Registration Methods

Reference Material

- ITK Software Guide
  - Chapter 8
- Lecture Notes (Rensselaer / CenSSIS ERC)
  - http://www.cs.rpi.edu/courses/spring04/imagereg/

- ** Extra information can be found in the book:
  - Insight Into Images (Yoo Book) Chapter 10

Overview

- Image Resampling
- Registration Framework
- Multi-Modality

Image Resampling

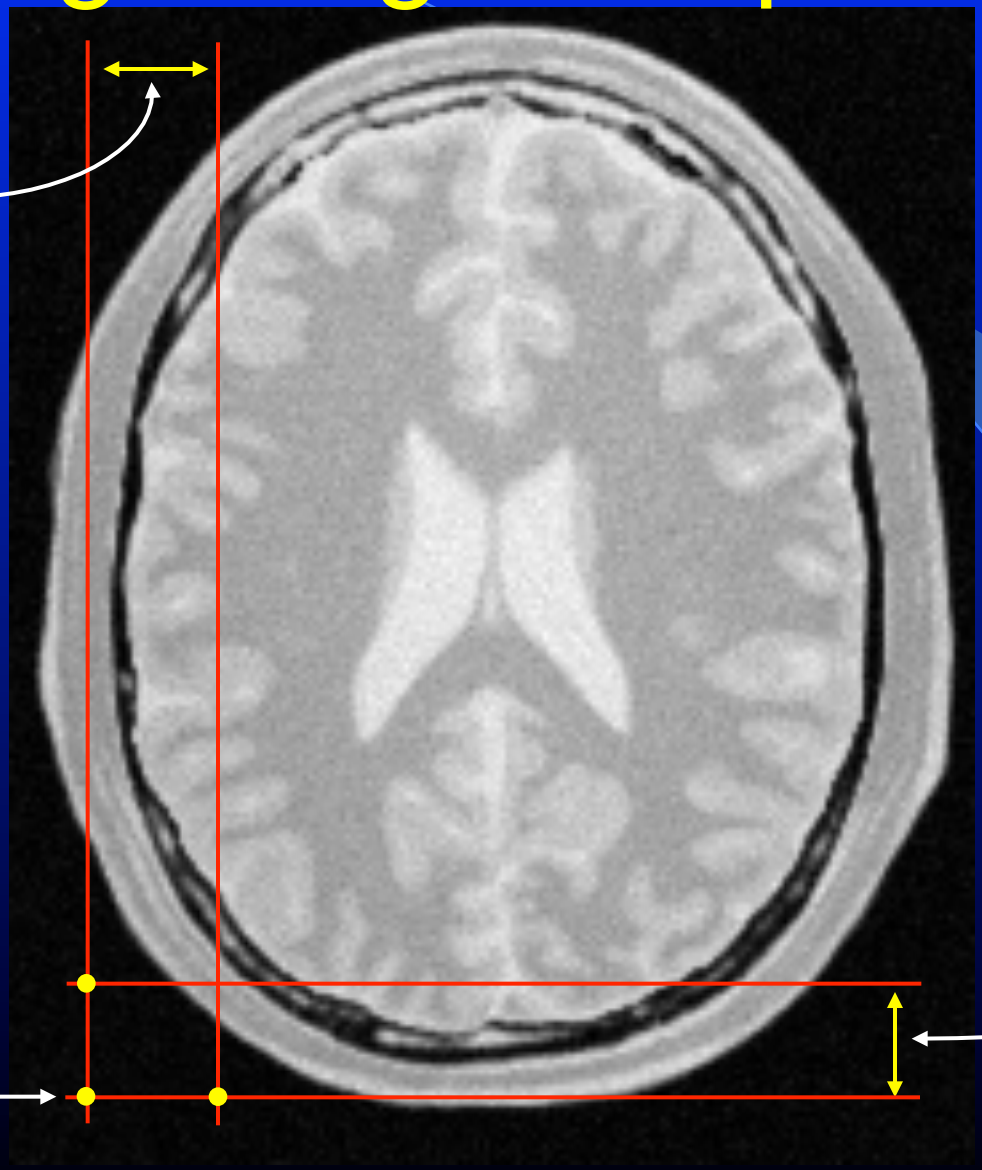
Why Resampling ?

Resampling
is the Essence
of Intensity-Based
Image Registration

What is an Image ?

An Image is
a sampling of a
continuous field
using a discrete grid

Image Origin & Spacing



Spacing (Sx)

y

x

Origin (Ox,Oy)

Spacing (Sy)

