

# Analysis of Micro-CT Images for Mouse Embryos

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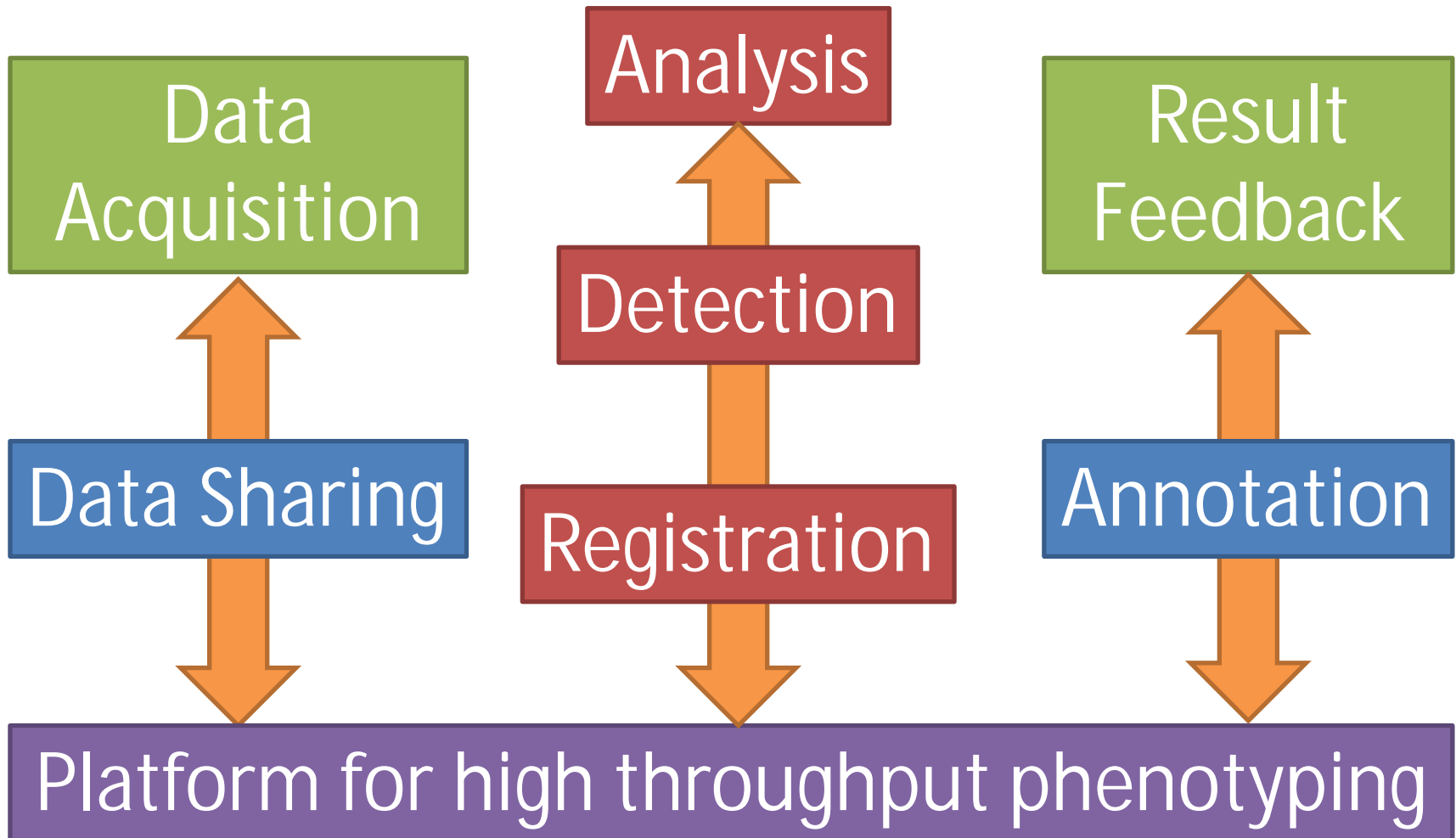
NIG

