Introduction to Image Registration in ITK

Kitware

Outline

- Image Resampling
- Registration Overview
- Registration Framework

Image Resampling

Image Origin and Spacing

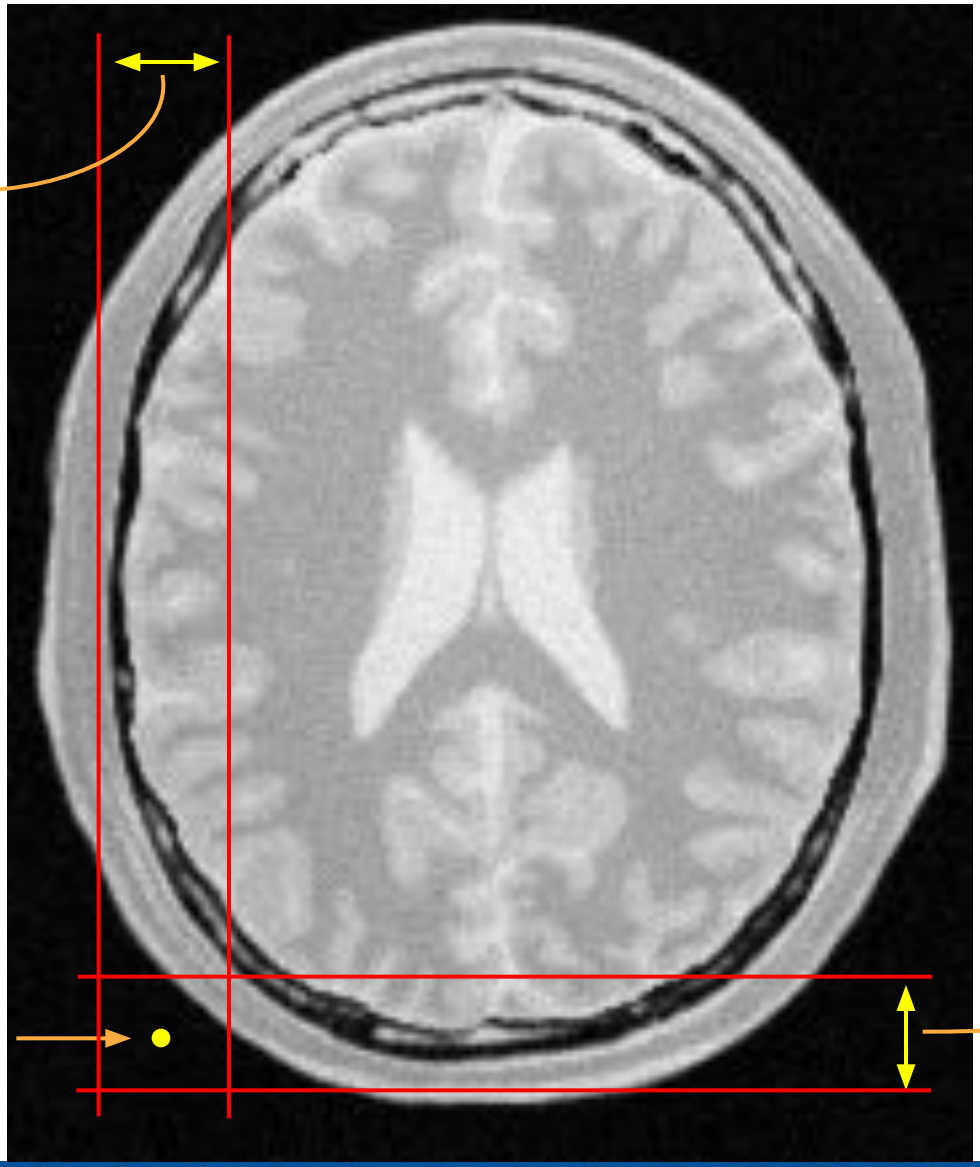

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Image Sampling Grid

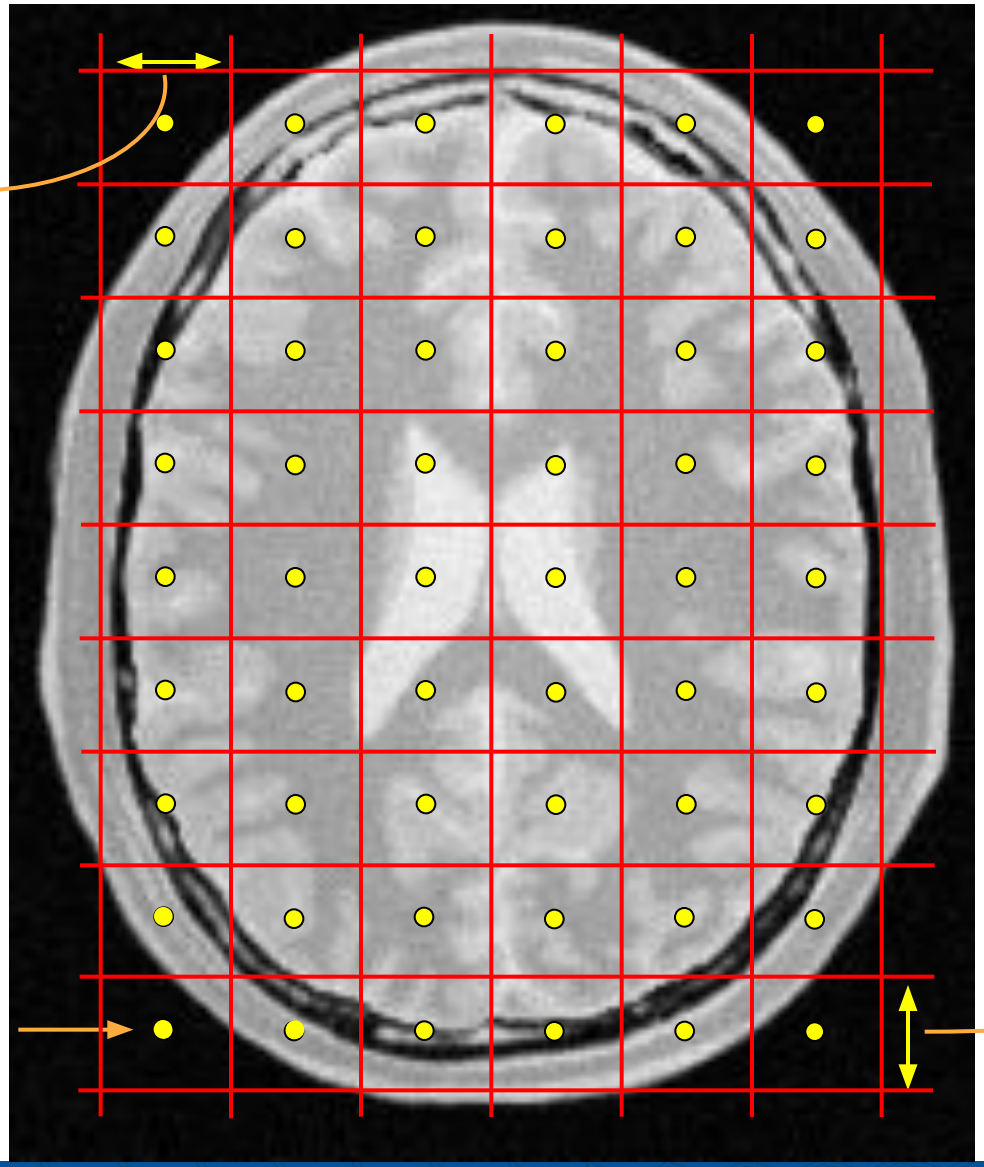

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Image