Image Origin & Spacing

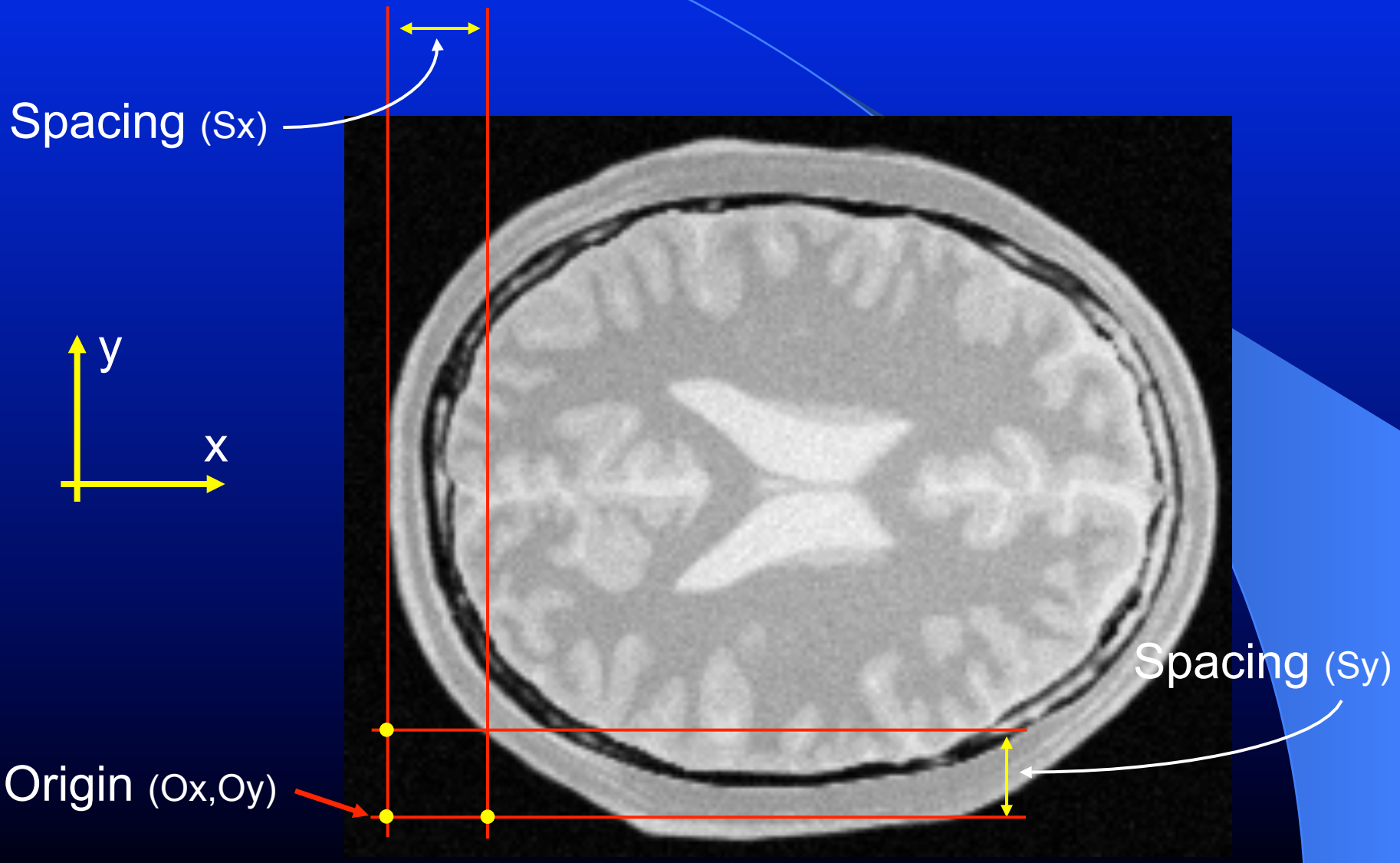


Image Sampling Grid

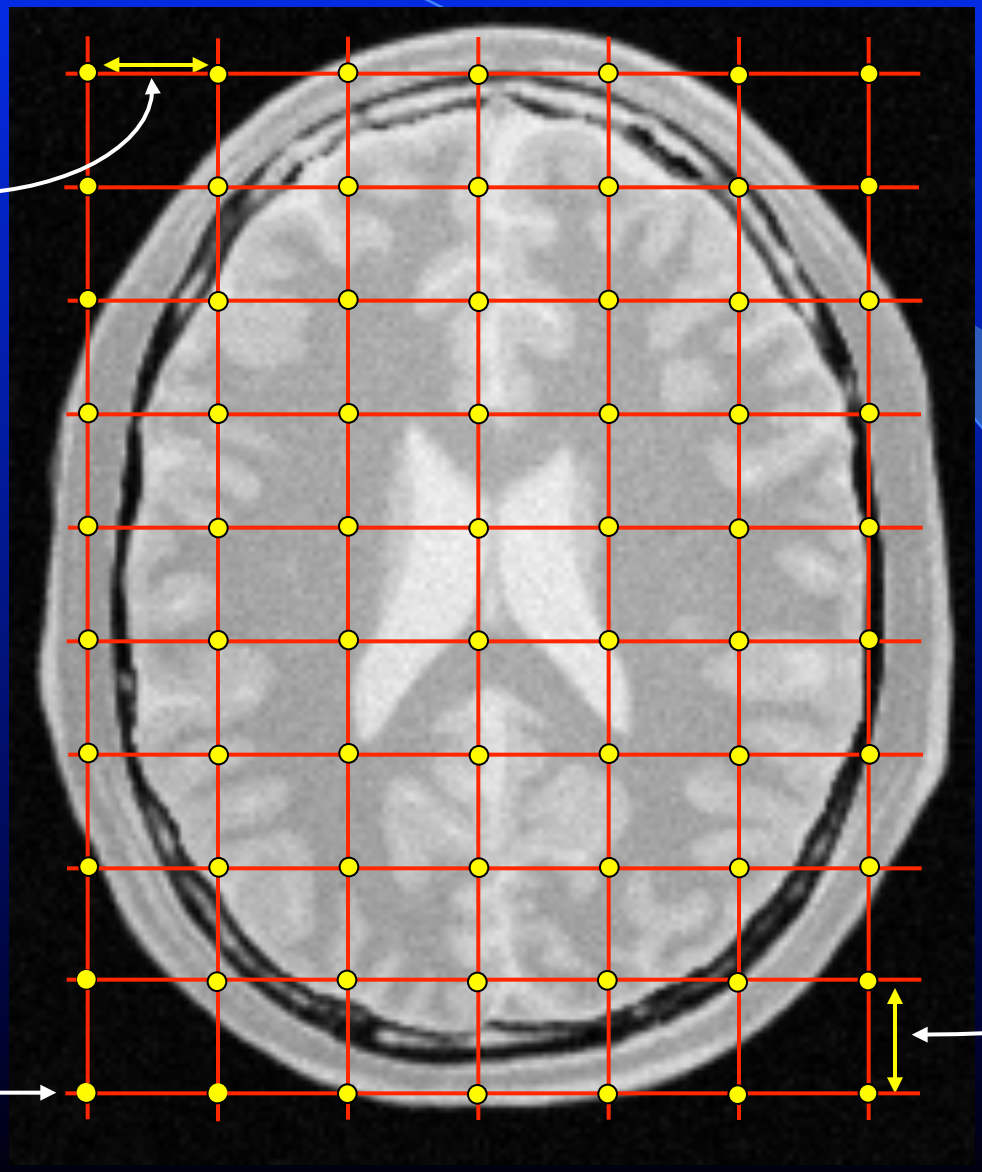


Image Pixel

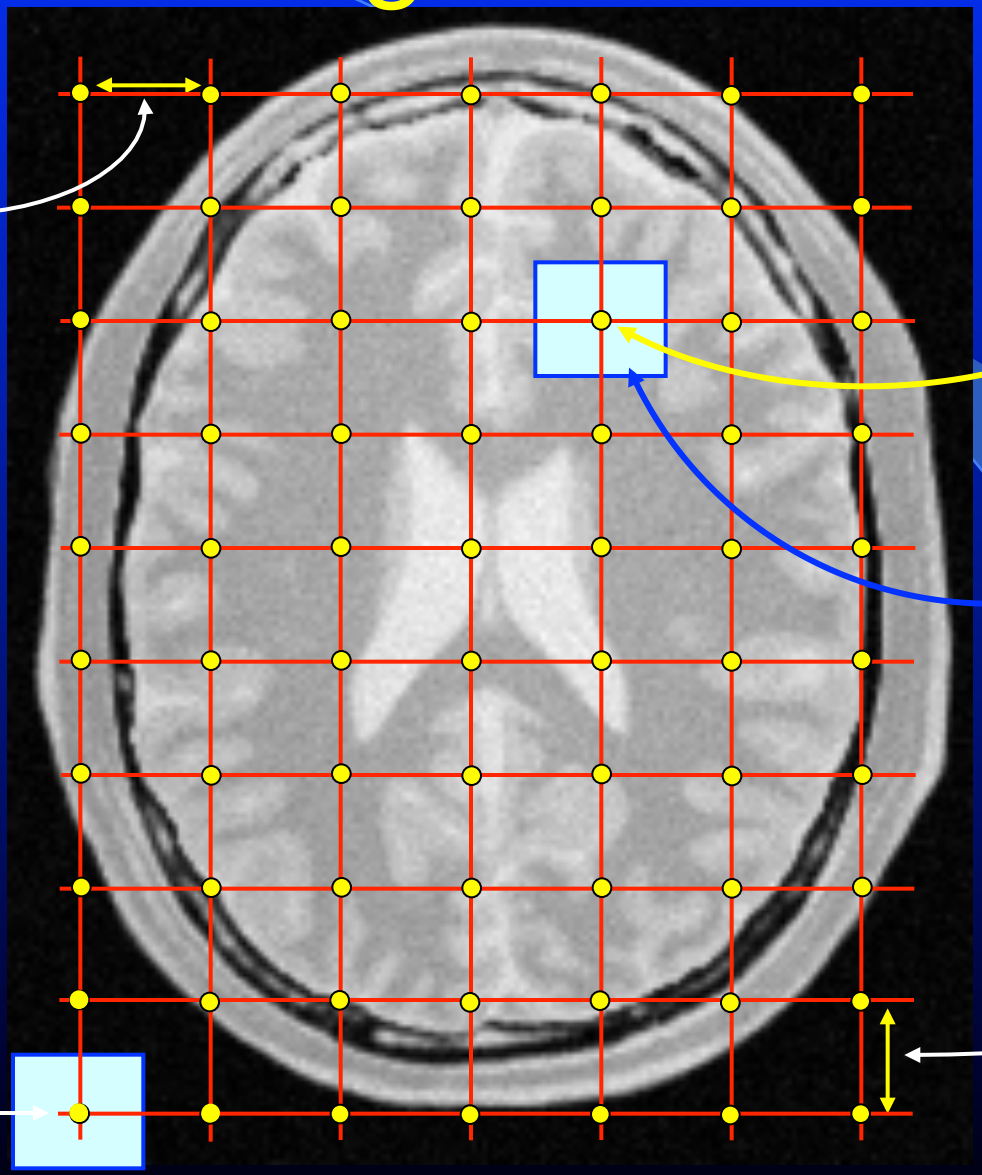
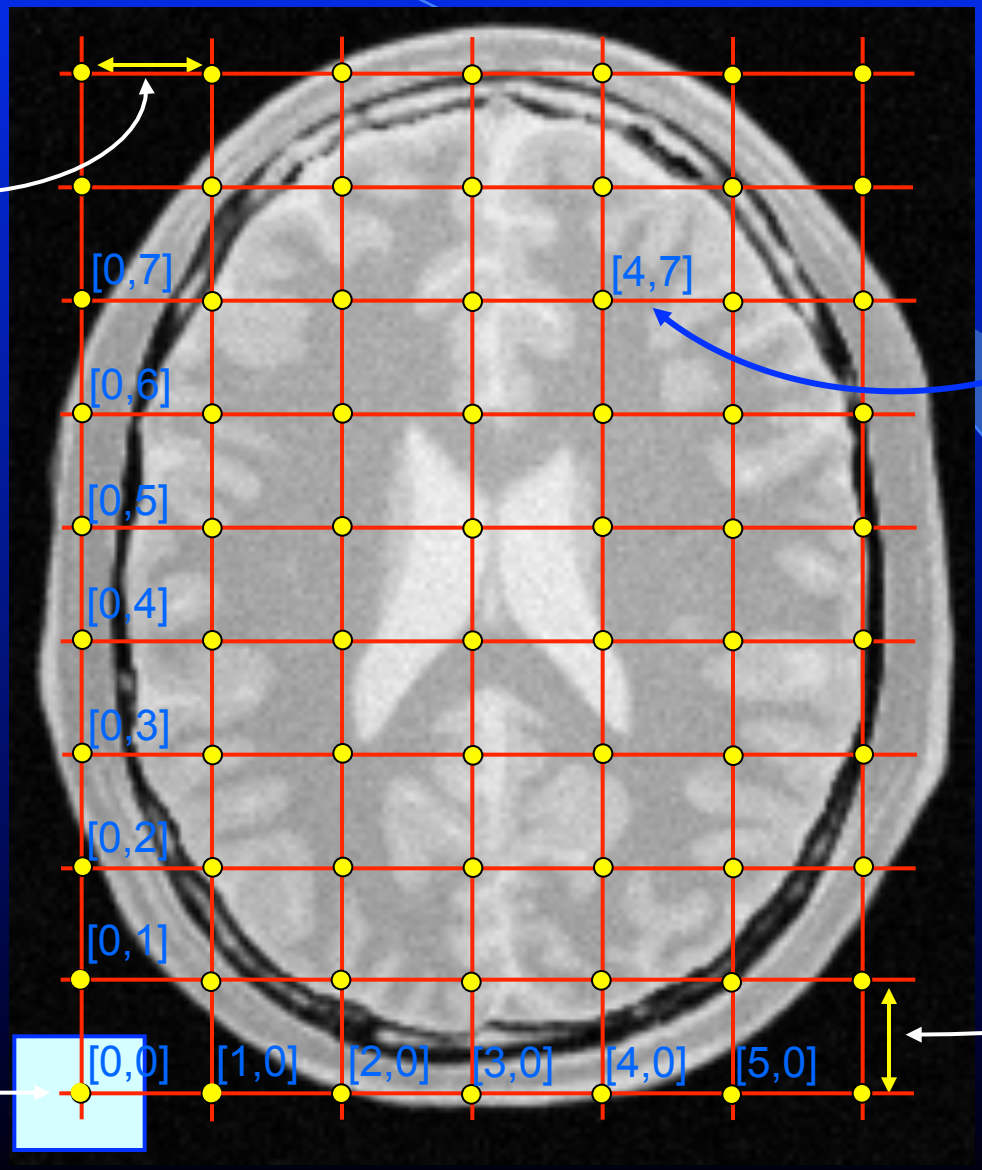
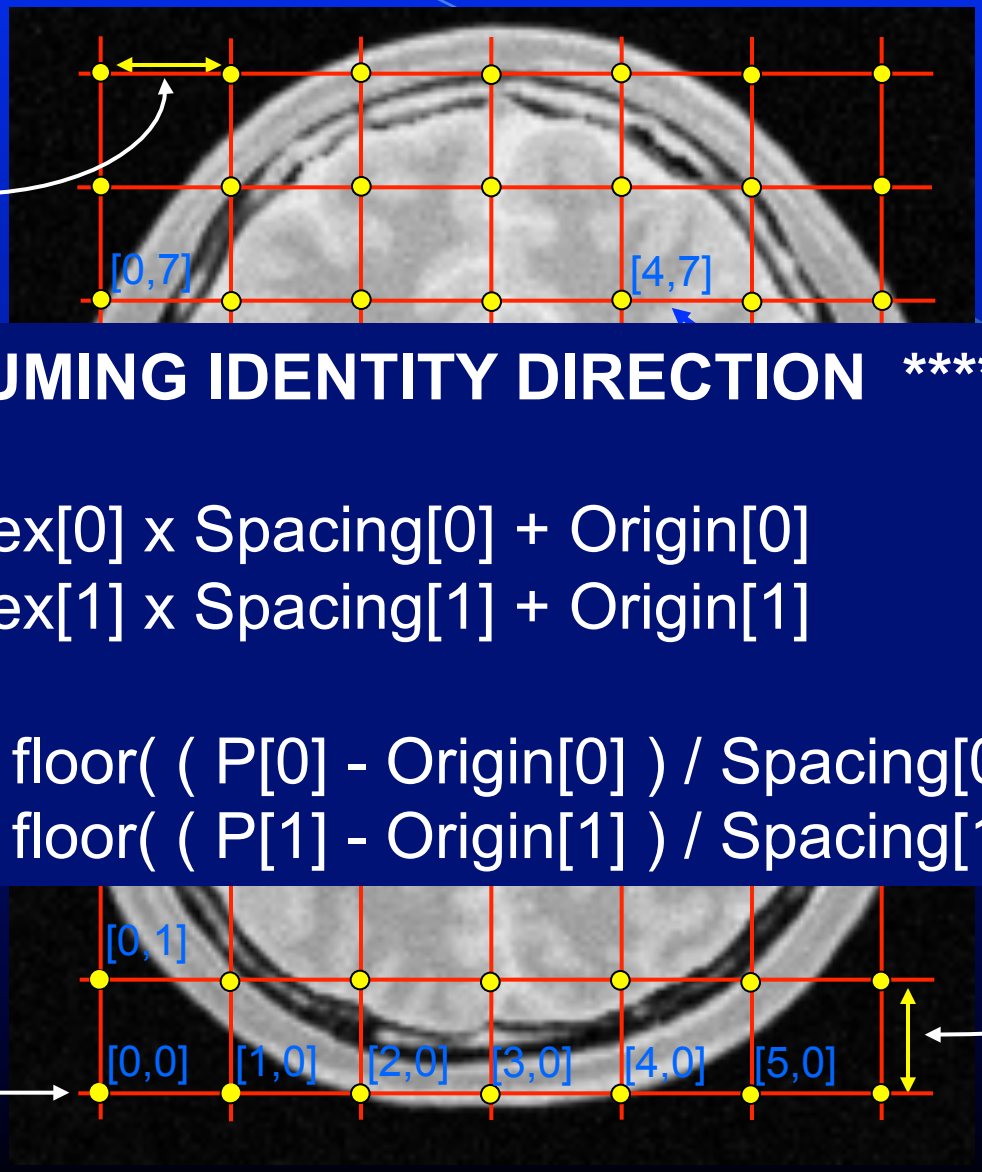


Image Indices



Index to Physical Coordinates

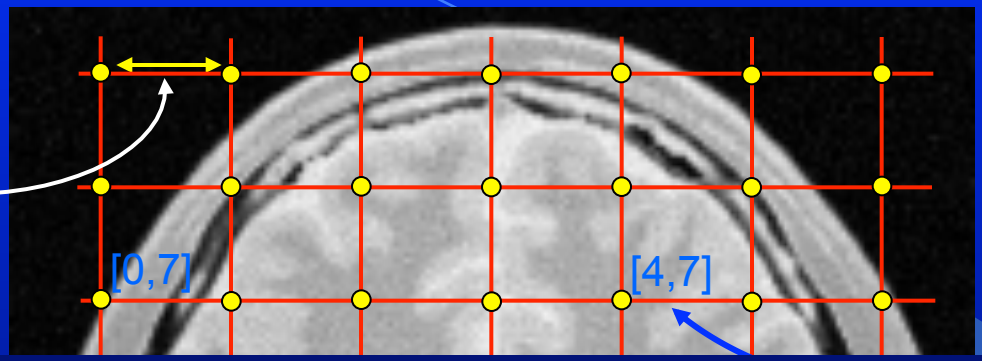


****** ASSUMING IDENTITY DIRECTION ******

P[0] = Index[0] x Spacing[0] + Origin[0]
P[1] = Index[1] x Spacing[1] + Origin[1]

Index[0] = floor((P[0] - Origin[0]) / Spacing[0] + 0.5)
Index[1] = floor((P[1] - Origin[1]) / Spacing[1] + 0.5)

Index to Physical Coordinates



With Direction Matrix

$$\vec{P}hysicalLocation = \vec{I}ndex * \hat{S}pacing * \hat{D}irection + \vec{O}rigin$$

$$Index = (\hat{S}pacing * \hat{D}irection)^{-1} * (\vec{P}hysicalLocation - \vec{O}rigin)$$