**Toshihiko Shiroishi**

RIKEN

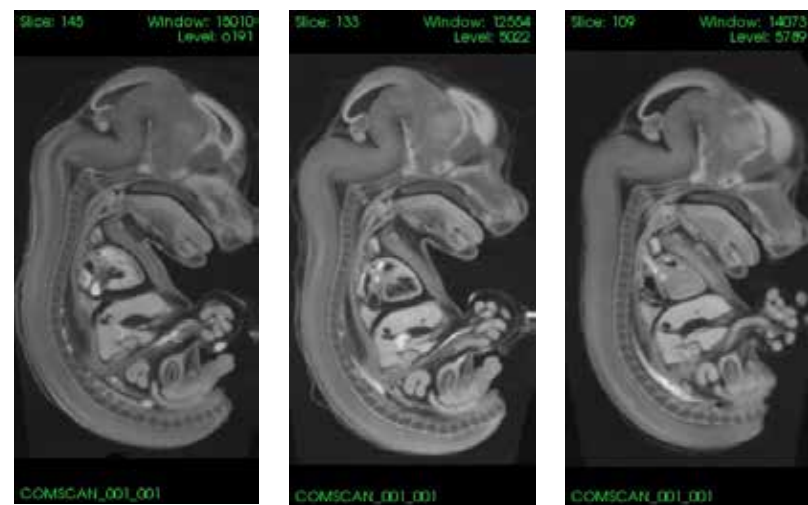
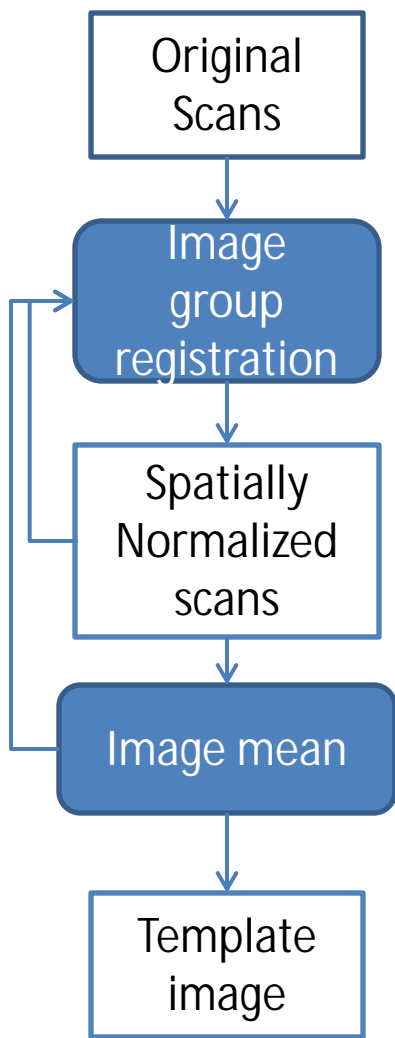
**Masaru Tamura**

# Phenotyping Pipeline

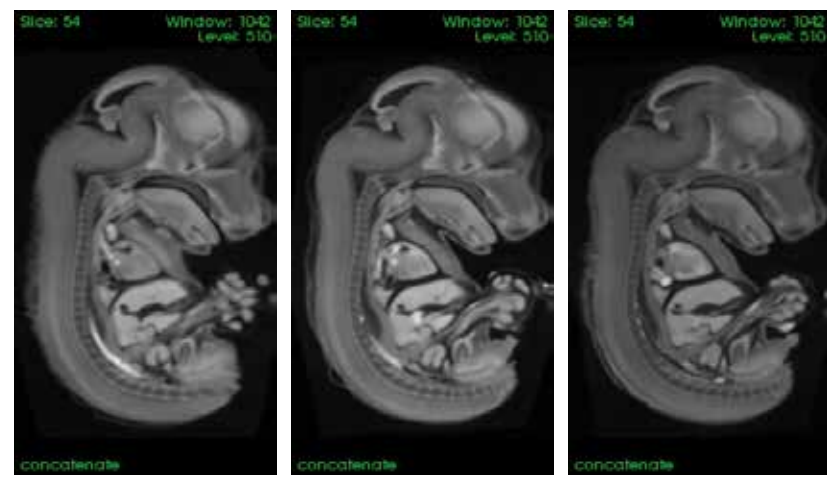


# Registration

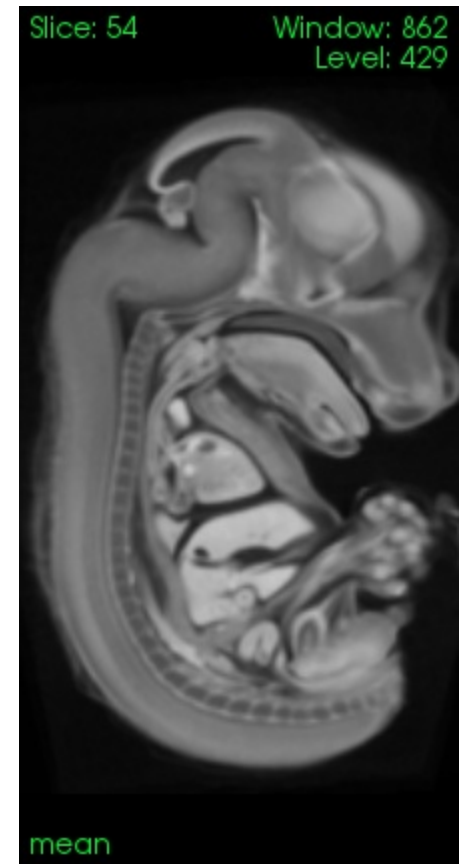
# Mouse template image through image registration