Pixel

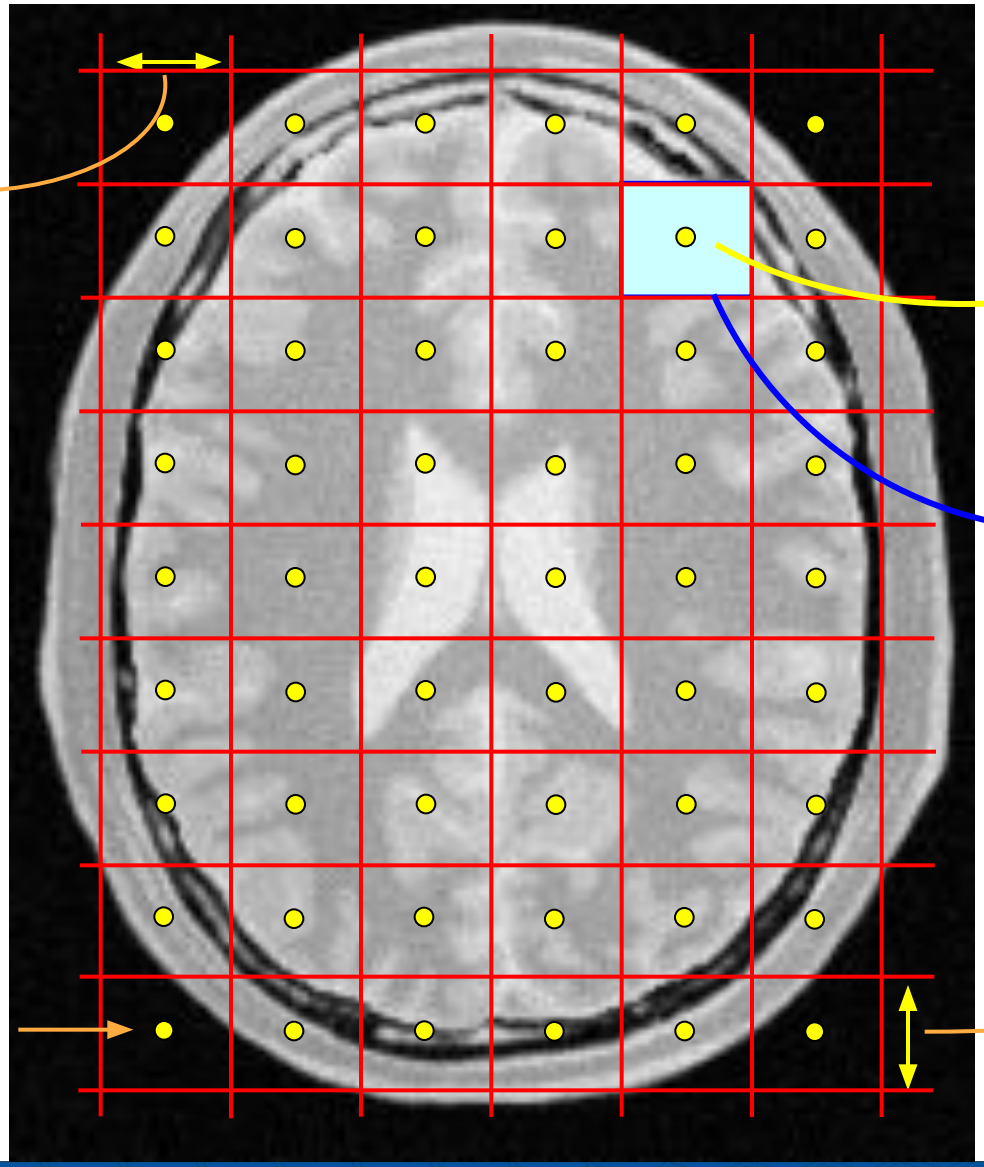

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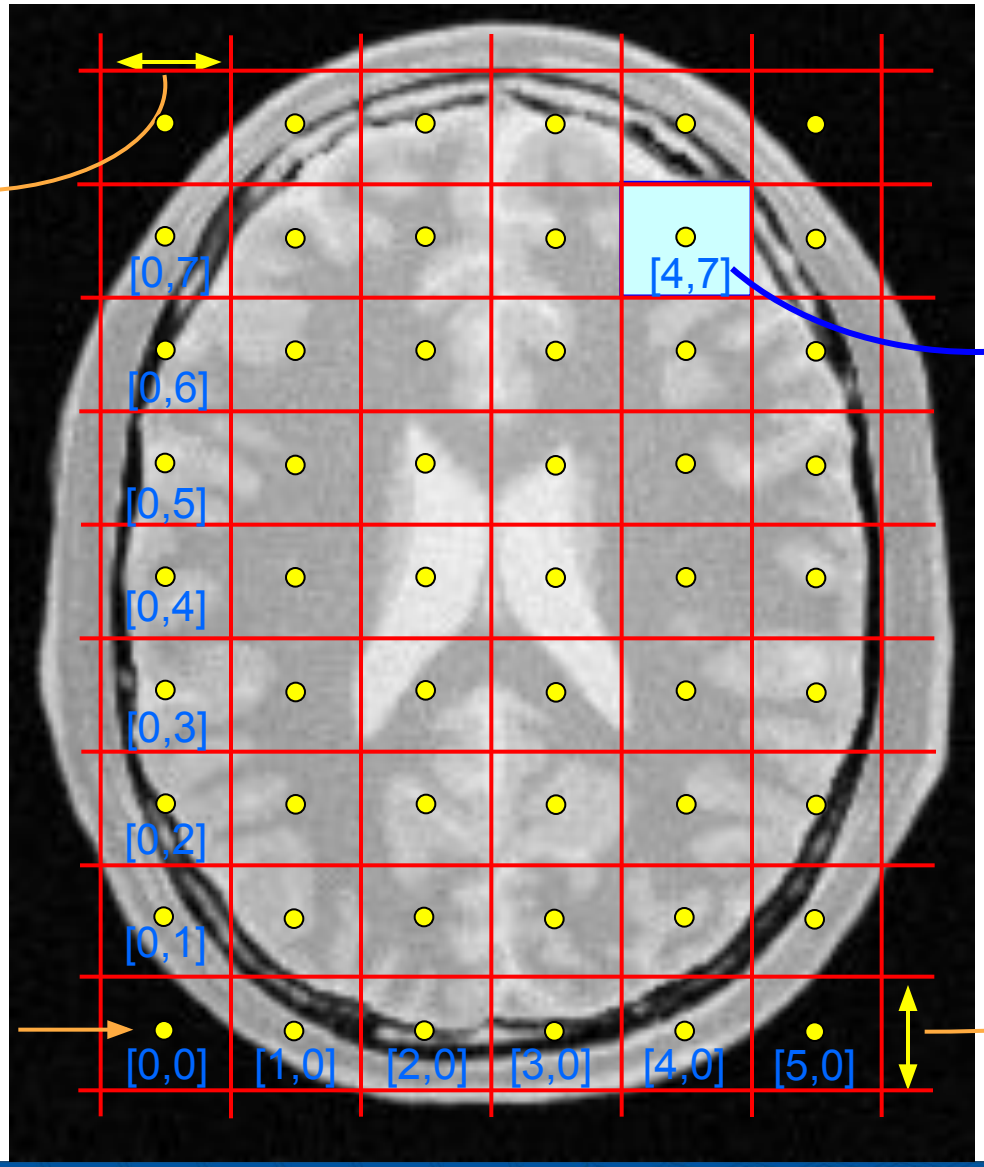
Image Indices