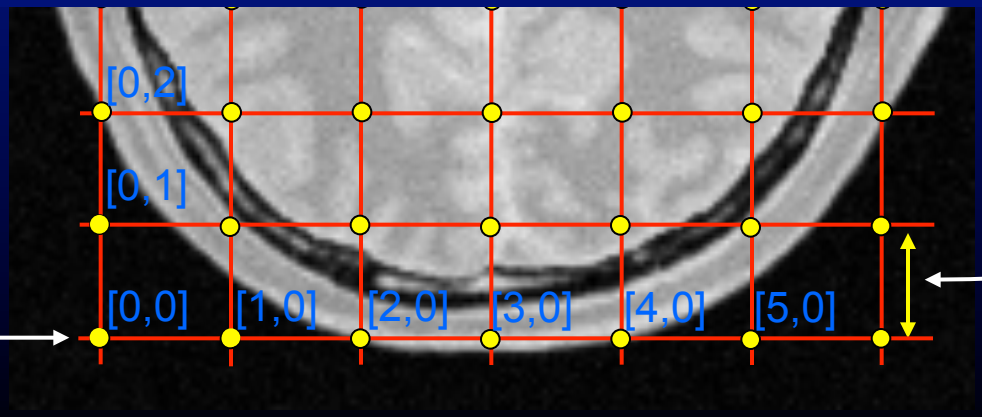


Image Region

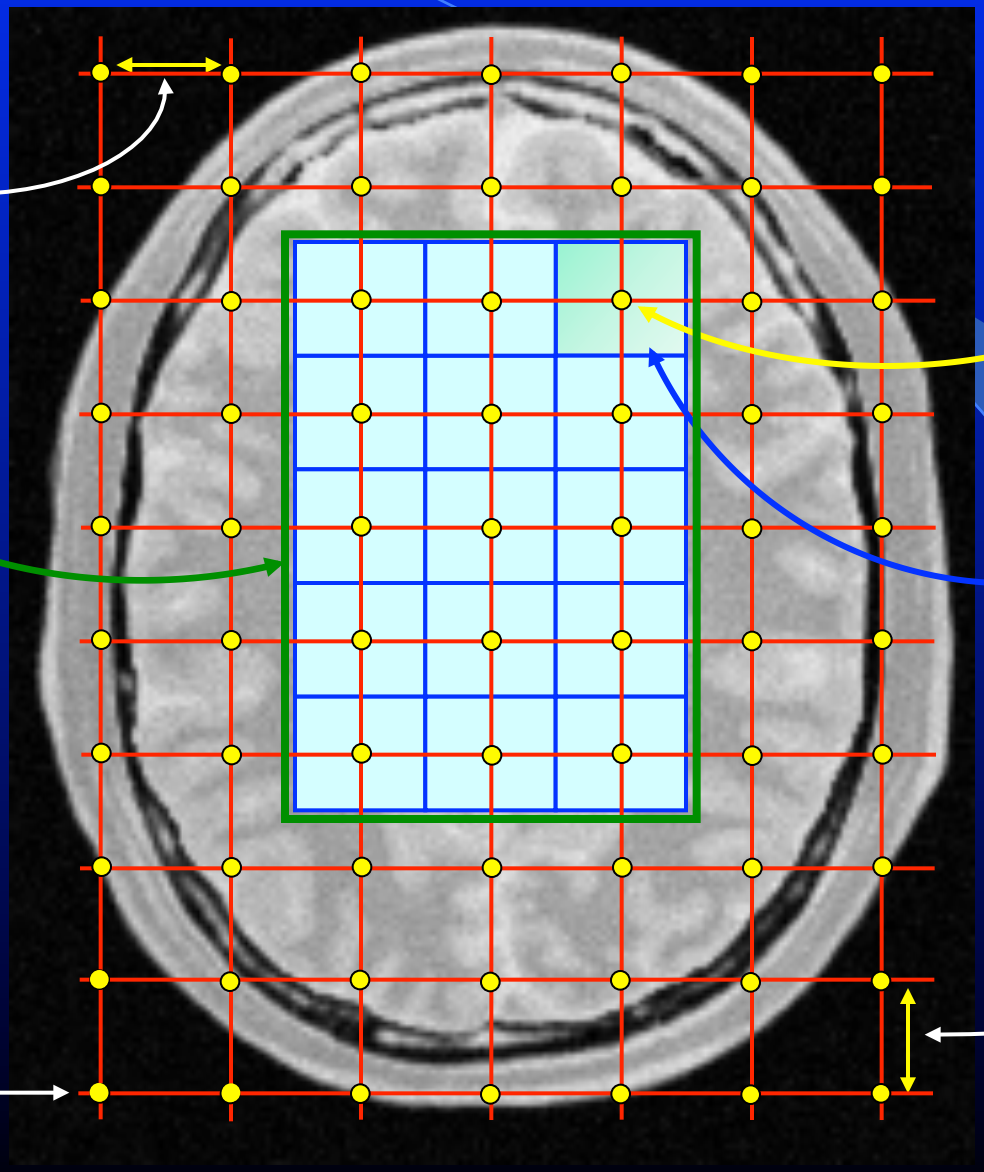
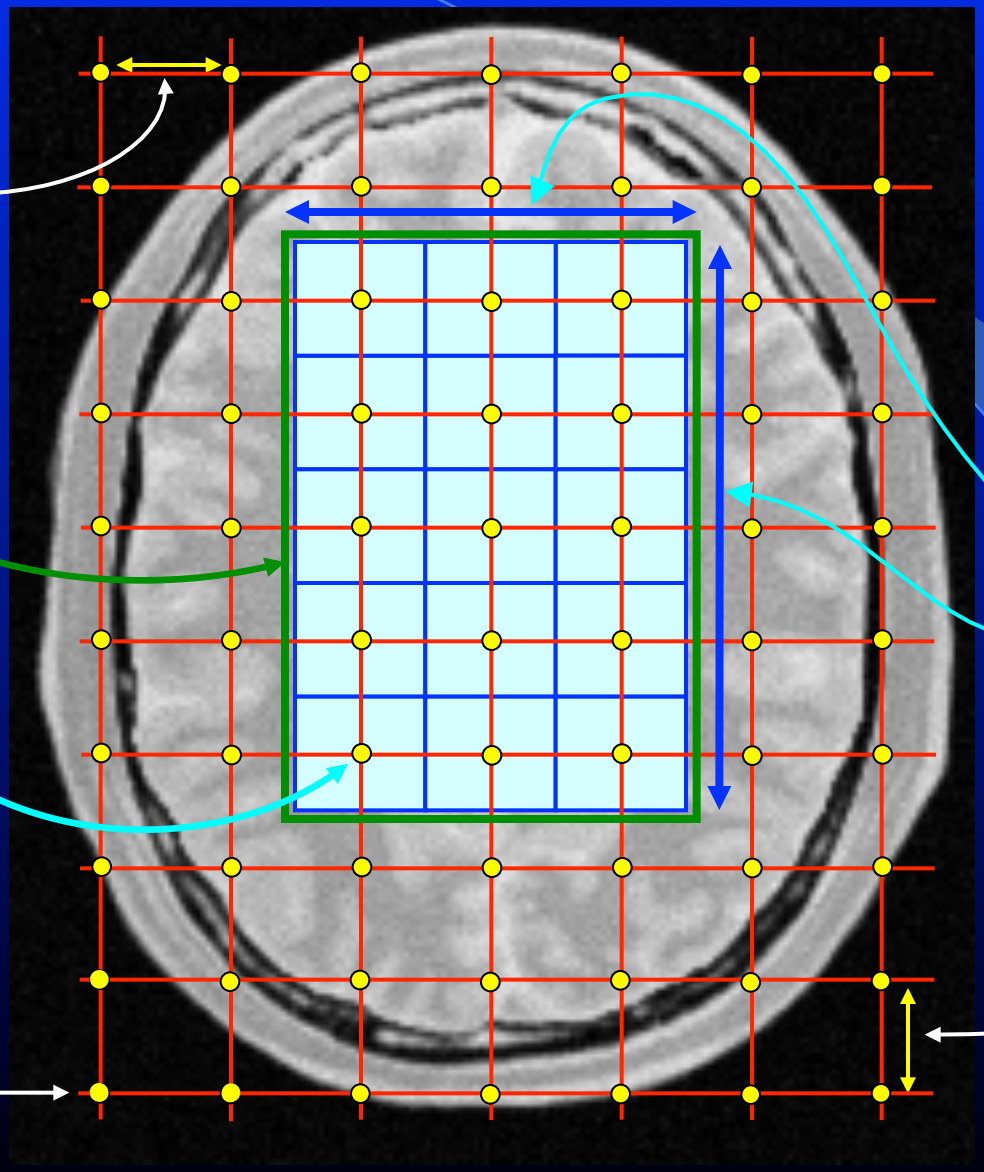