Original scans

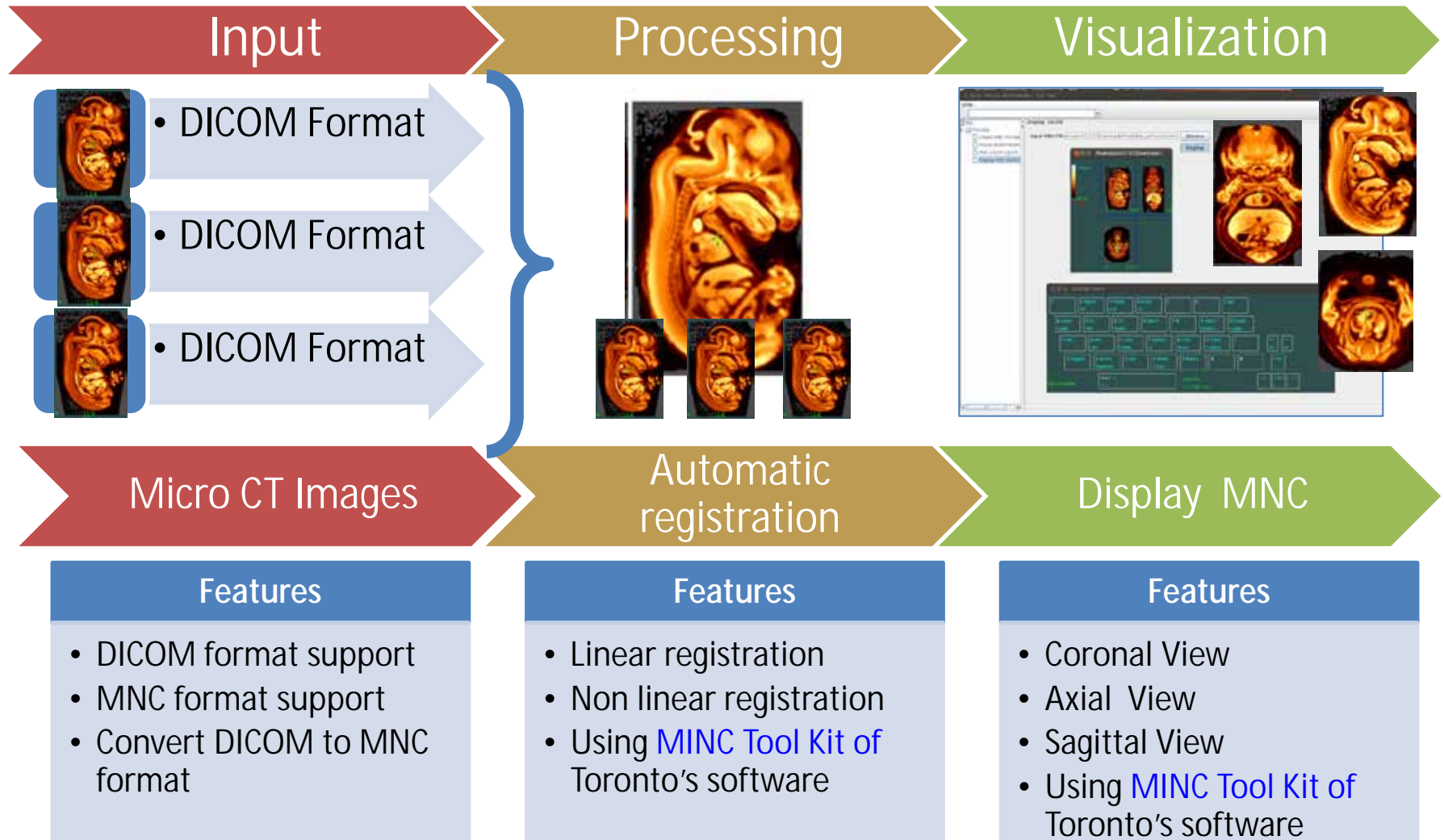


Spatially normalized scans



Template image

# Utilization of MINC Toolkit for micro-CT images of mice and the design of a GUI tool



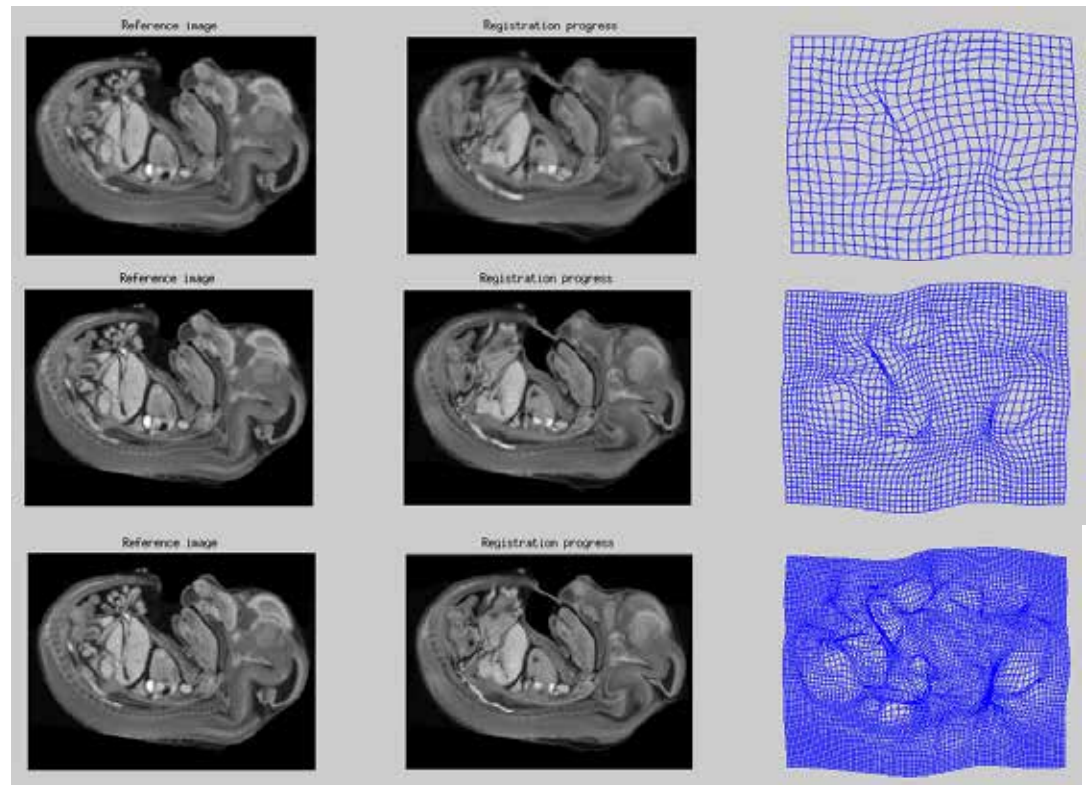
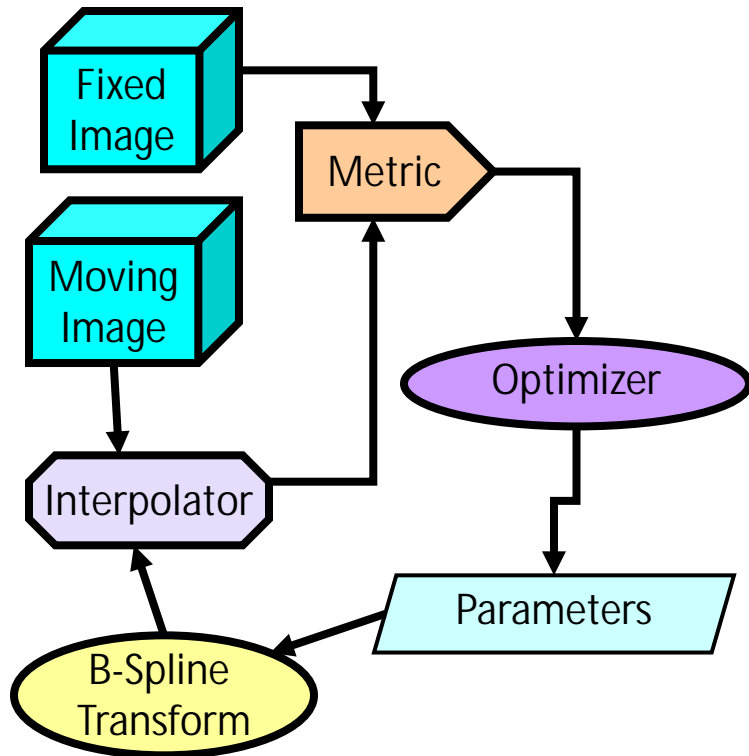
# 2D Non Rigid Mouse Registration

**Aim:-** To successfully register mouse images using Non rigid B-Spline Registration.

**Problem:-** Non-uniformity in image intensity makes registration very challenging.

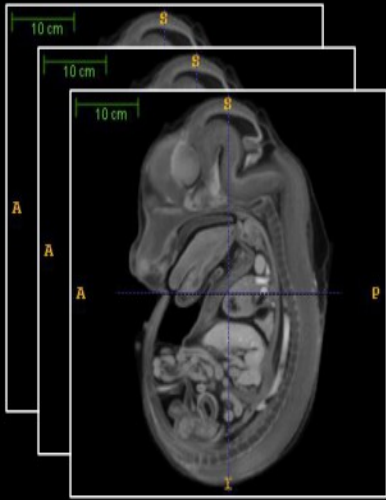
**Proposed Solution:-** We divide the image into small regions and using principal components for mutual information computation (EMPCA-MI) between them using a multi-resolution approach.