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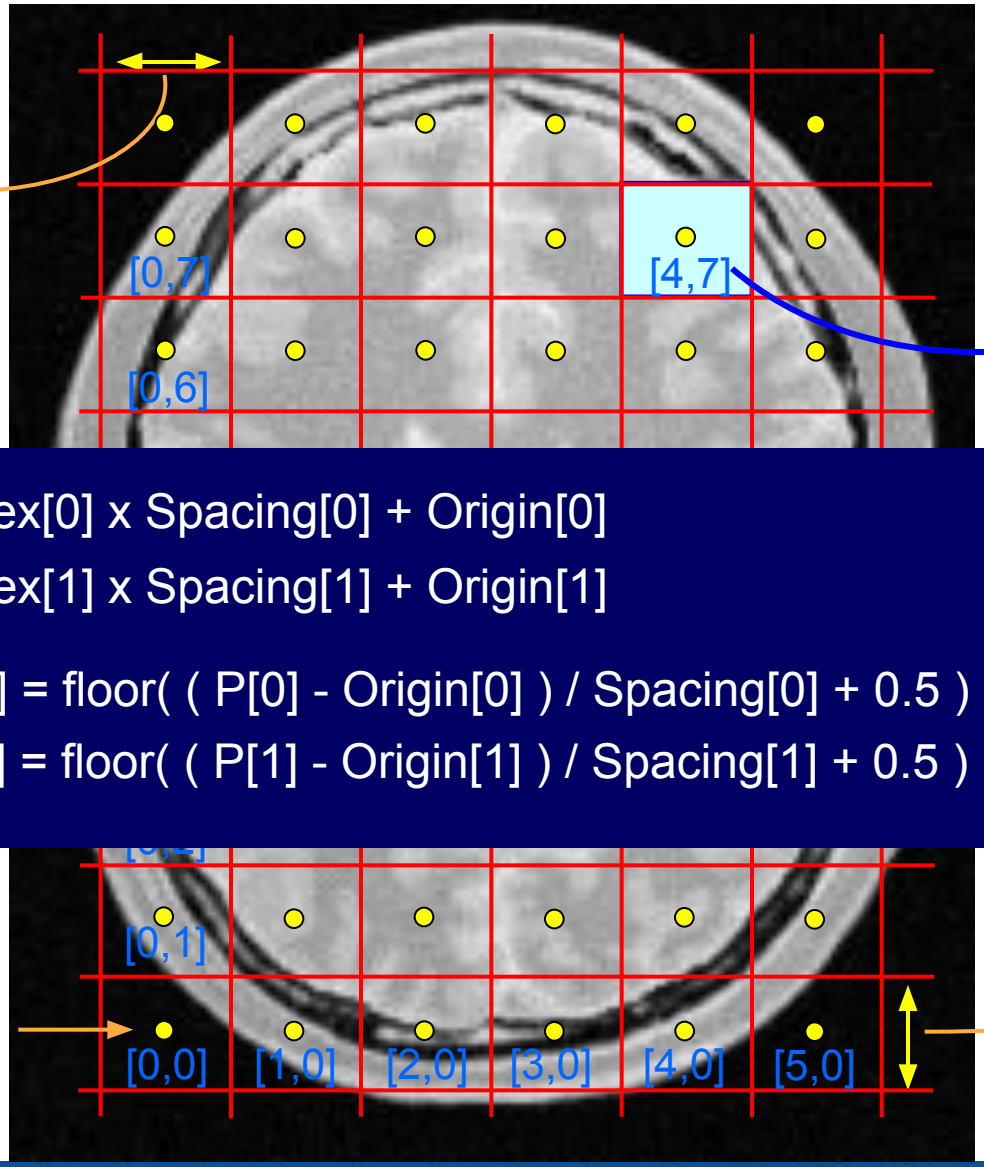
Index to Physical Coordinates