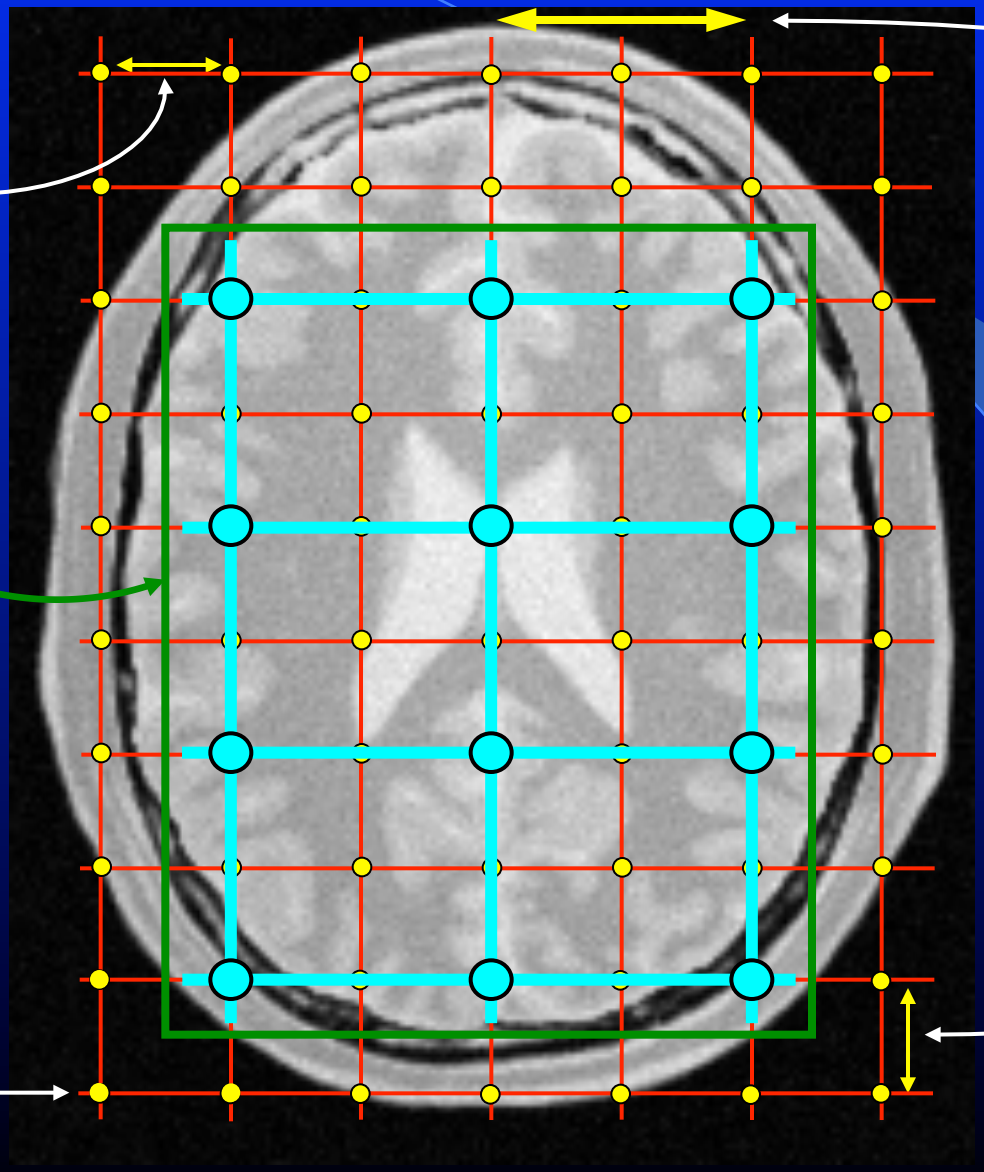
Image Region



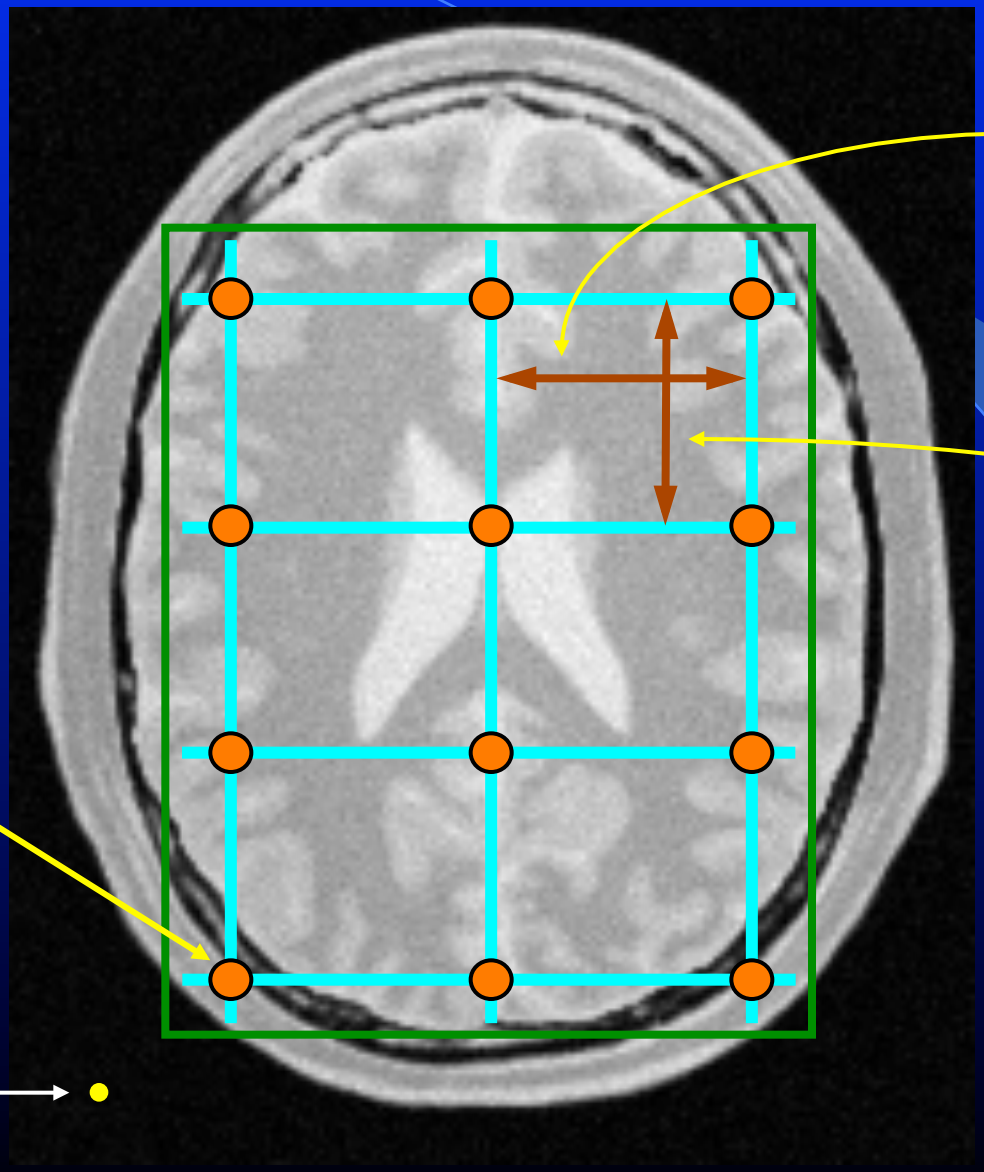
Basic Resampling

Resampling
Trivial Cases

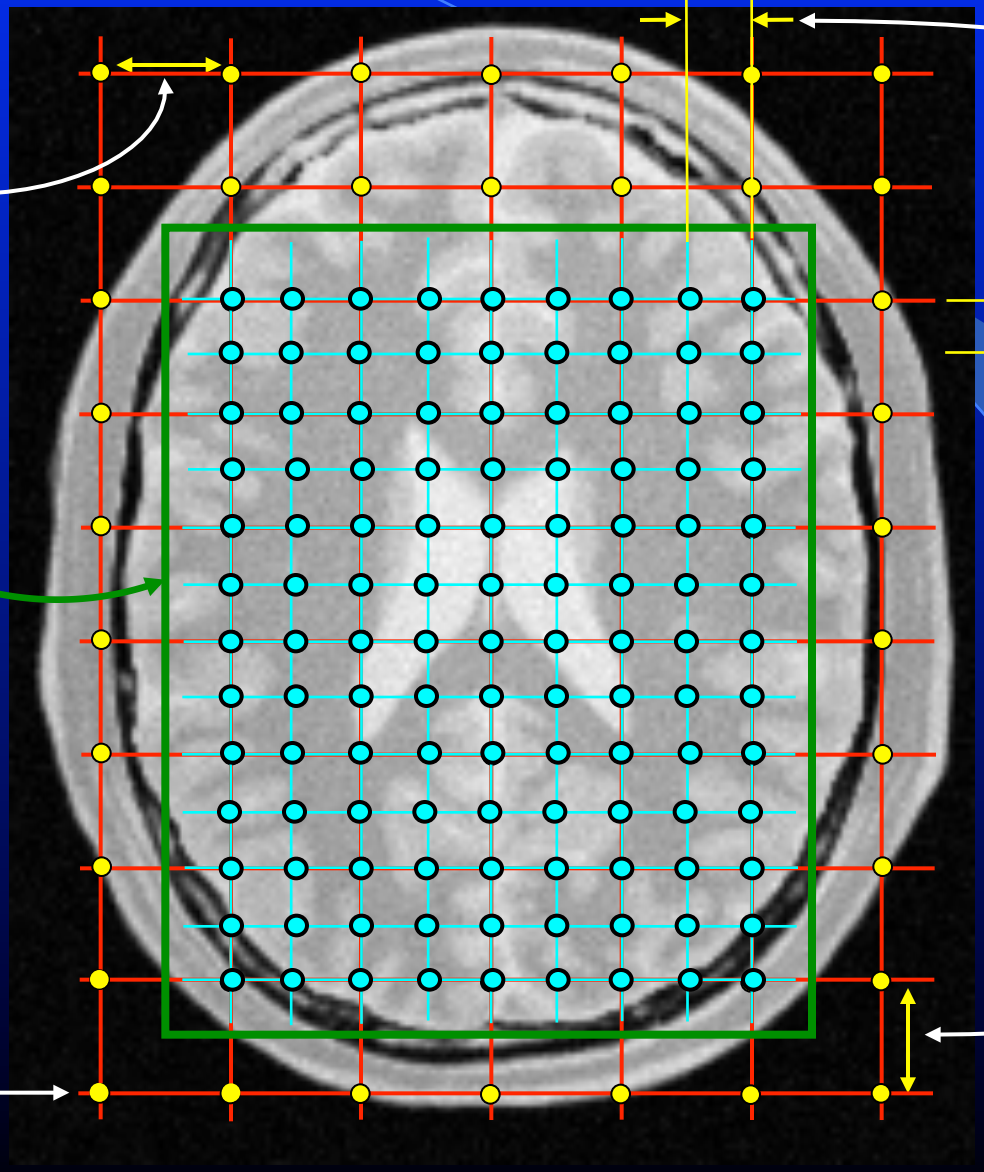
Sub-Sampling by Half



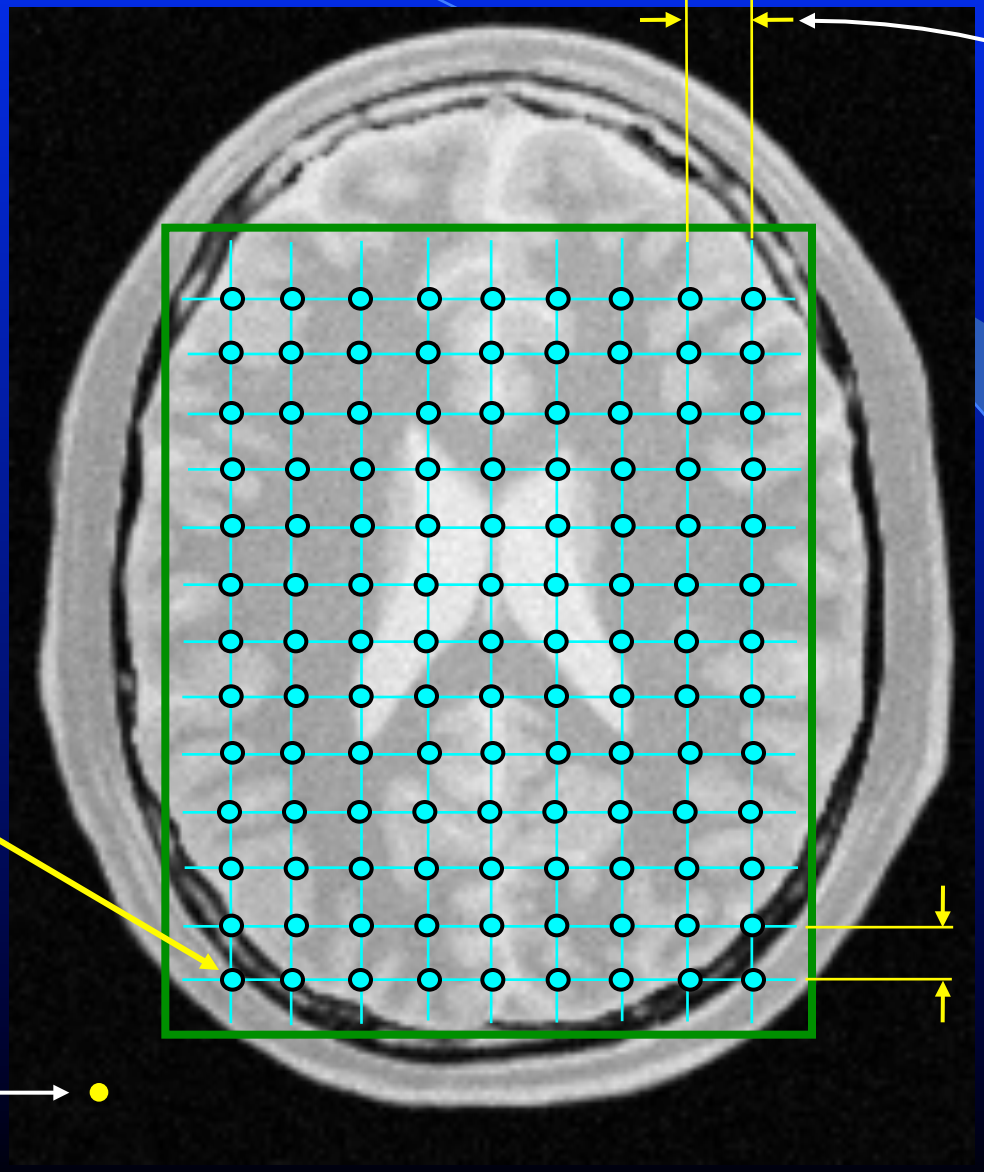
Sub-Sampling by Half



Super-Sampling by Double



Super-Sampling by Double



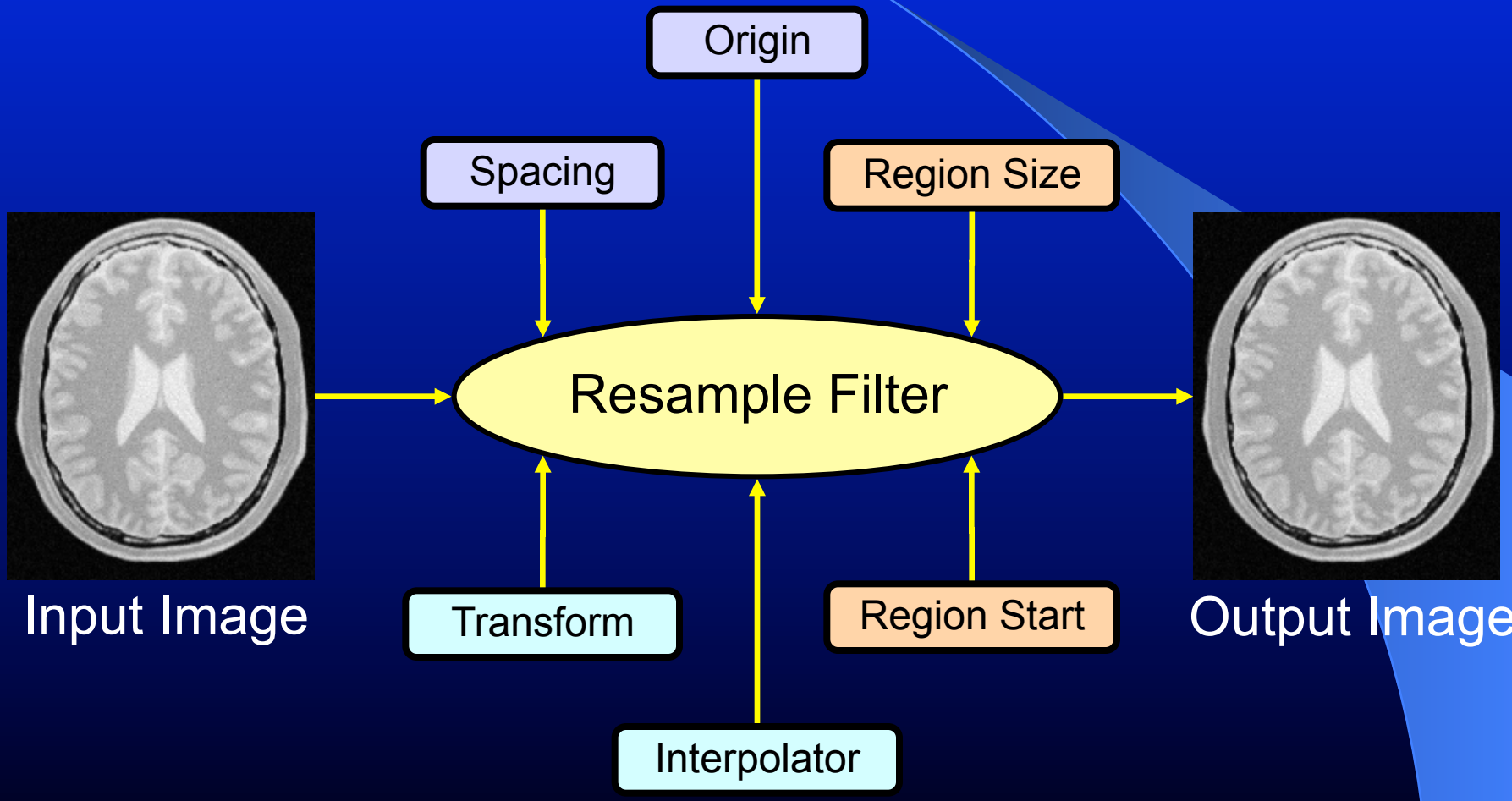
New Spacing
S'x

New Origin
(O'x,O'y)

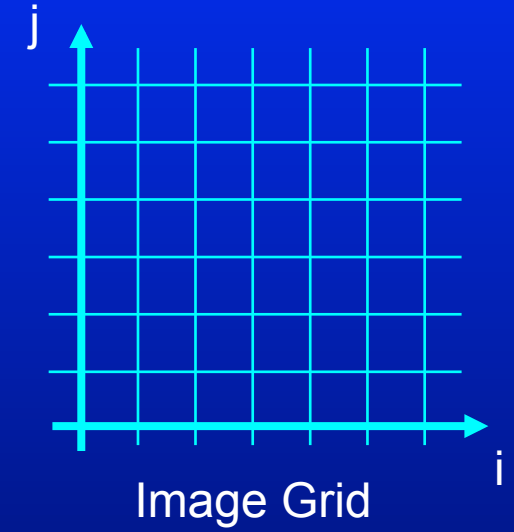
New Spacing
S'y

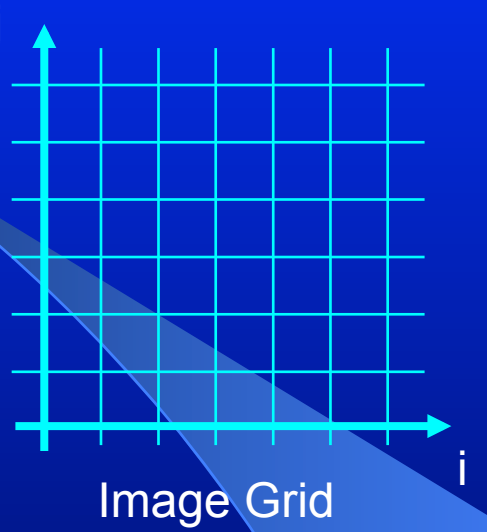
Origin (Ox,Oy)