**Result:** Following figure shows the registration framework and hetro/wild mouse registration result with Bspline control points.



**Detection**

# Phenotype Detection in Morphological Mutant Mice using Deformation Features

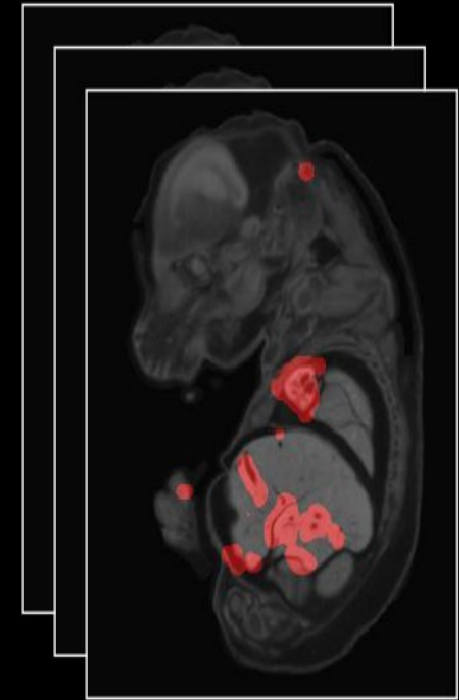


Non Defective (Wild)  
Mouse Images

Image Processing  
Techniques



Defective (Homo/Hetero)  
Mouse Images



Candidate Phenotype  
Detection



# Solution: Step 1

Original Wild Mice Images



Preprocess to Extract  
Mouse Area

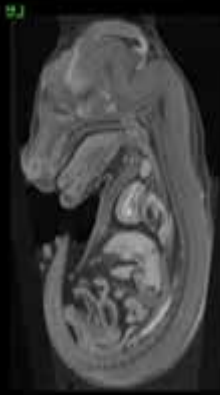
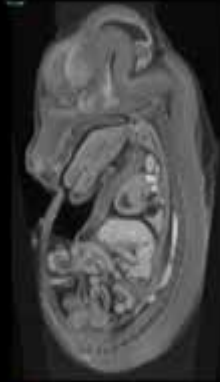