$$P[0] = Index[0] \times Spacing[0] + Origin[0]$$

$$P[1] = Index[1] \times Spacing[1] + Origin[1]$$

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

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

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Image Region

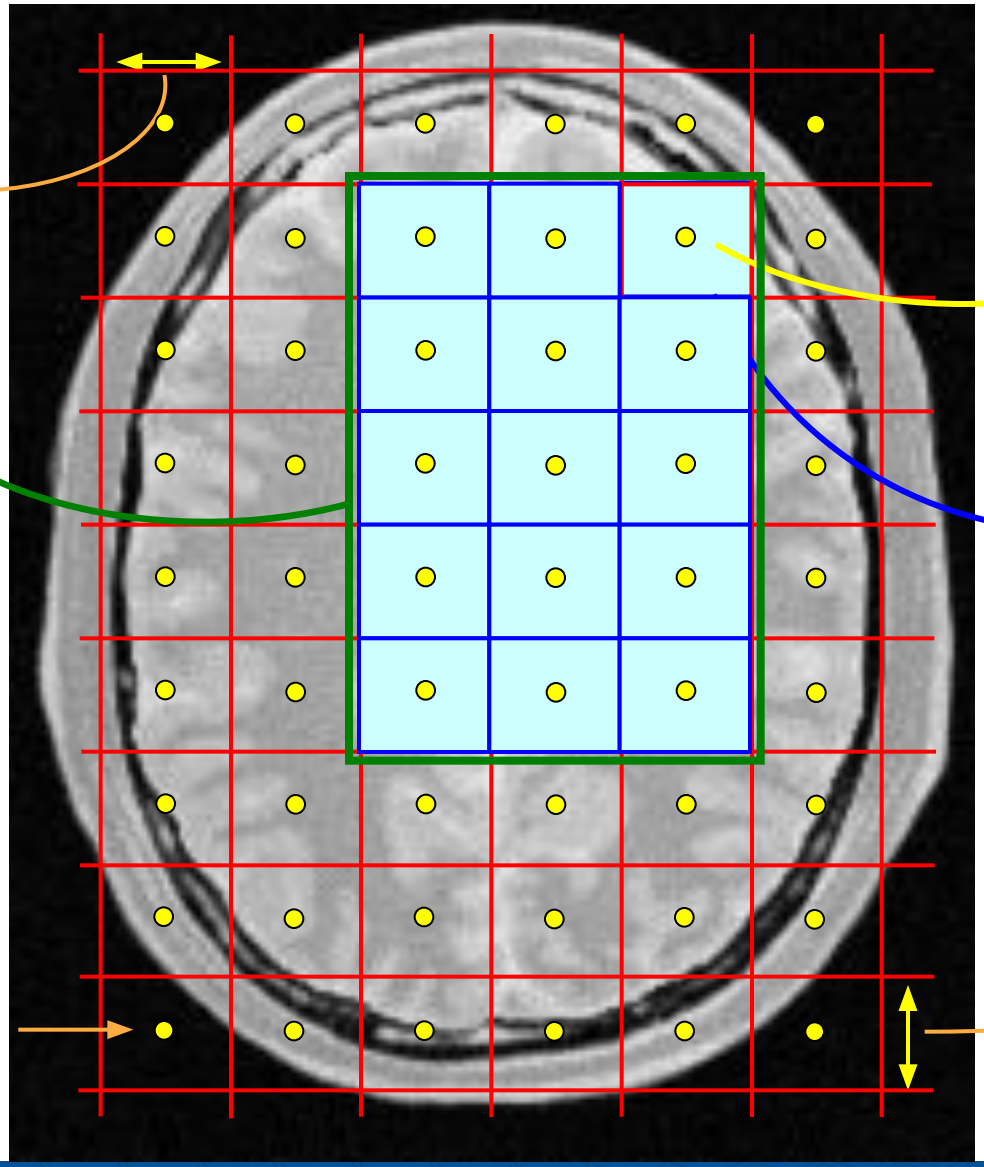

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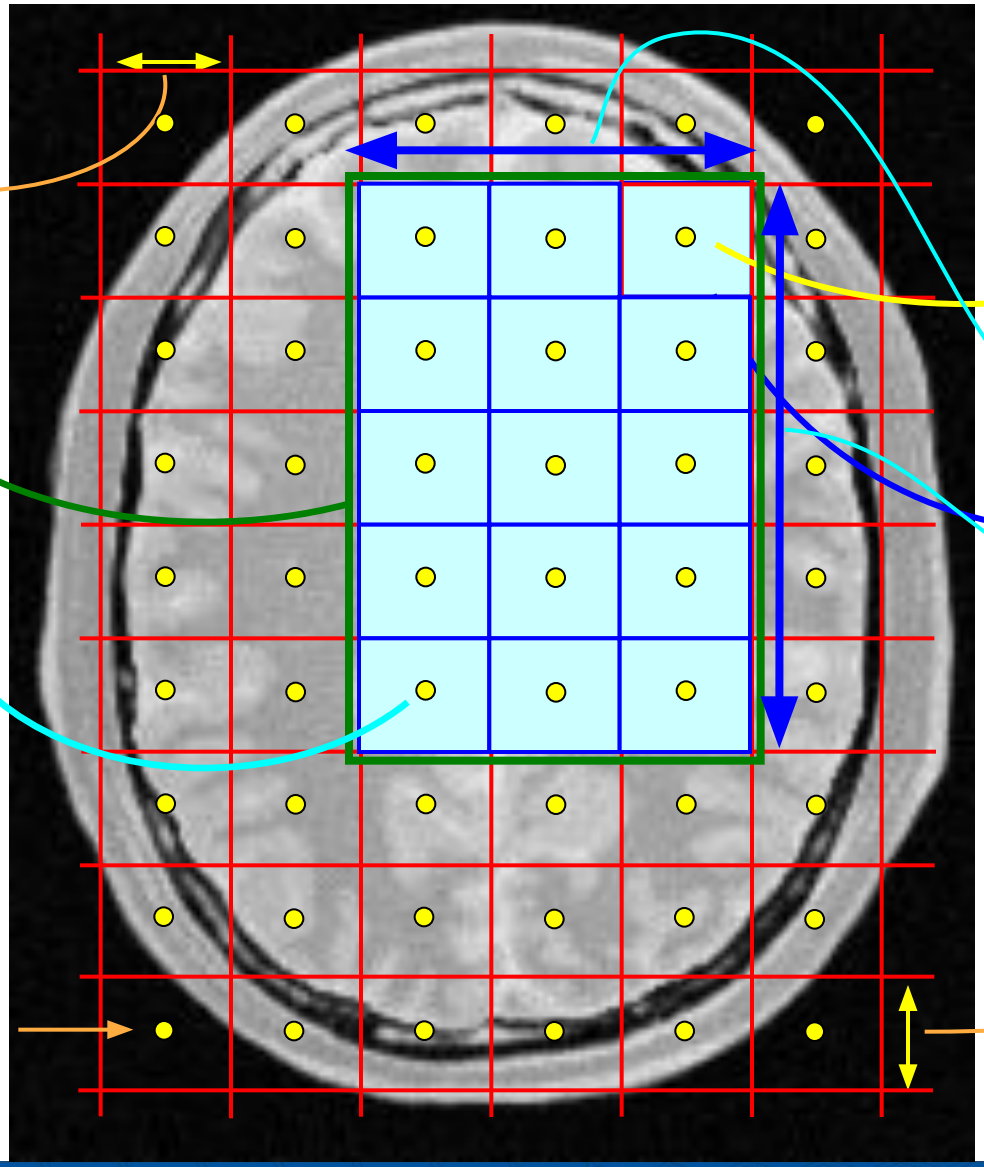
Image Region



