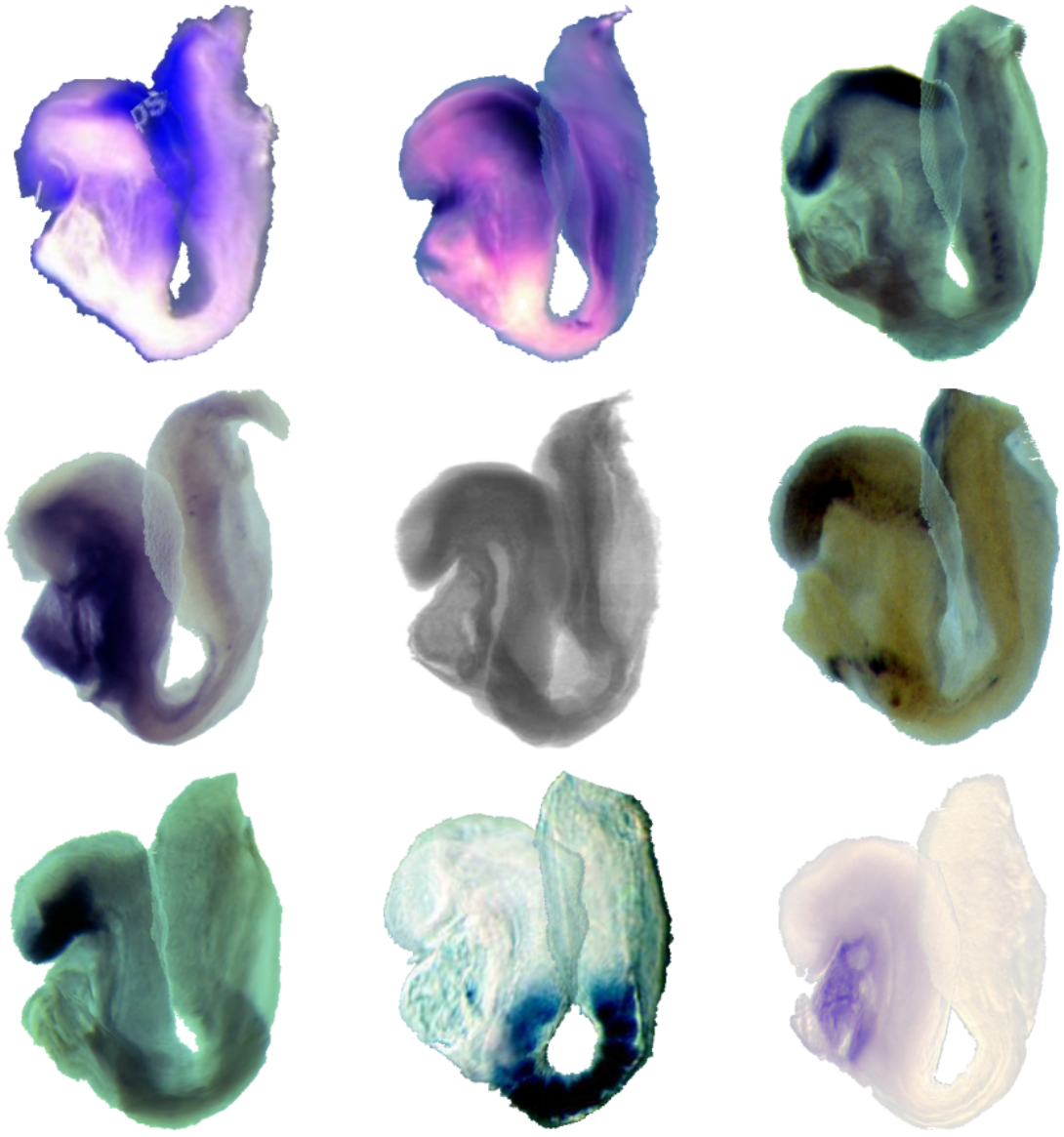


Results 1/4: TS12 Wholemount

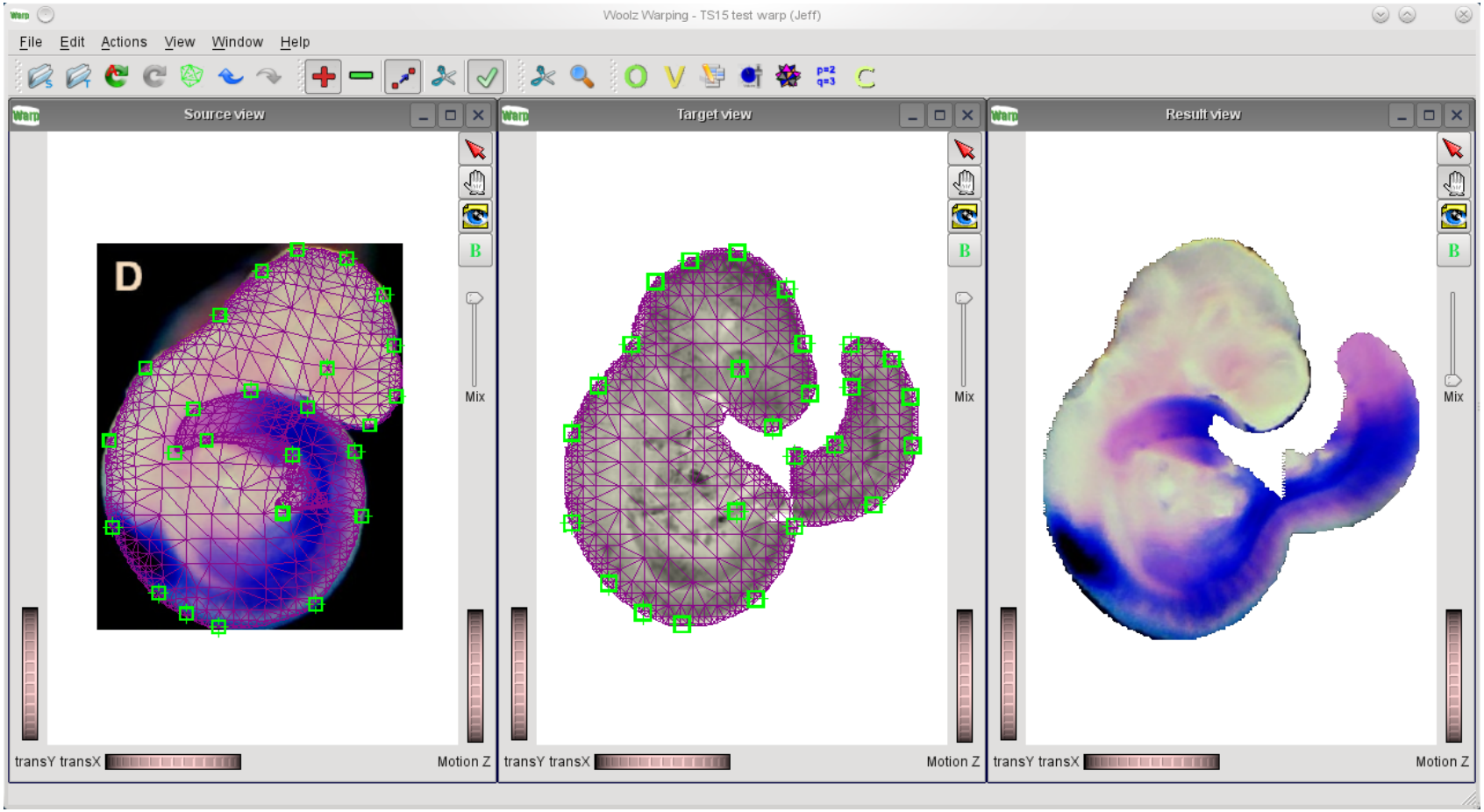


Results 1/4: TS12 Wholemount



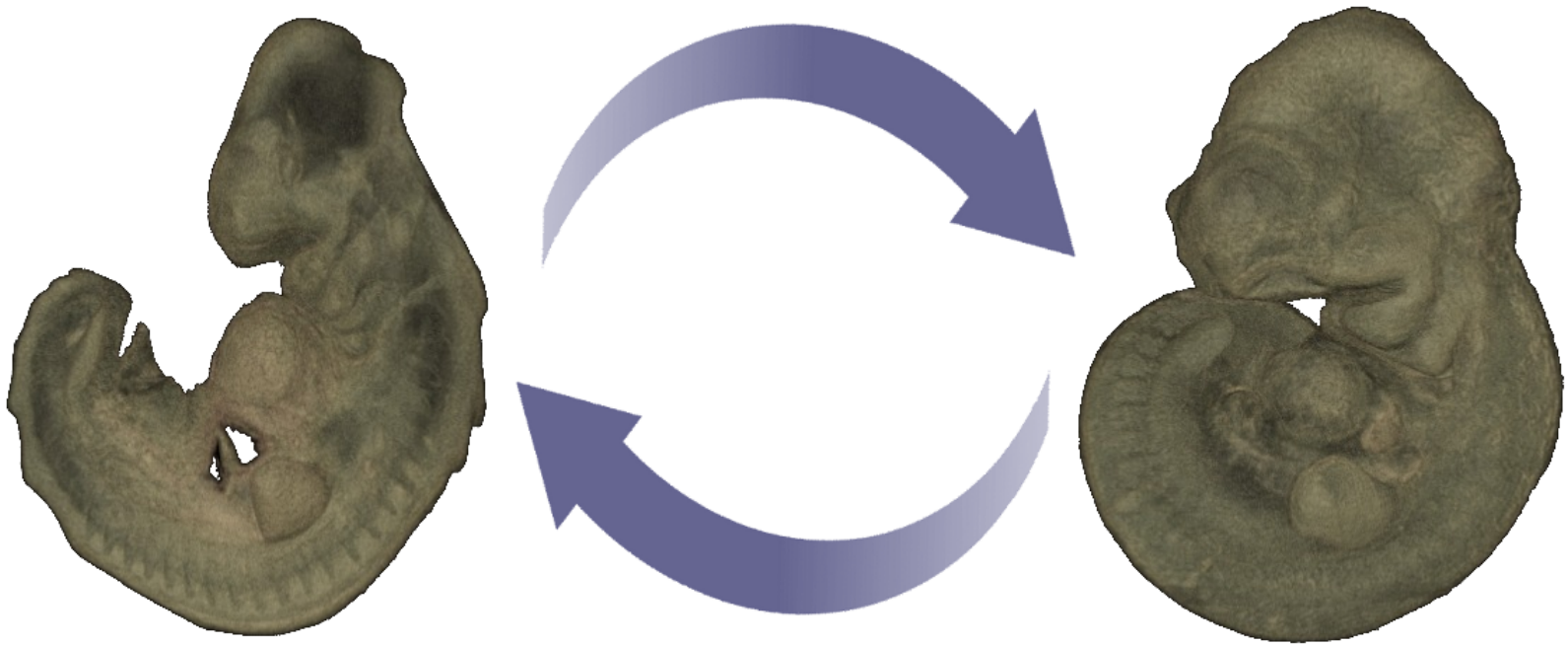
Results 1/4: TS12 Wholemount

Results 2/4: TS15 Wholemount



Results 2/4: TS15 Wholemount

Results 3/4: HUDSEN–EMAGE 3D Inter–Atlas Mapping



Results 3/4: HUDSEN–EMAGE 3D Inter–Atlas Mapping

CS14 → TS17

Results 4/4: HUDSEN Inter–Stage Mapping

CS17 → CS18 → CS19

Conclusions & Observations

CDT for atlas registration in 2 and 3D

Landmark placement is non-trivial

Warps may not be satisfactory for some high deformation gradients

Live update not usable for large 3D meshes

Fine tuning

Interpolation, 4D and beyond –

$$atlas \leftarrow model_{ND} + \{assay\}_A$$

Acknowledgements

Zsolt Husz & Elias Theocharopoulos (NIH)

Janet Kerwin (NIH)

EMAGE & EMAP (http://www.emouseatlas.org)

HUDSEN (http://www.hudsen.org/)