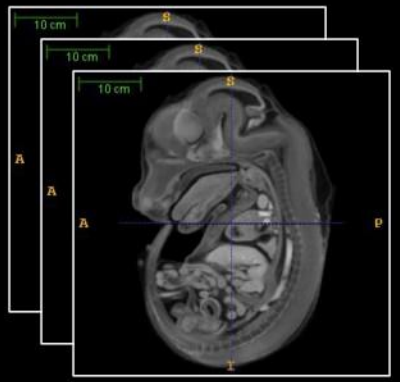
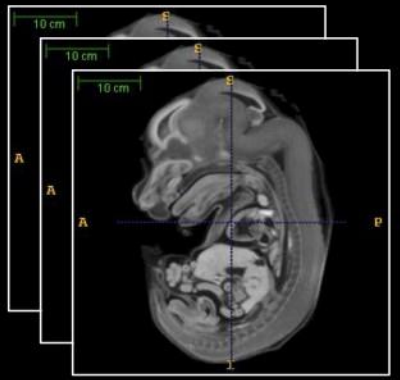
Phenotype Detection in Morphological Mutant Mice using Deformation Features

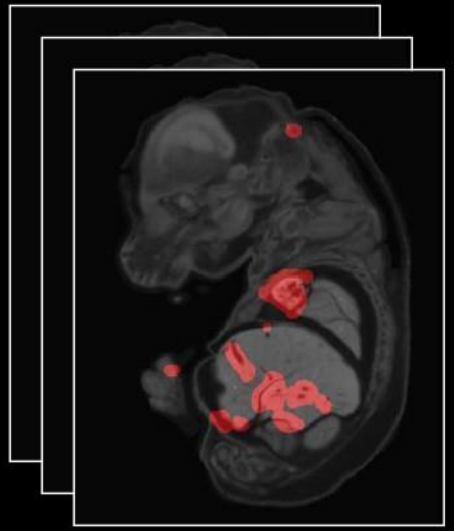


Non Defective (Wild)
Mouse Images



Defective (Homo/Hetero)
Mouse Images

Image Processing
Techniques

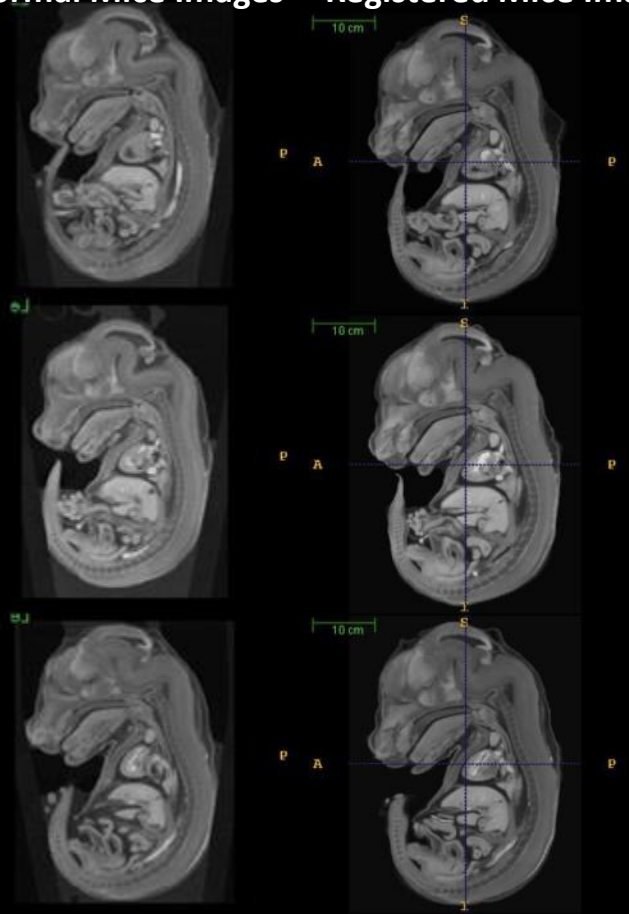


Candidate Phenotype
Detection

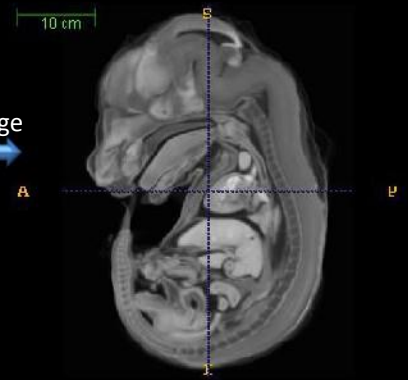
Solution: Step 1

- Original Wild Mice Images
- Preprocess to Extract Mouse Area
- Align mice images via a group -wise registration scheme
- Compute a average image for the normal mouse population

Normal Mice Images **Registered Mice Images**



Average



Normal Mouse Atlas

1. Construct normal mouse atlas
2. Register abnormal mouse to normal mouse atlas and compute suspicious areas