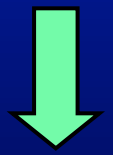
Resampling in ITK

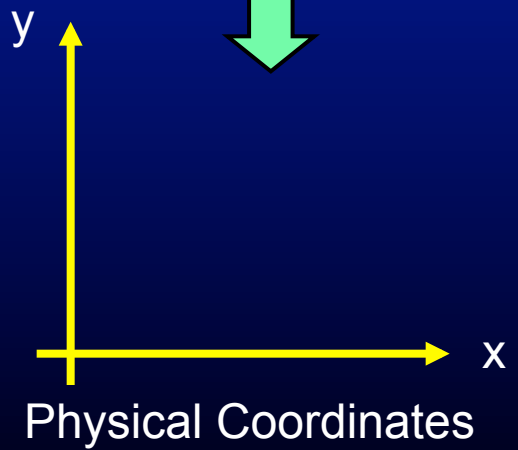


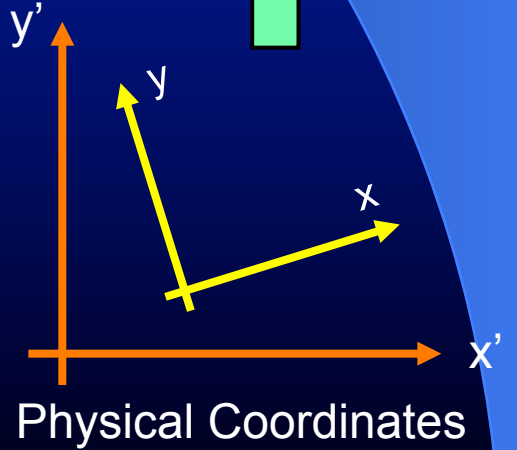
Coordinate System Conversions







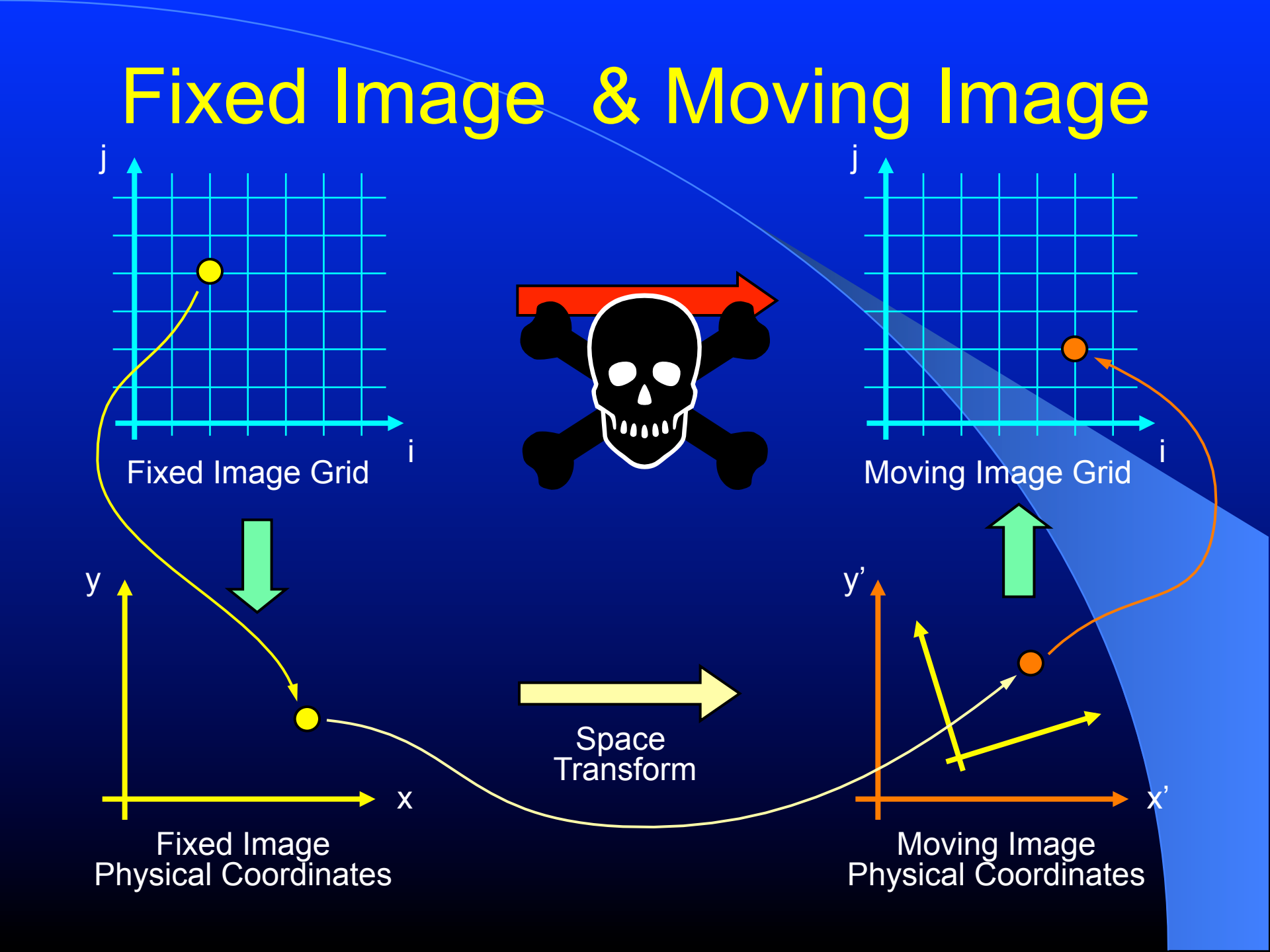




Things I will not do…

I will not register images in pixel space
I will not register images in pixel space
I will not register images in pixel space
I will not register images in pixel space
I will not register images in pixel space
I will not register images in pix

Fixed Image & Moving Image



Registration Framework

Components

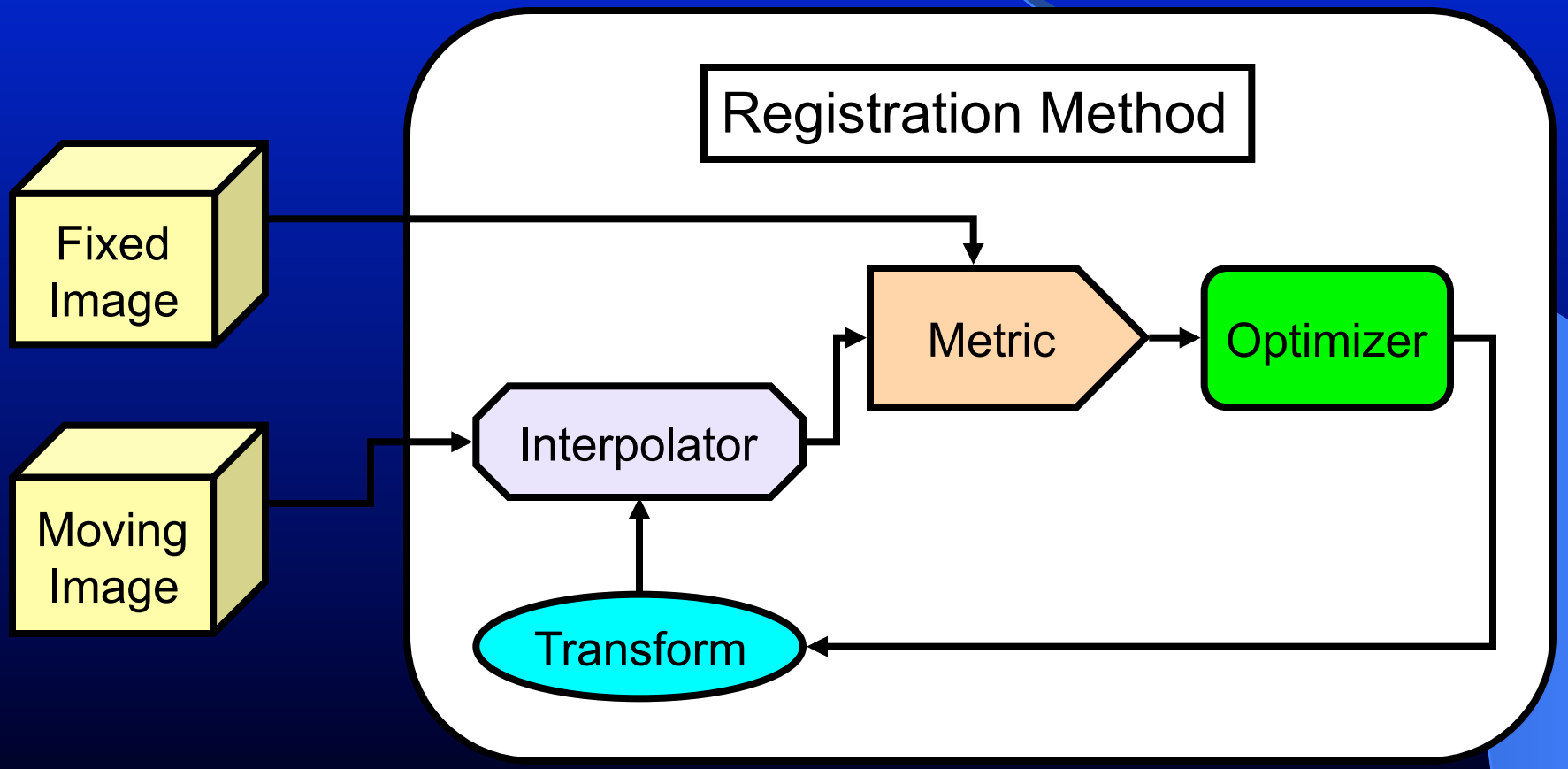

Registration Method
Fixed Image
Moving Image
Interpolator
Metric
Optimizer
Transform

Image Metrics

- Mean Squares
- Normalized Correlation
- Mean Reciprocal Square Difference
- Mutual Information
  - Viola-Wells
  - Mattes
  - Histogram based
  - Histogram normalized

Transforms

- Translation
- Scaling
- Rotation
- Rigid3D
- Rigid2D
- Affine
- BSplines
- Splines: TPS, EBS, VS

Optimizers

- Gradient Descent
- Regular Step Gradient Descent
- Conjugate Gradient
- Levenberg-Marquardt
- One plus One Evolutionary Algorithm

Interpolators

- Nearest Neighbor
- Linear
- BSpline

Image Metrics

How similar is

image A to image B ?

Image Metrics

Does Image B

matche Image A better

than Image C ?

Image Metrics

Match(A , B) < > Match(A , C)

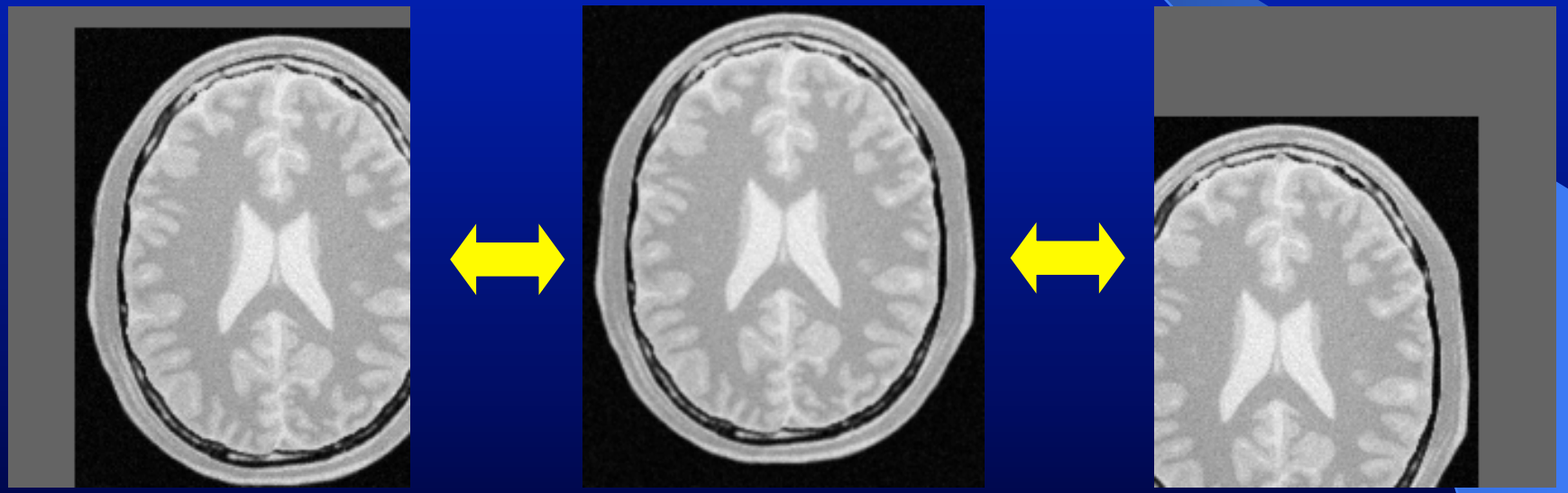


Image B Image A Image C

Image Metrics

Match(A , B)