Align mice images via a group  
-wise registration scheme

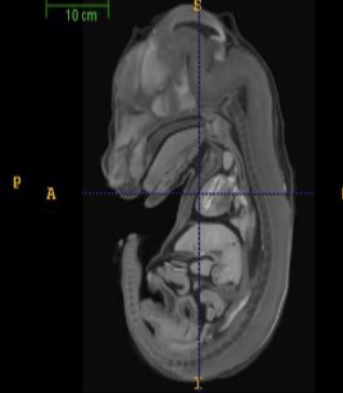
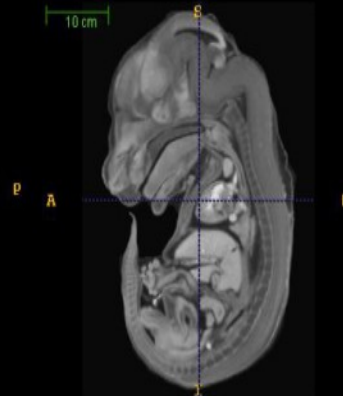
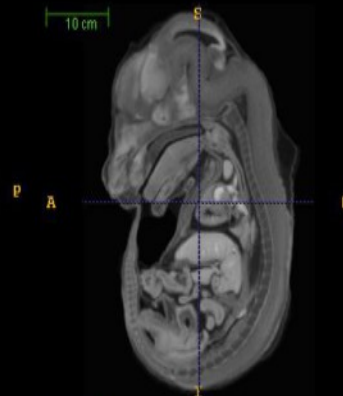


Compute a average image  
for the normal mouse  
population

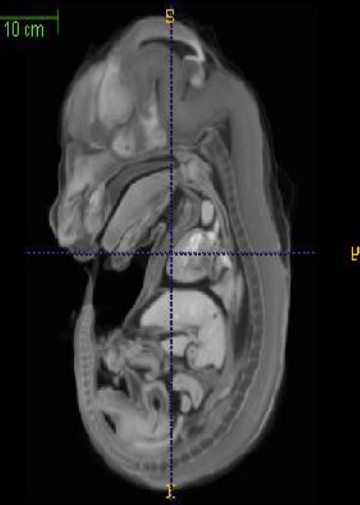
Normal Mice Images



Registered Mice Images



Average



Normal Mouse Atlas

1. Construct normal mouse atlas

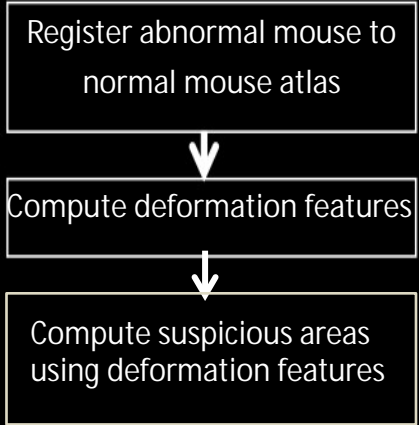


2. Register abnormal mouse to  
normal mouse atlas and  
compute suspicious areas

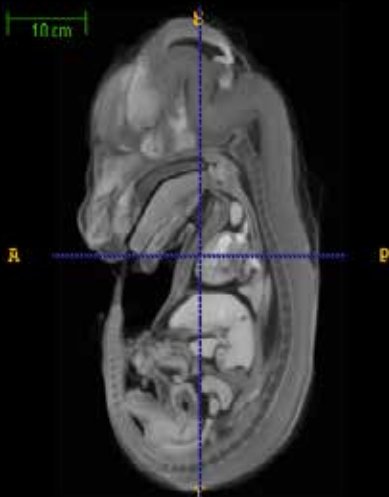
# Solution: Step 2

1. Construct normal mouse atlas

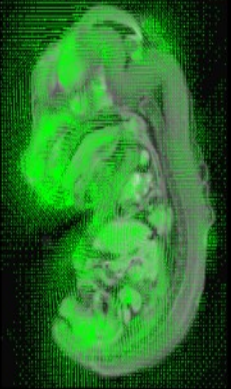
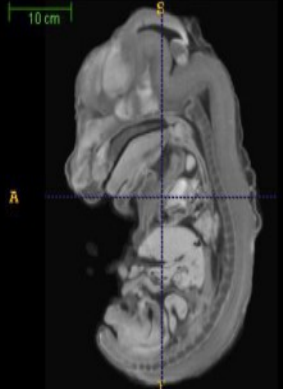
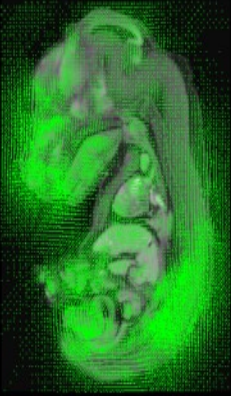
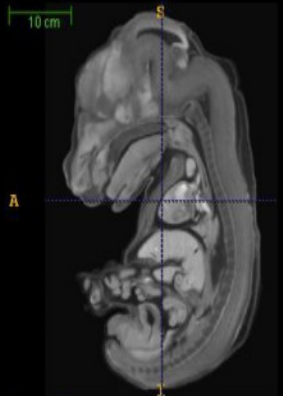
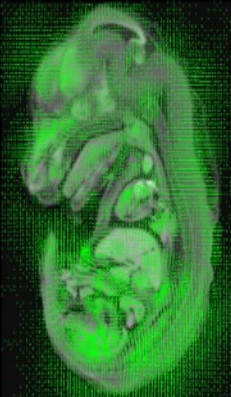
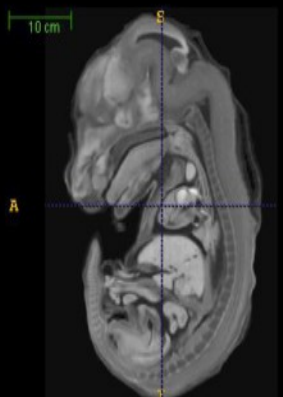
2. Register abnormal mouse to normal mouse atlas and compute suspicious areas