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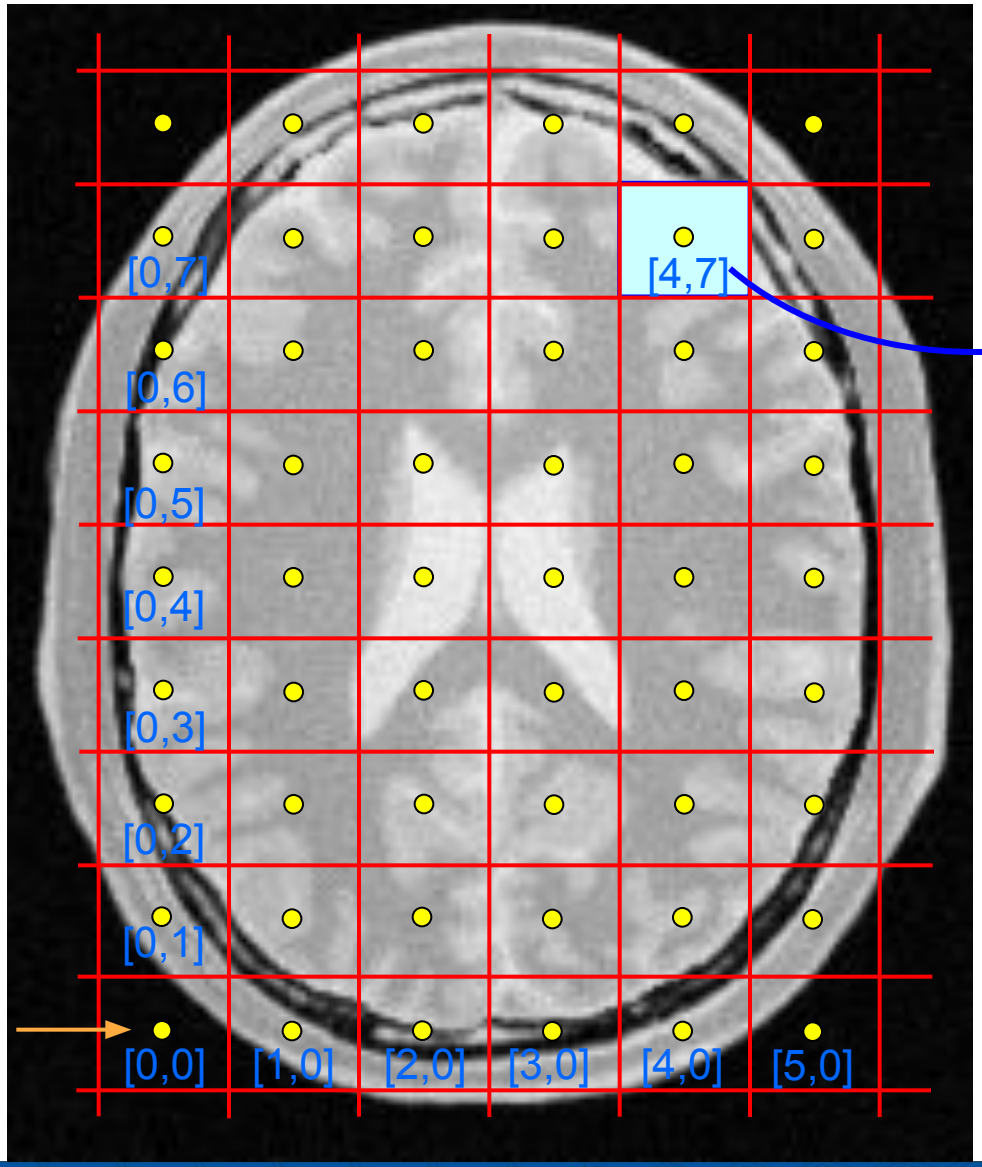
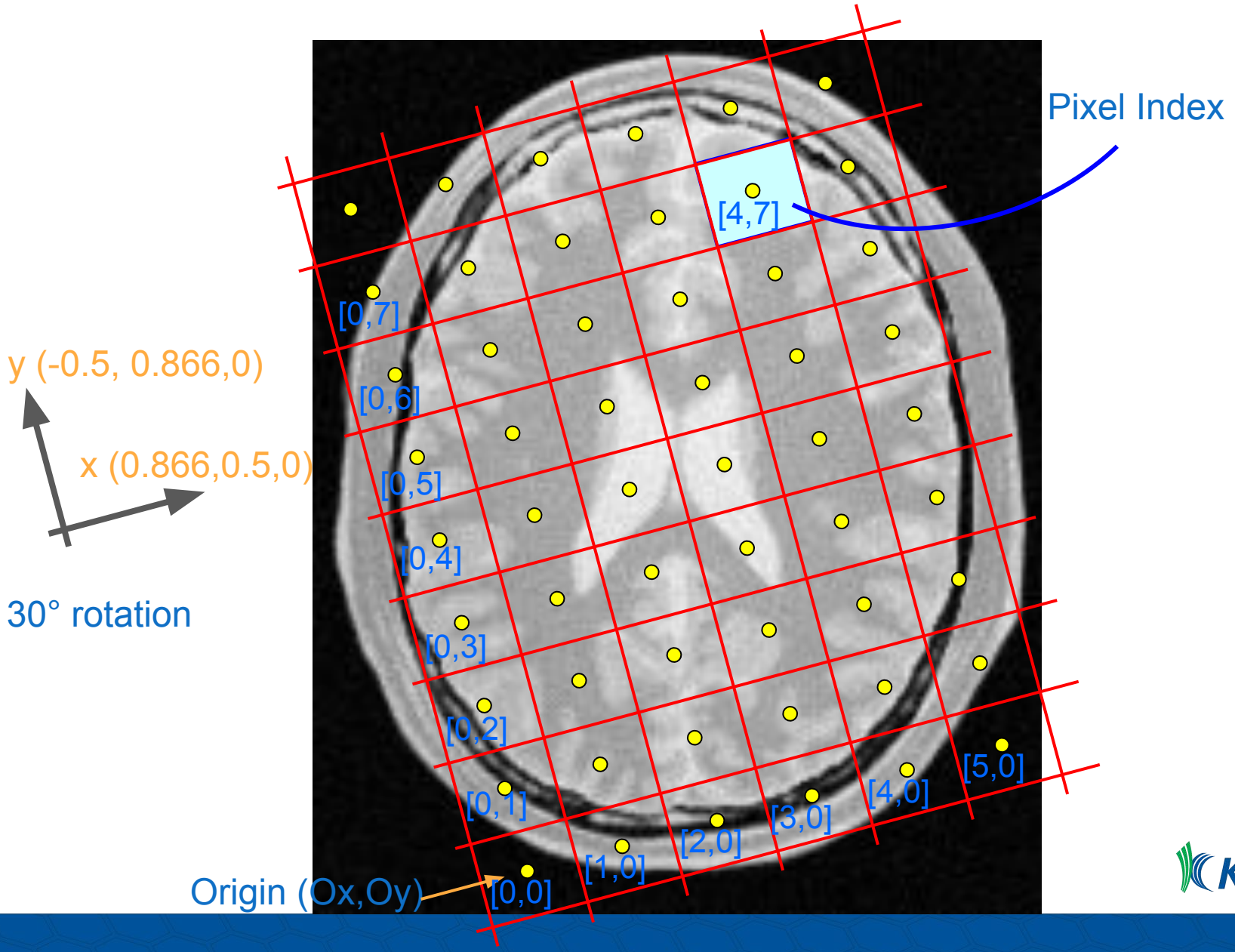
Axes directions