Simplest Metric

Mean Squared Differences

Mean Squared Differences

For each pixel in A

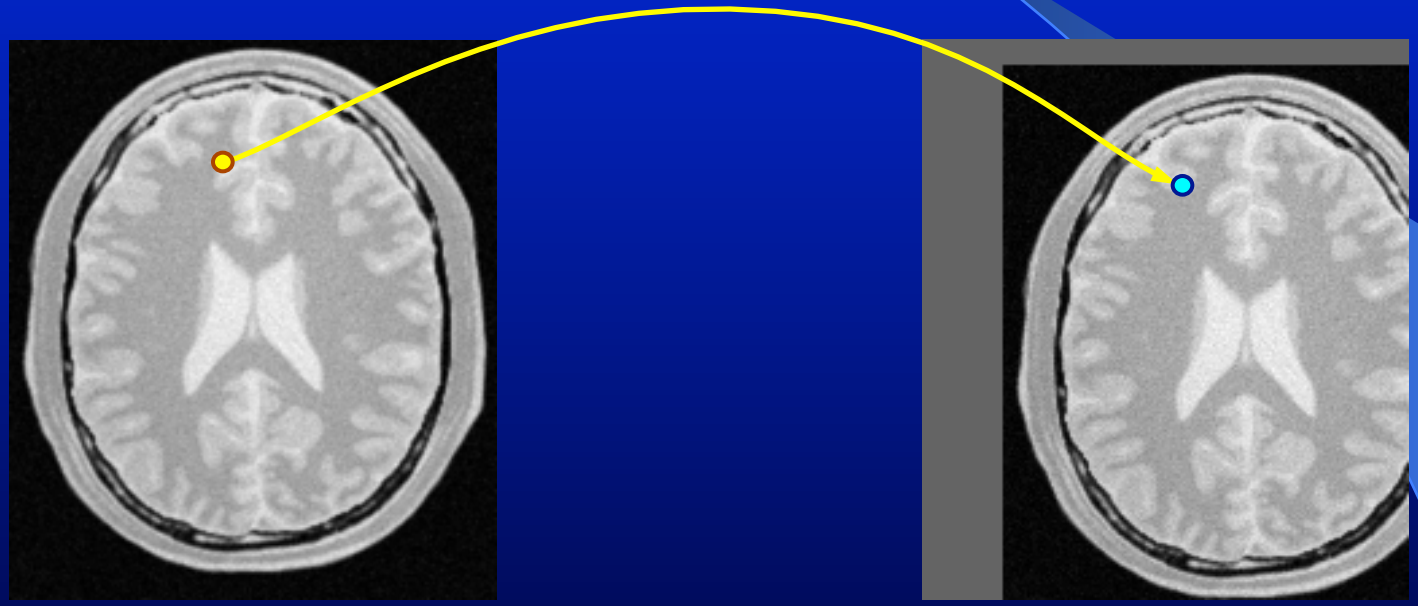


Image A

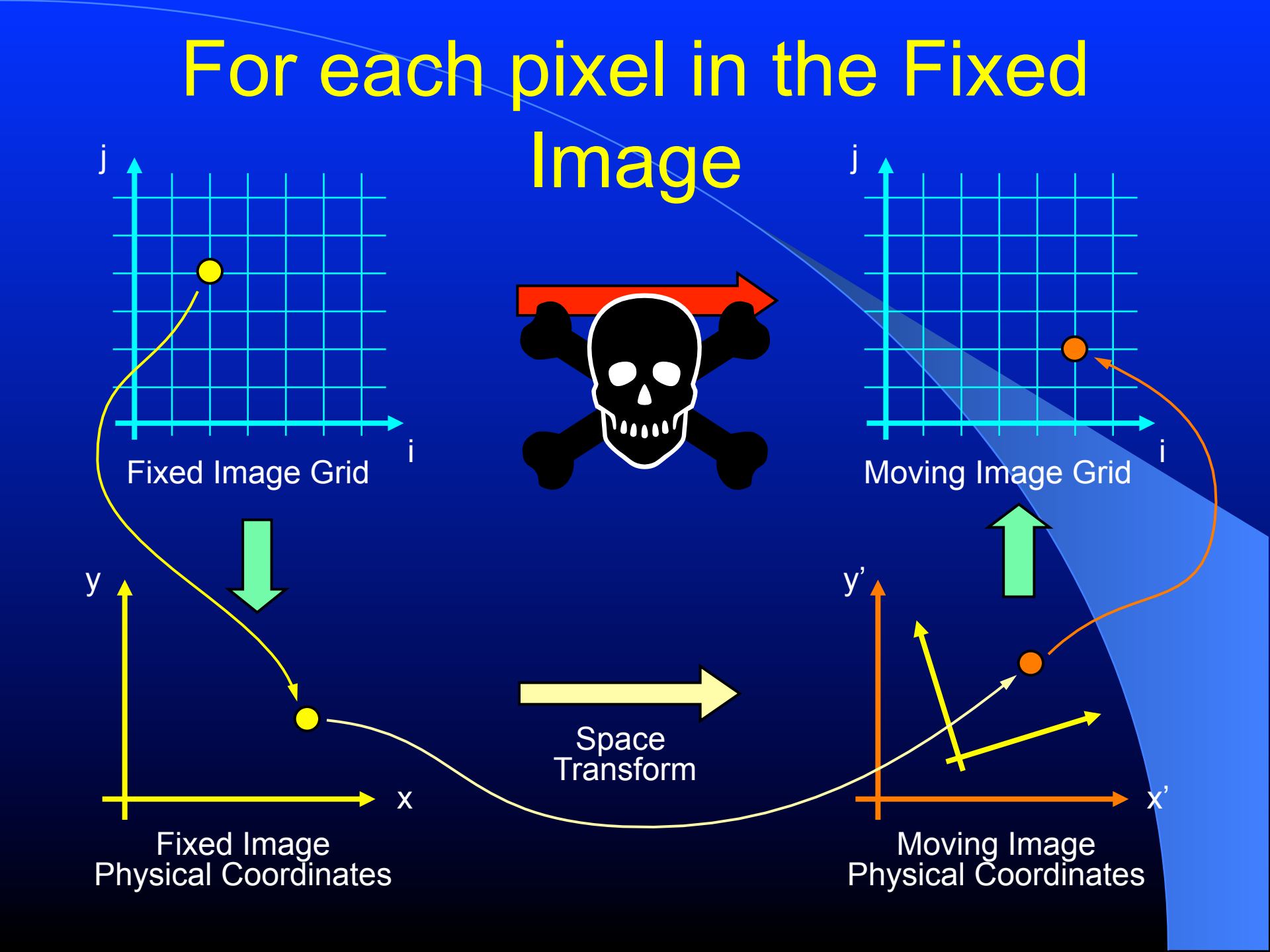
Image B

$$Difference(index) = A(index) - B(index)$$

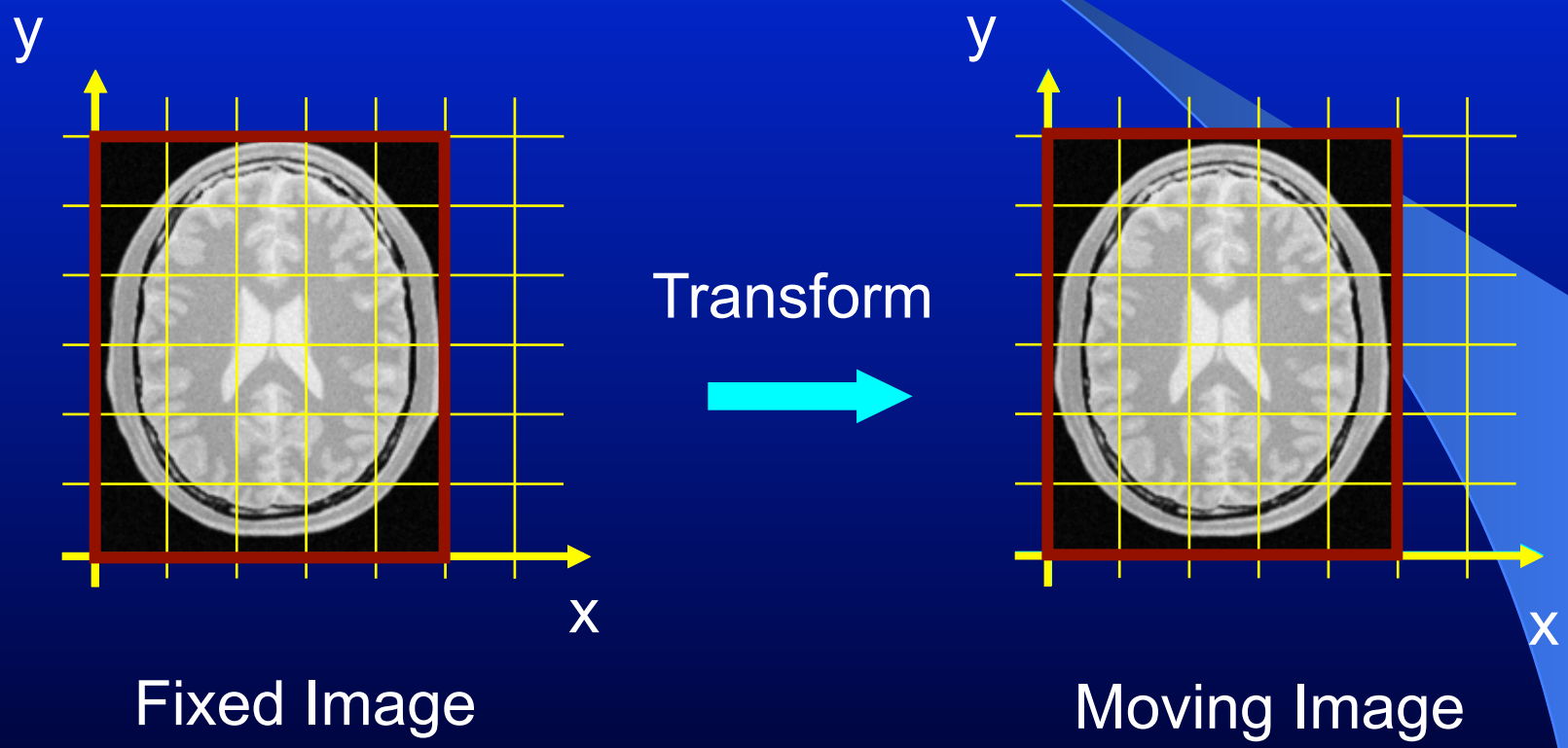
$$Sum \mathrel{+}= Difference(index)^2$$