Defective Mice Registered to Normal Mean      Deformation field resulting from the registration



Normal Mean



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 =

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

$$\Theta = [\theta_x, \theta_y, \theta_z]^T$$

Divide the image into small blocks and find blocks which have high entropy of  $\Theta$  (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

1. Construct normal mouse atlas

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

Register abnormal mouse to normal mouse atlas



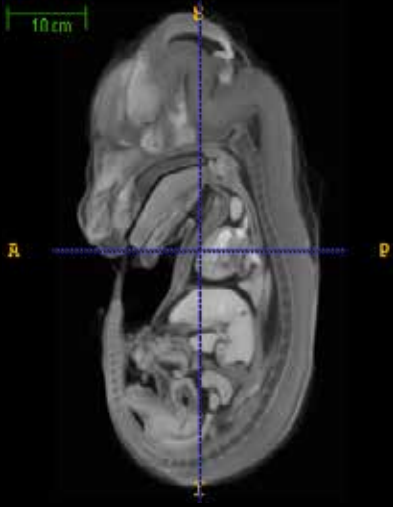
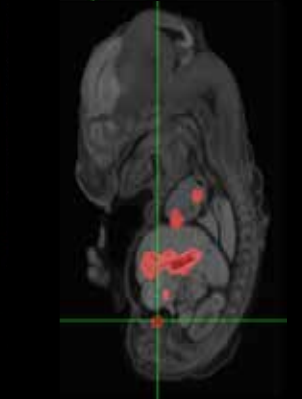
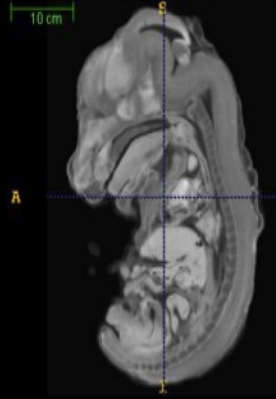
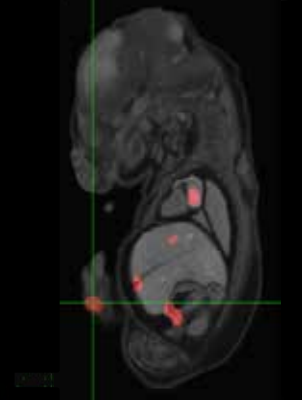
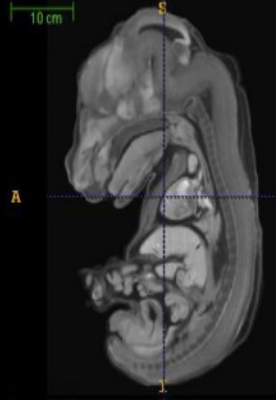
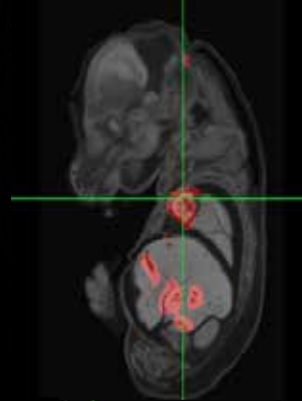
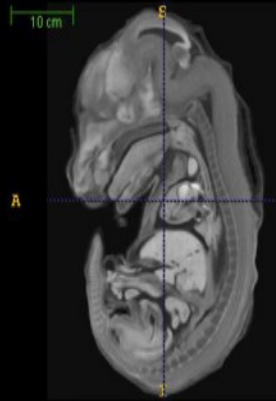
Compute deformation features