Solution: Step 2

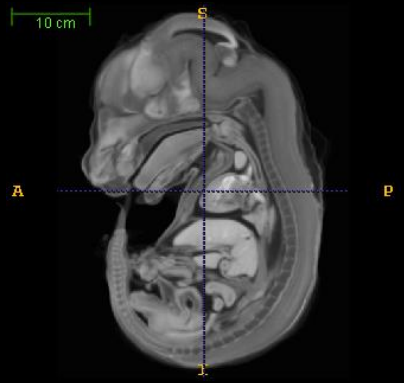
Register abnormal mouse to normal mouse atlas

↓

Compute deformation features

↓

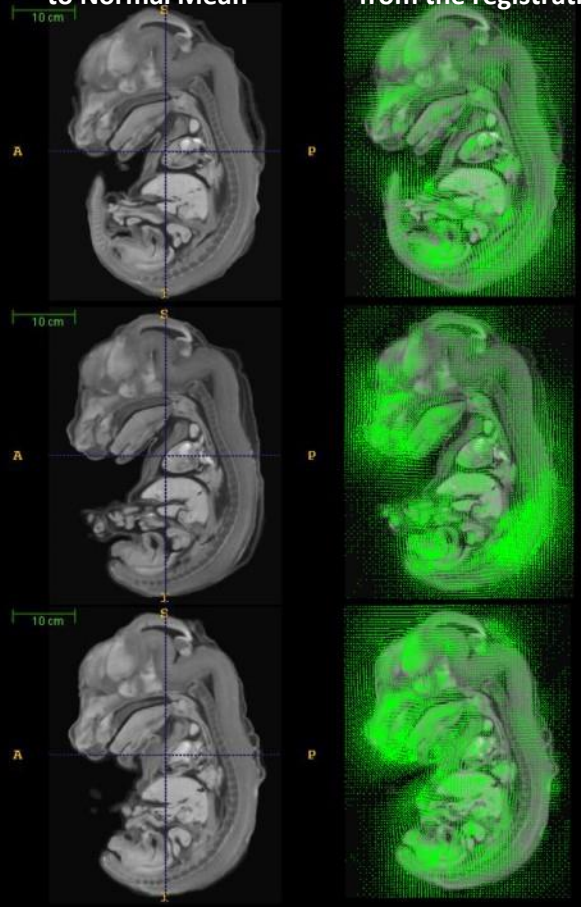
Compute suspicious areas using deformation features



Normal Mean

Defective Mice Registered to Normal Mean

Deformation field resulting from the registration



1. Construct normal mouse atlas

2. Register abnormal mouse to normal mouse atlas and compute suspicious areas

For each pixel we have:

Transformation in x-direction – T_x
Transformation in y-direction – T_y
Transformation in z-direction – T_z

Trans. direction $\theta_x = T_x/\sqrt{(T_x^2 + T_y^2 + T_z^2)}$
Trans. direction $\theta_y = T_y/\sqrt{(T_x^2 + T_y^2 + T_z^2)}$
Trans. direction $\theta_z = T_z/\sqrt{(T_x^2 + T_y^2 + T_z^2)}$

Compute 3 registration based features:

1. Determinant of Spatial Jacobian of Transformation =

$$\begin{vmatrix} 1+\partial(T_x)/\partial(x) & \partial(T_x)/\partial(y) & \partial(T_x)/\partial(z) \\ \partial(T_y)/\partial(x) & 1+\partial(T_y)/\partial(y) & \partial(T_y)/\partial(z) \\ \partial(T_z)/\partial(x) & \partial(T_z)/\partial(y) & 1+\partial(T_z)/\partial(z) \end{vmatrix}$$

2. $\Theta = [\theta_x\ \theta_y\ \theta_z]^T$
Divide the image into small blocks and find blocks which have high entropy of Θ (deformation direction).

3. For a population of M images registered to image j, compute voxel-wise intensity variance across all registered images:

$$IV_j(x) = \frac{1}{M-1}\sum_{i=1}^{M}(T(I(x)) - avg(x))^2$$

$$avg(x) = \frac{1}{M}\sum_{i=1}^{M}T(I(x))$$

Solution: Step 2

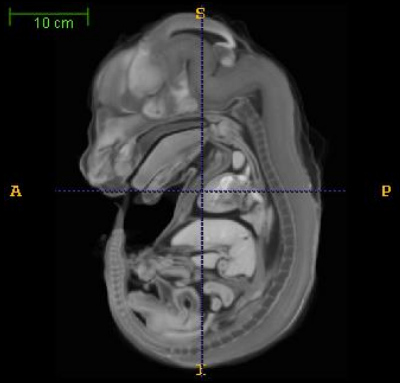
Register abnormal mouse to normal mouse atlas

↓

Compute deformation features

↓

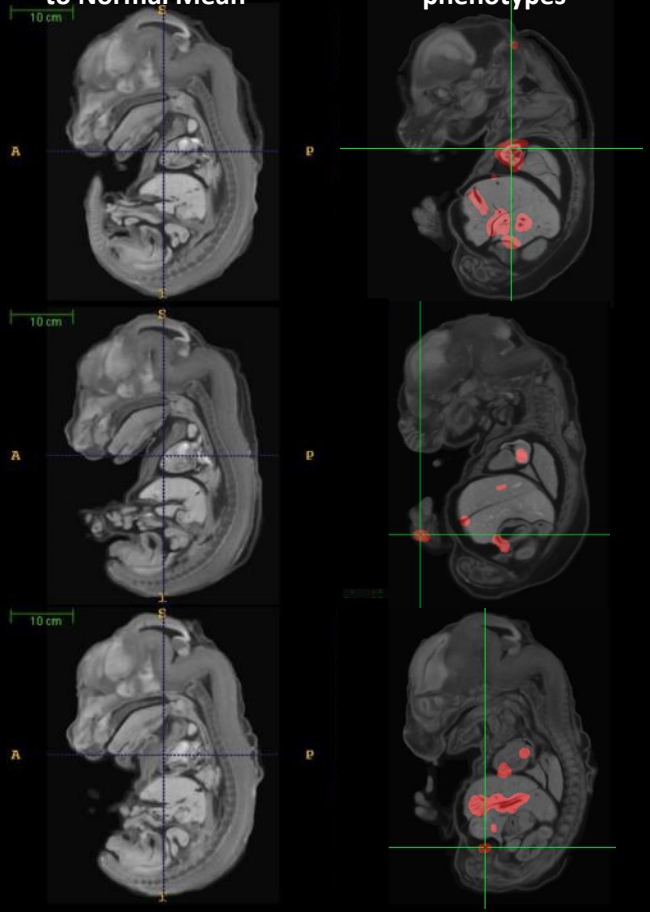
Compute suspicious areas using deformation features



Normal Mean

Defective Mice Registered to Normal Mean

Output candidate phenotypes



1. Construct normal mouse atlas

2. Register abnormal mouse to normal mouse atlas and compute suspicious areas

I_{IV} = Areas with high intensity variance

I_J = Areas with high local expansion/ compression

I_s = Areas with high stress

Defective Area = $(I_{IV} \cap I_J) \cup (I_{IV} \cap I_s) \cup (I_J \cap I_s)$

Some Results