$$Match(A , B) = Sum / numberOfPixels$$

For each pixel in the Fixed Image

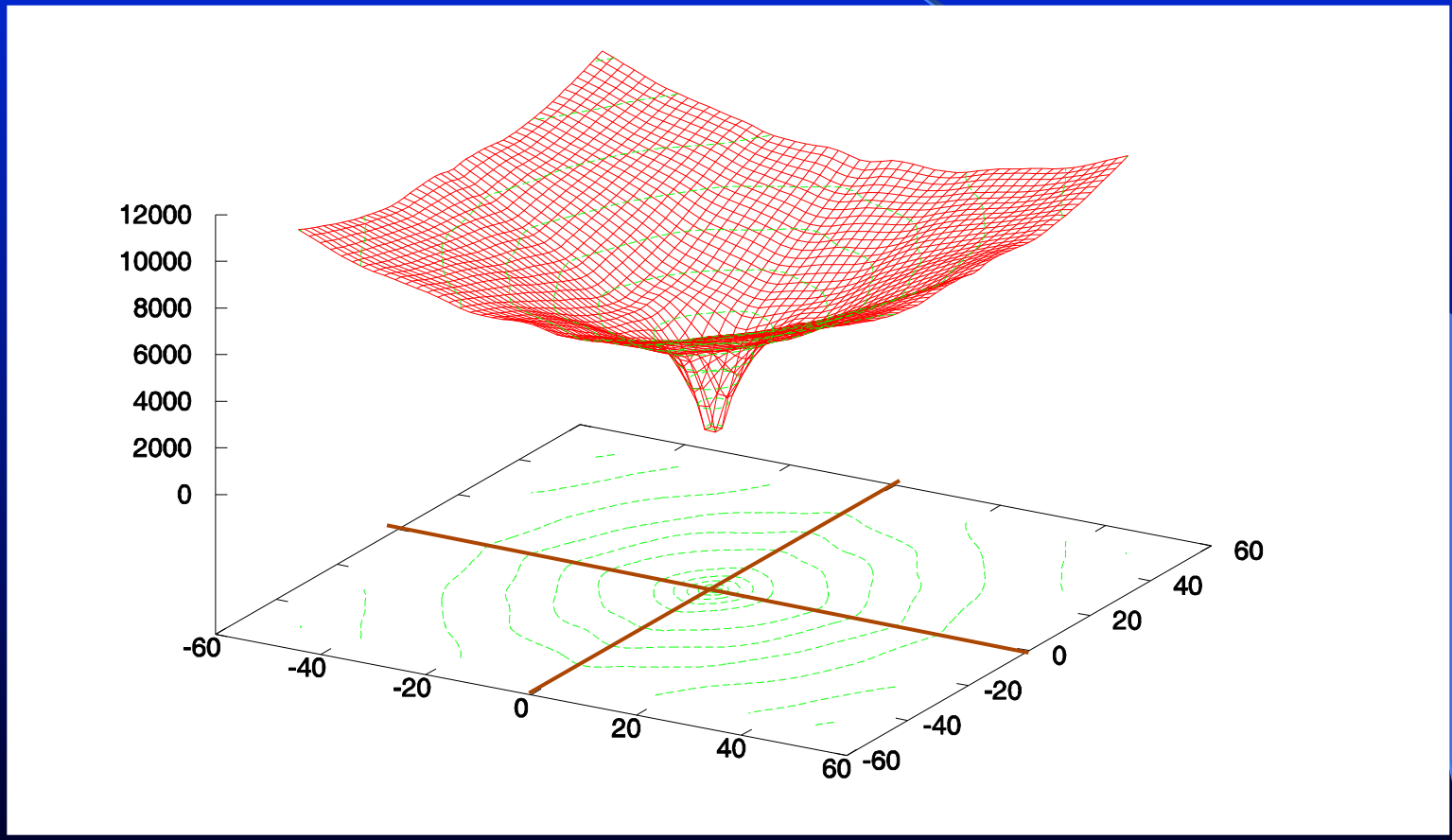


Evaluating many matches



Plotting the Metric

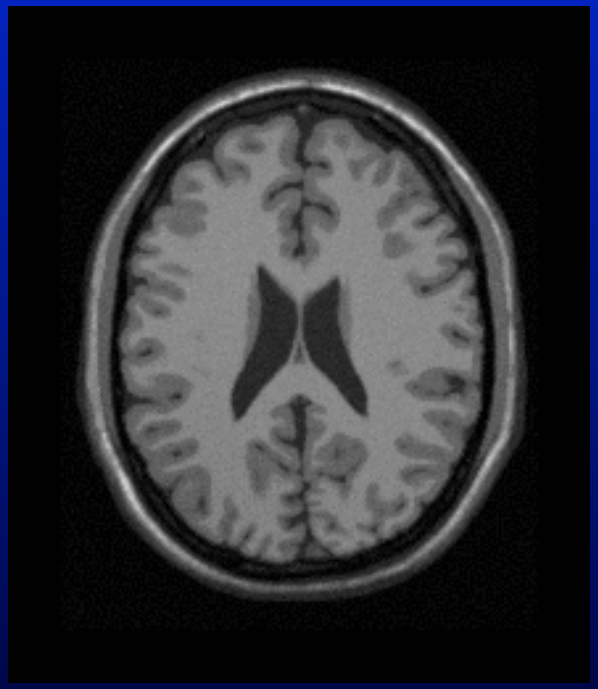
Mean Squared Differences



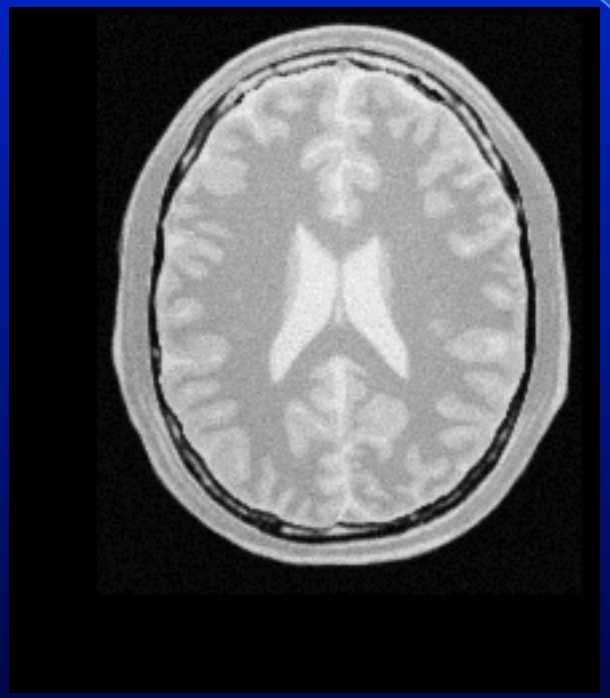
Transform Parametric Space

Multi - Modality

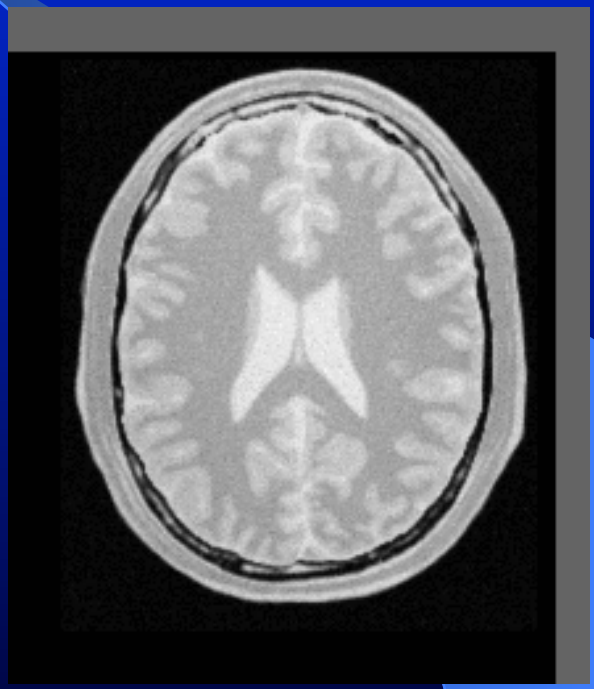
Multi-Modality Registration



Fixed Image

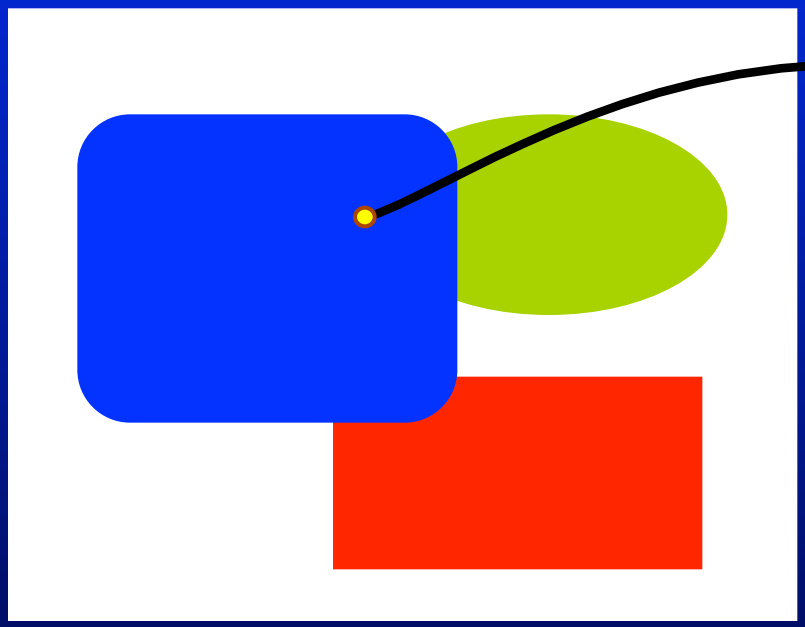


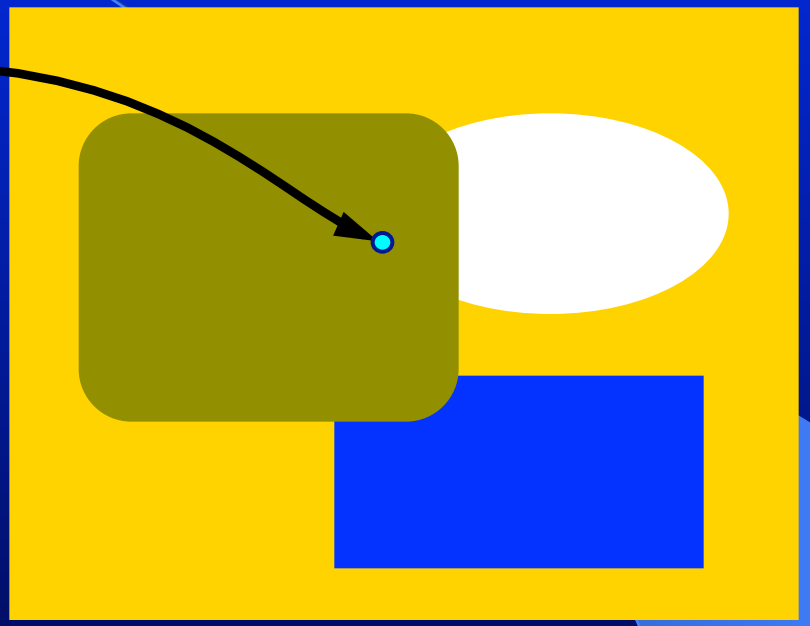
Moving Image

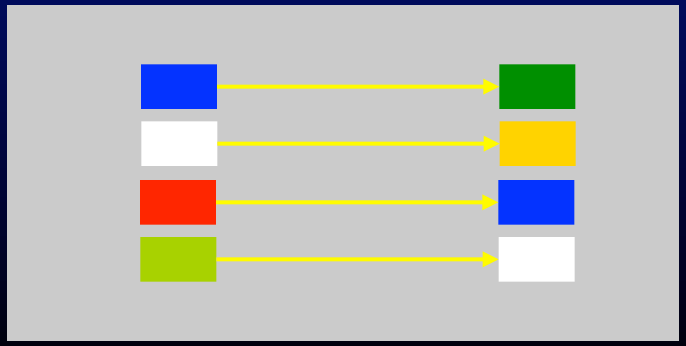


Registered
Moving Image

Multiple Image Modalities

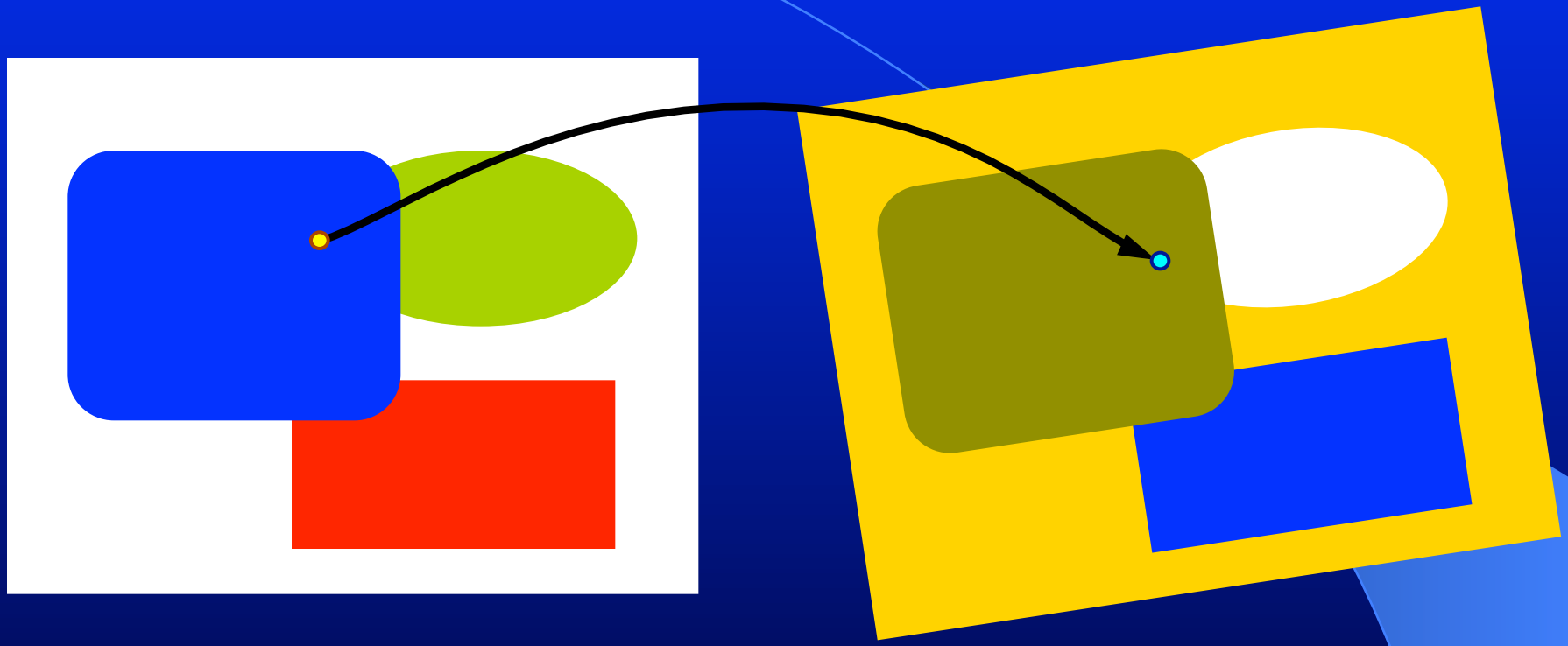


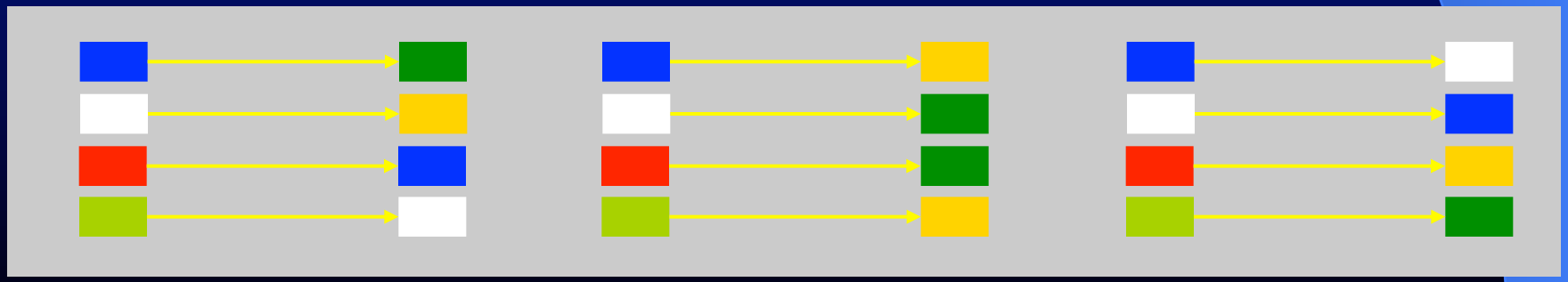




Number of pairs

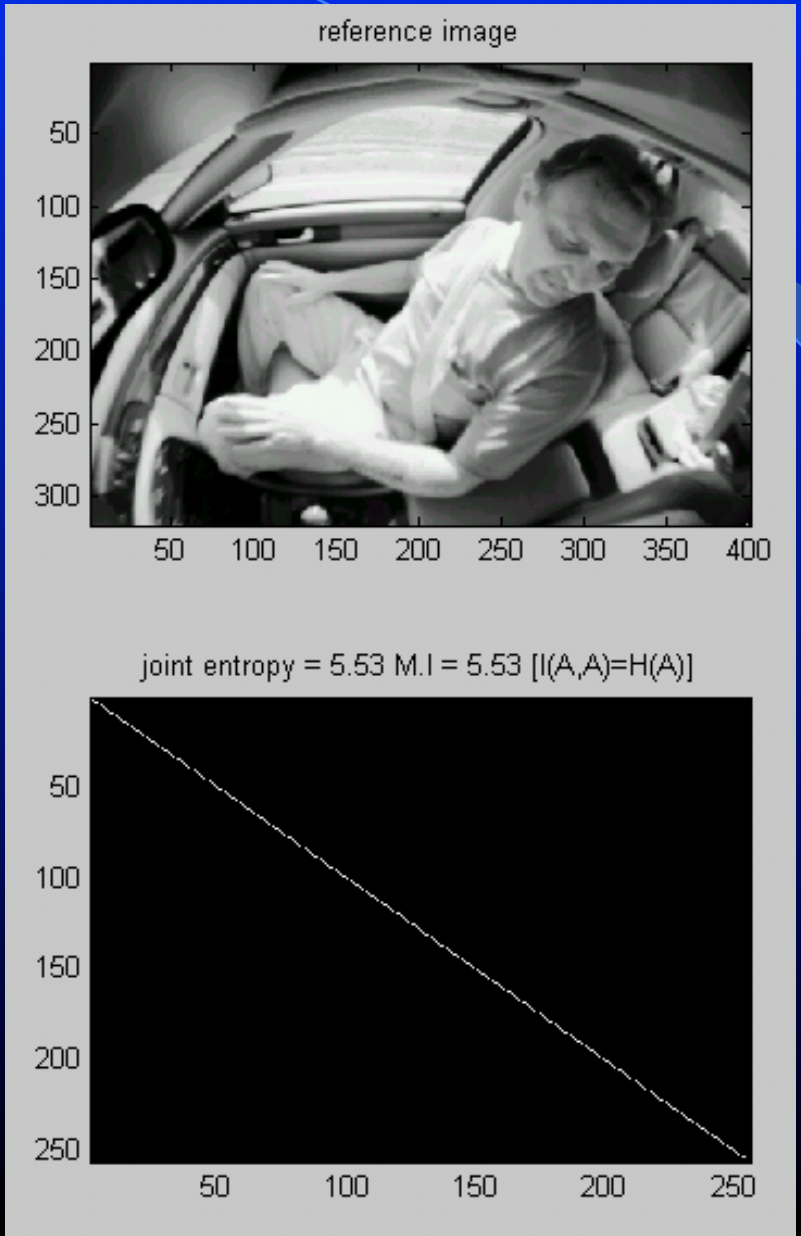
Multiple Image Modalities