Compute suspicious areas using deformation features

Defective Mice Registered to Normal Mean

Output candidate phenotypes



Normal Mean

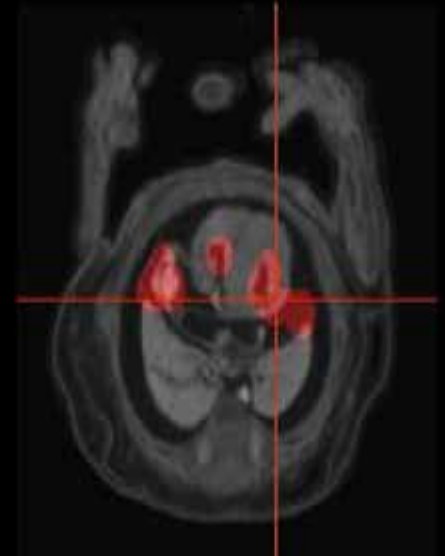
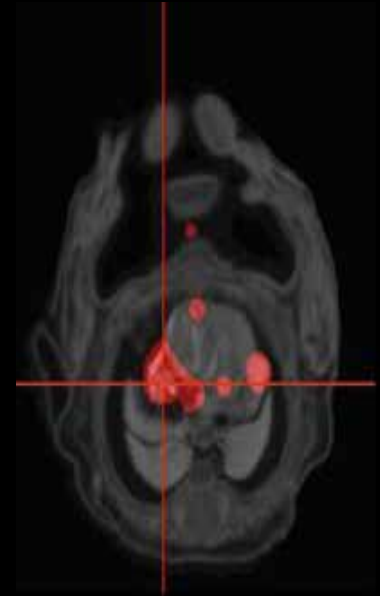
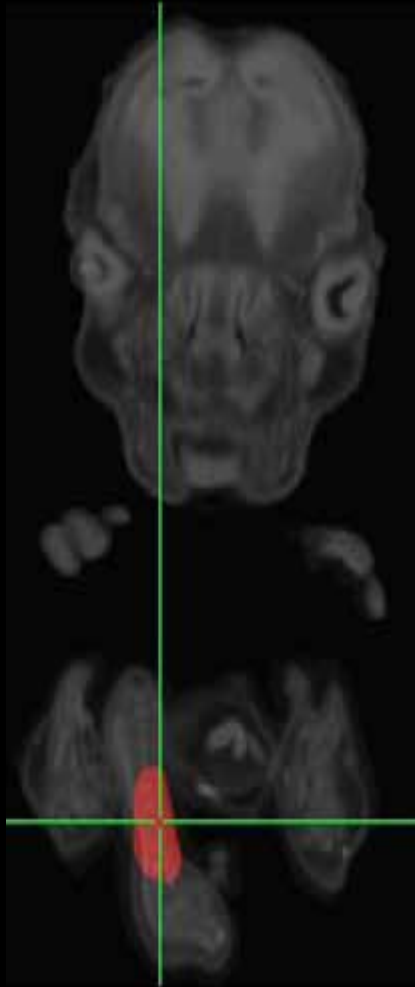
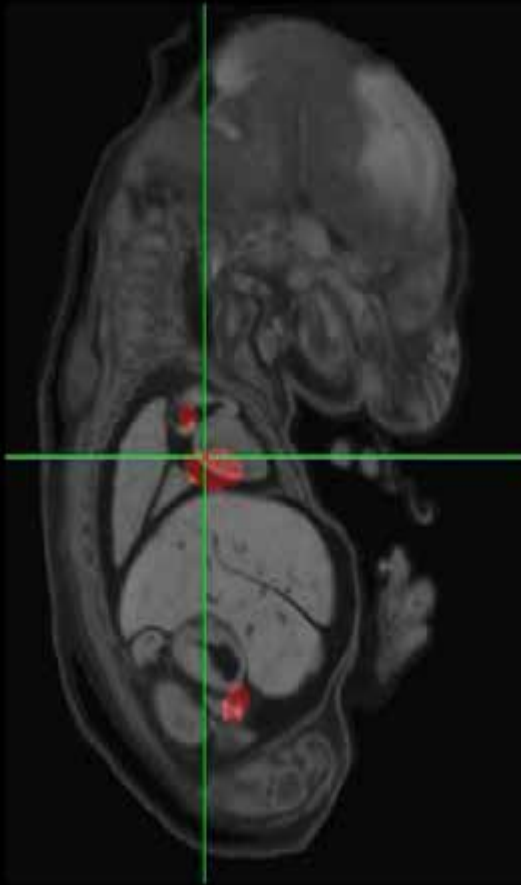
$I_{IV}$  = Areas with high intensity variance