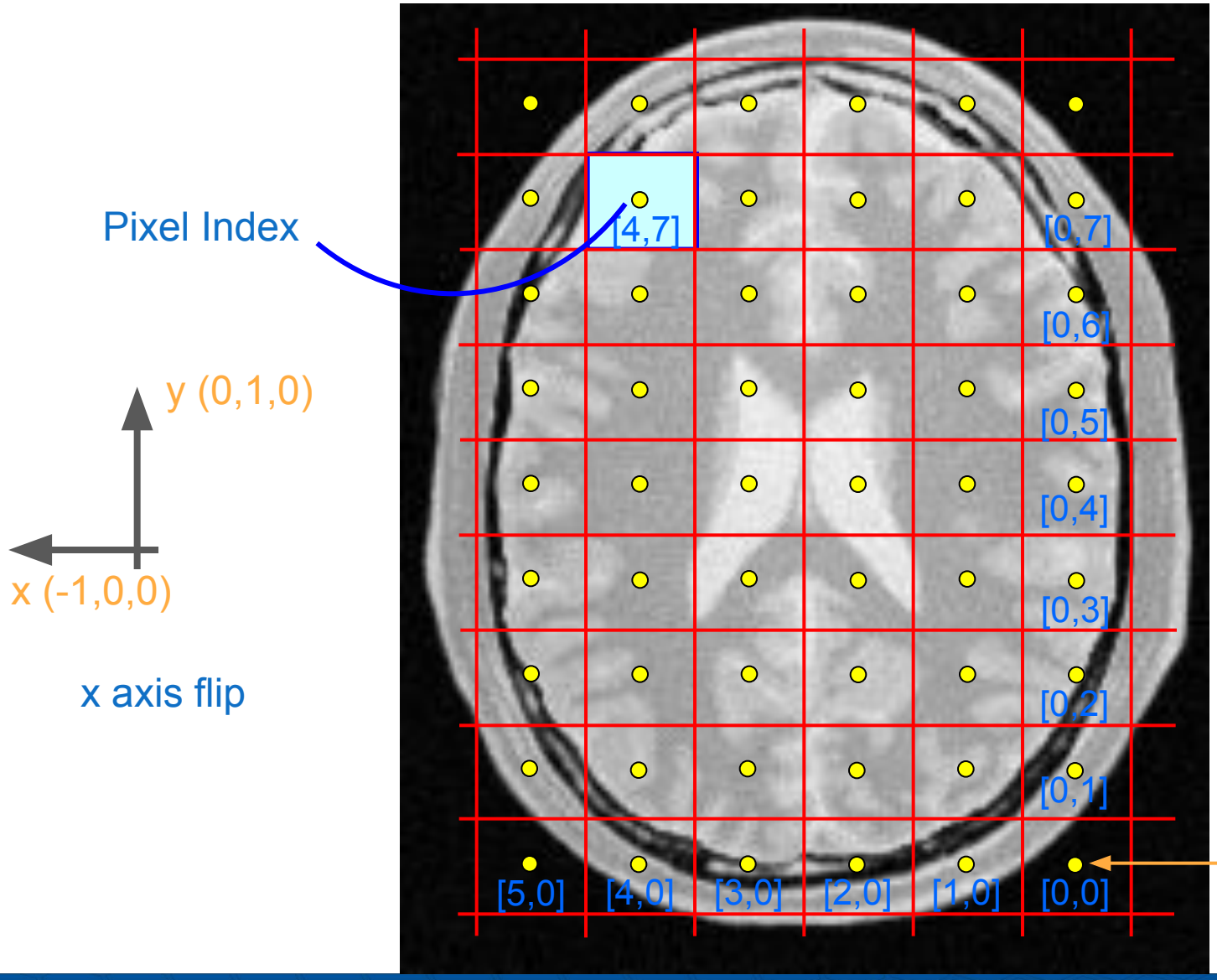
Kitware

Axes directions



Kitware

Axes directions



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