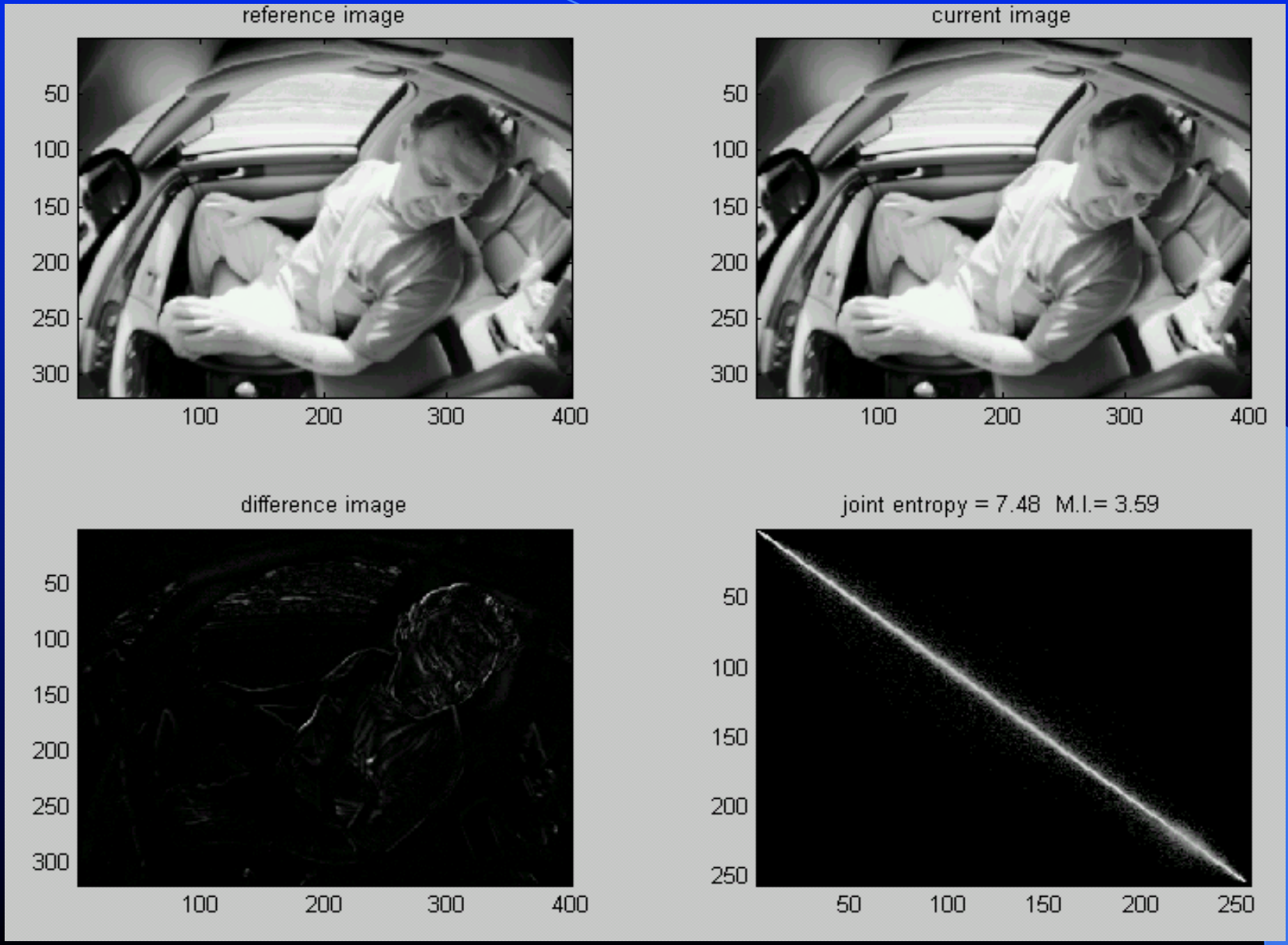
More possible pairs

M.I. for Image Registration



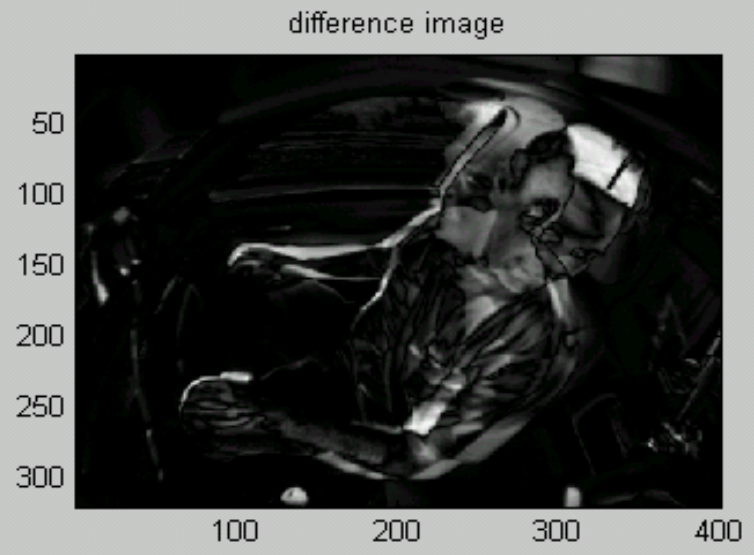
www.cse.msu.edu/~cse902/S03/mut_info.ppt

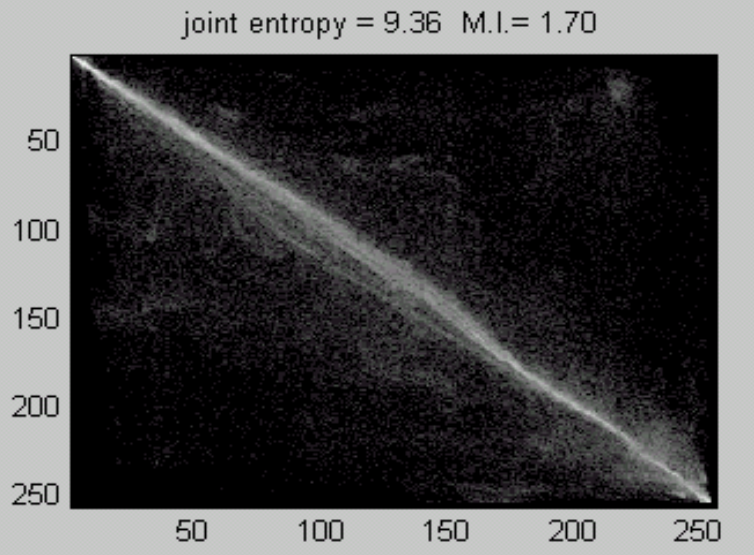
M.I. for Image Registration



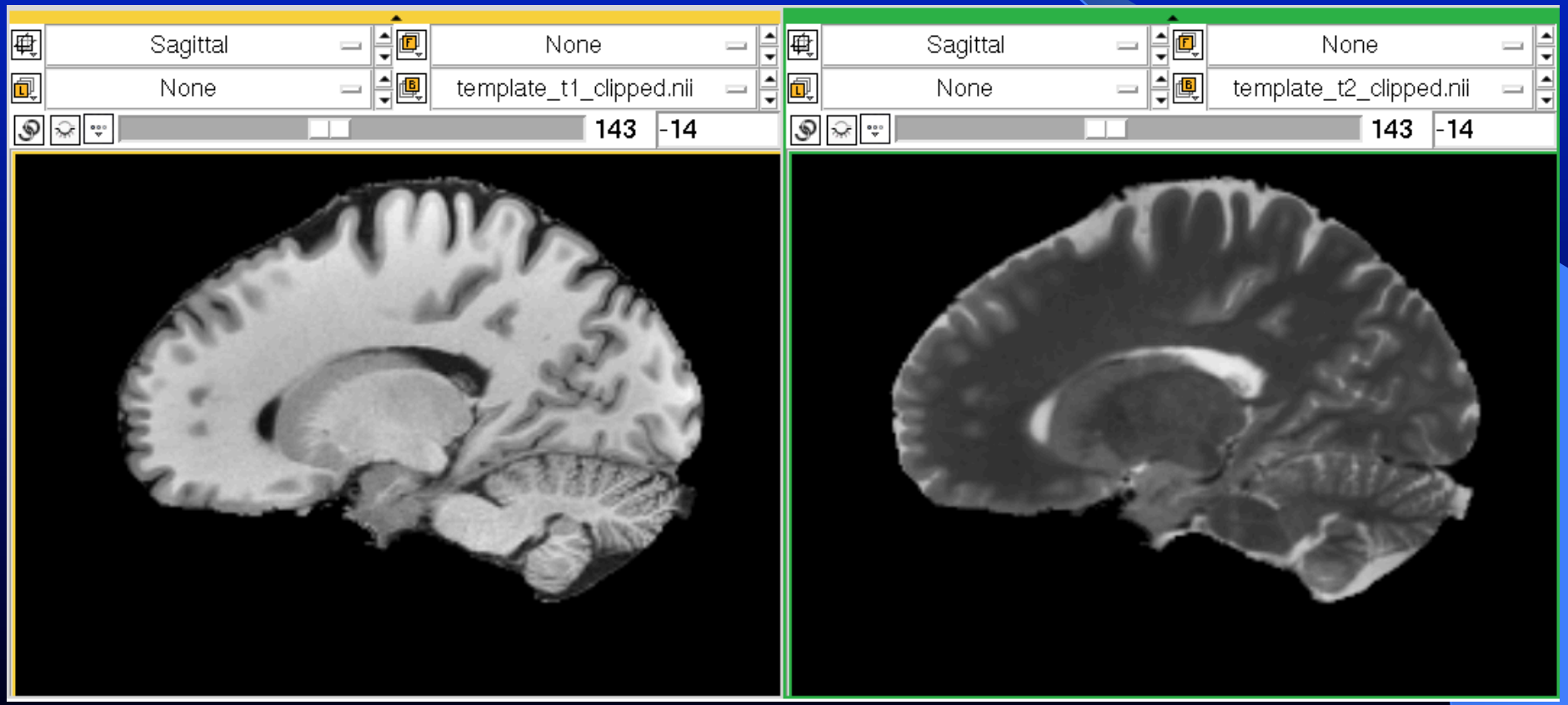
www.cse.msu.edu/~cse902/S03/mut_info.ppt

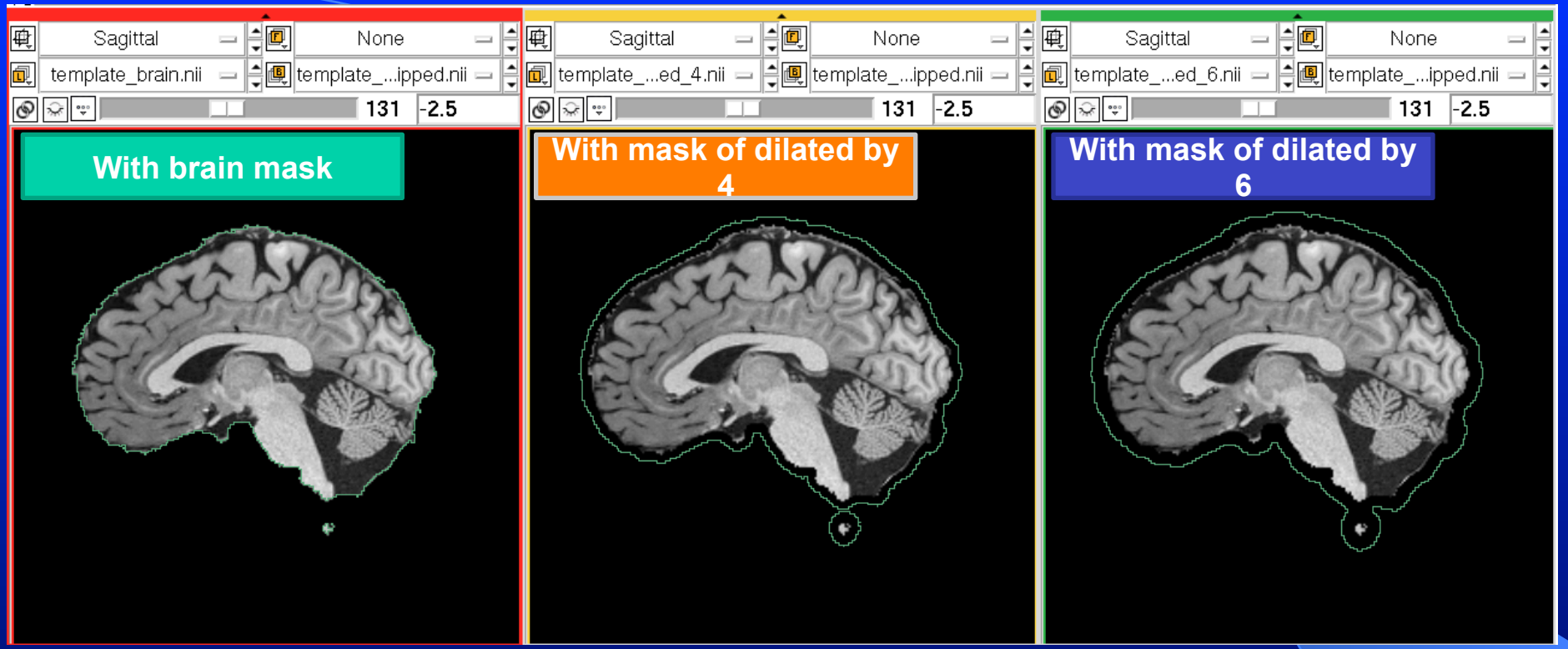
M.I. for Image Registration

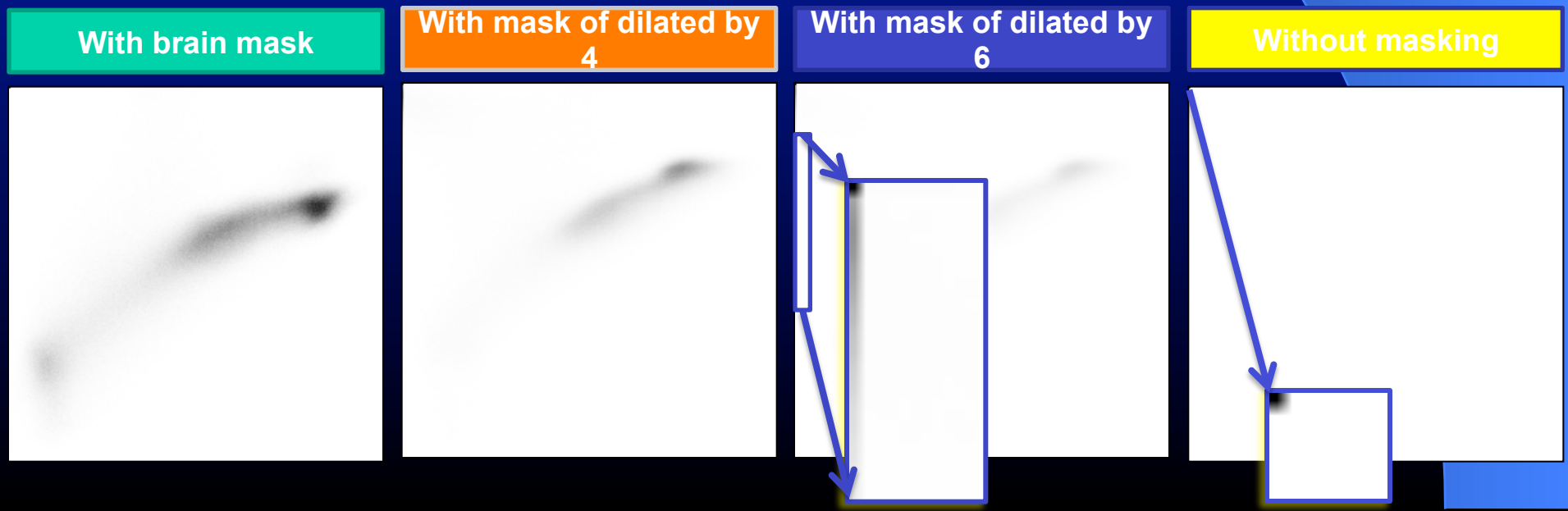




Register T1 & T2




Sagittal
None
template_brain.nii
template_...ipped.nii
131
-2.5
With brain mask
Sagittal
None
template_...ed_4.nii
template_...ipped.nii
131
-2.5
With mask of dilated by 4
Sagittal
None
template_...ed_6.nii
template_...ipped.nii
131
-2.5
With mask of dilated by 6


With brain mask
With mask of dilated by 4
With mask of dilated by 6
Without masking