$I_J$  = Areas with high local expansion/ compression

$I_S$  = Areas with high stress

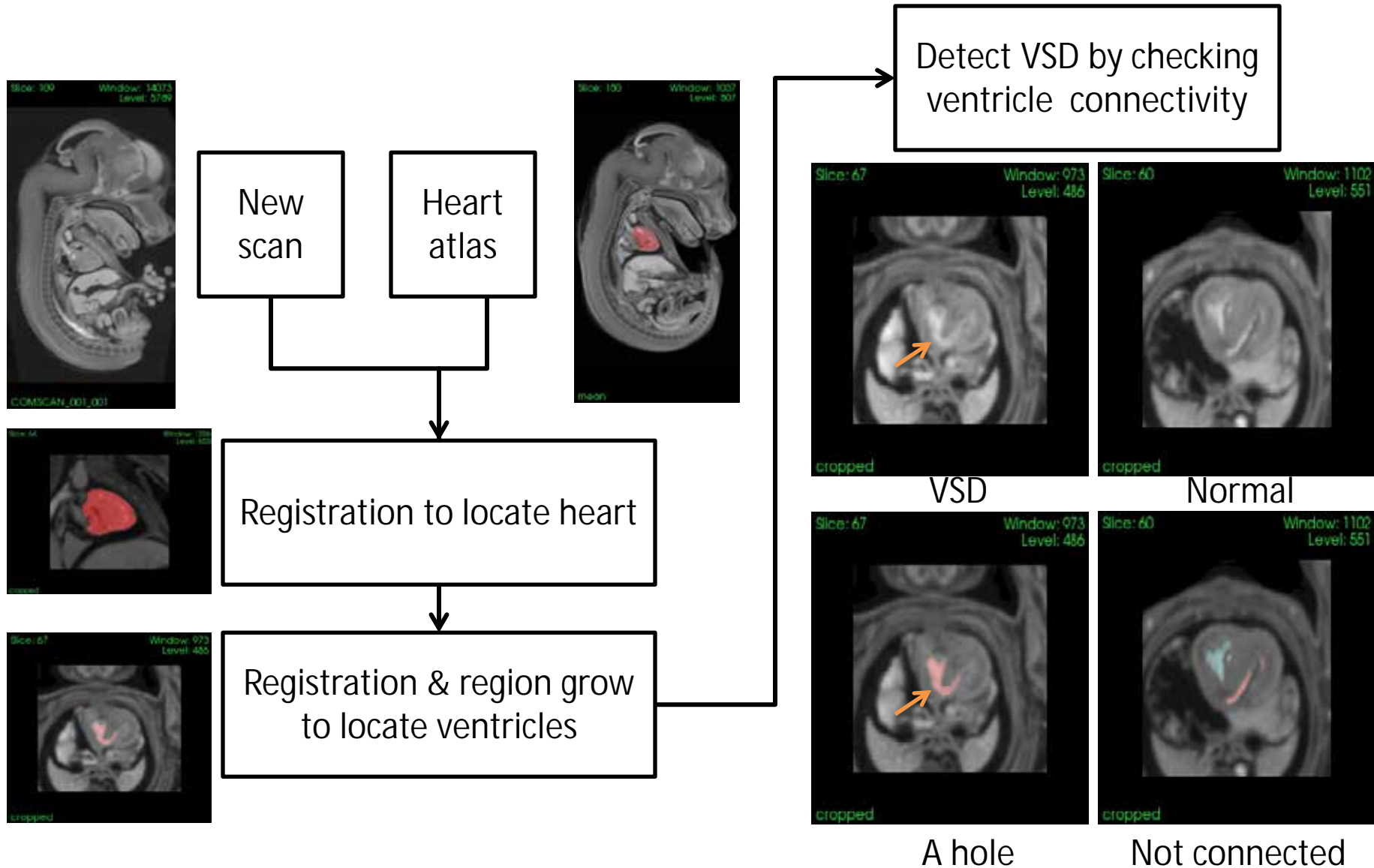
$$\text{Defective Area} = (I_{IV} \cap I_J) \cup (I_{IV} \cap I_S) \cup (I_J \cap I_S)$$

# Some Results



# Analysis

# Ventricular septal defect (VSD) detection

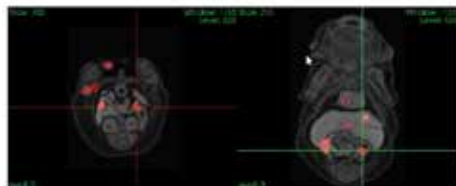


# Annotation

# Feedback Mechanism

**Objective:** To improve the ease and efficiency by which NIG can provide feedback from  $\mu$ CT scans of mouse embryos

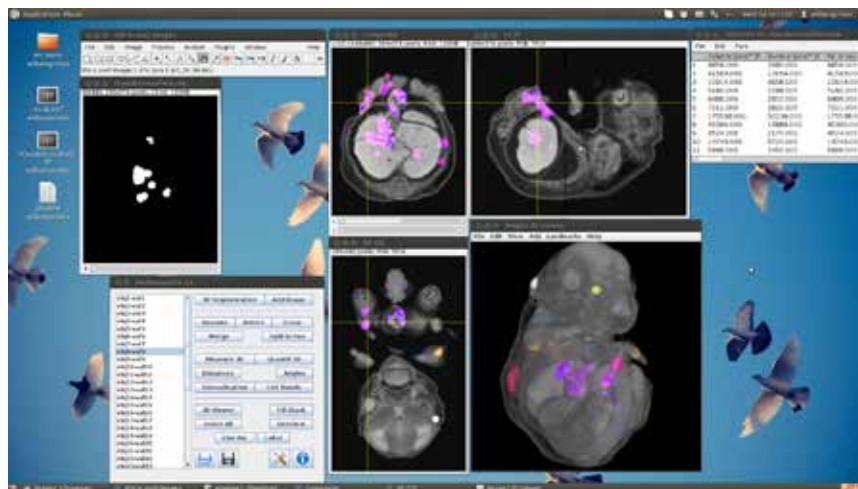
Area No. 15



Slice number 87-116 in the axial mouse image in vsSlicer4D or slice number XY364-XY393 in the original mouse series from NIG.

Does the area under the cursor seem suspicious? Y/N

*I think that it is probably No. The cursor indicates pancreas. During the mouse embryogenesis, the pancreas shows an irregular form like fat.*



## Current System

- 200 page pdf
- Comments overwritten
- View single slices
- Lengthly process to analyse
- Data difficult to interpret

## Proposed System

- | ImageJ plugin (extension)
- | Comments associated to ROIs
- | ROIs assigned a unique ID
- | View slices nearby ROI so easier to analyse.
- | Data easier to interpret



# Future Work

- International Mouse Phenotyping Consortium is expected to produce “big data.”
- Image processing can help for image retrieval, mining, tracking, and shape analysis.
- How to scale from a tiny MATLAB program to high-performance stable software platform?
- Link with other data, such as genotypes and known defects, for knowledge-based analysis.