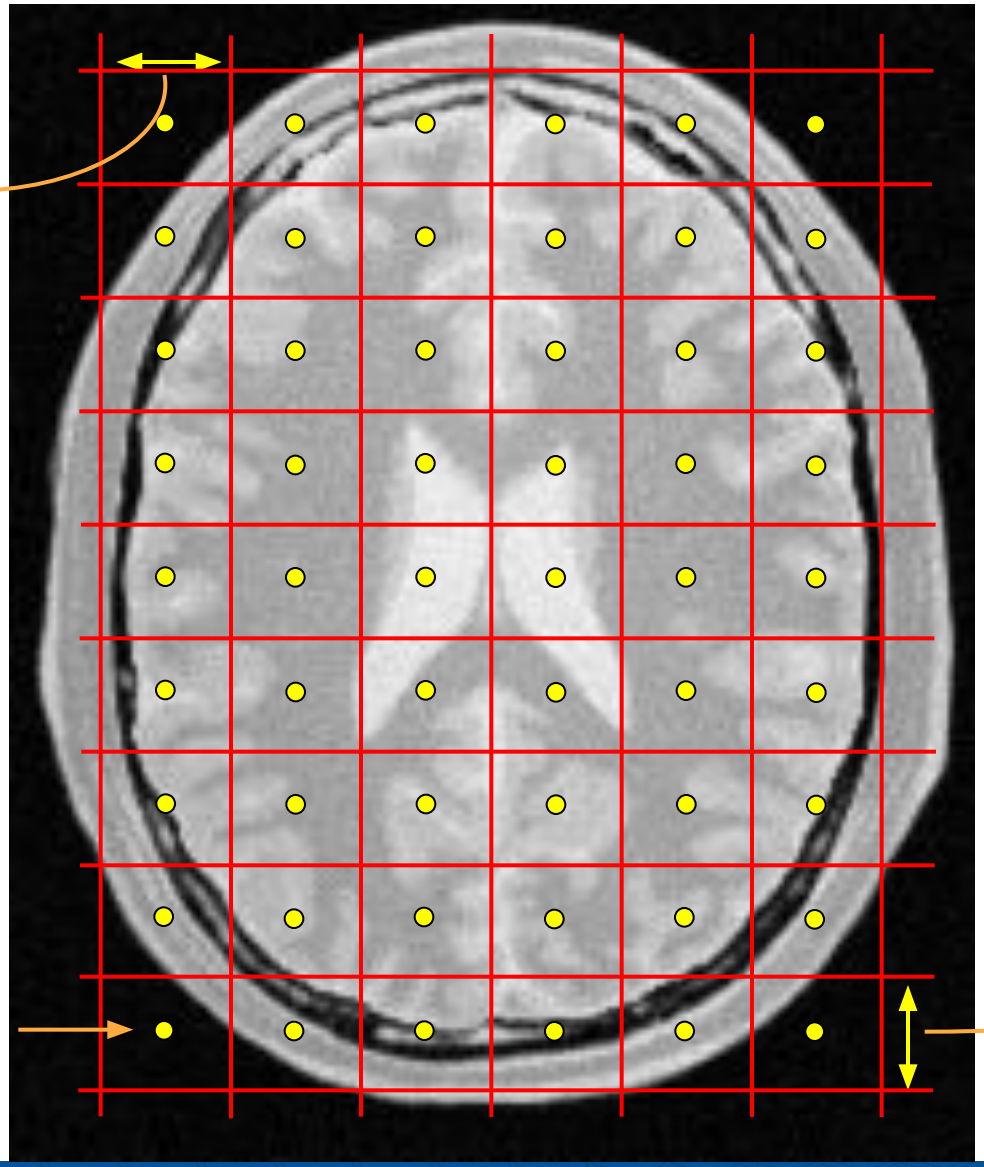
Basic Resampling

- Resampling Trivial Cases

Image Pixel



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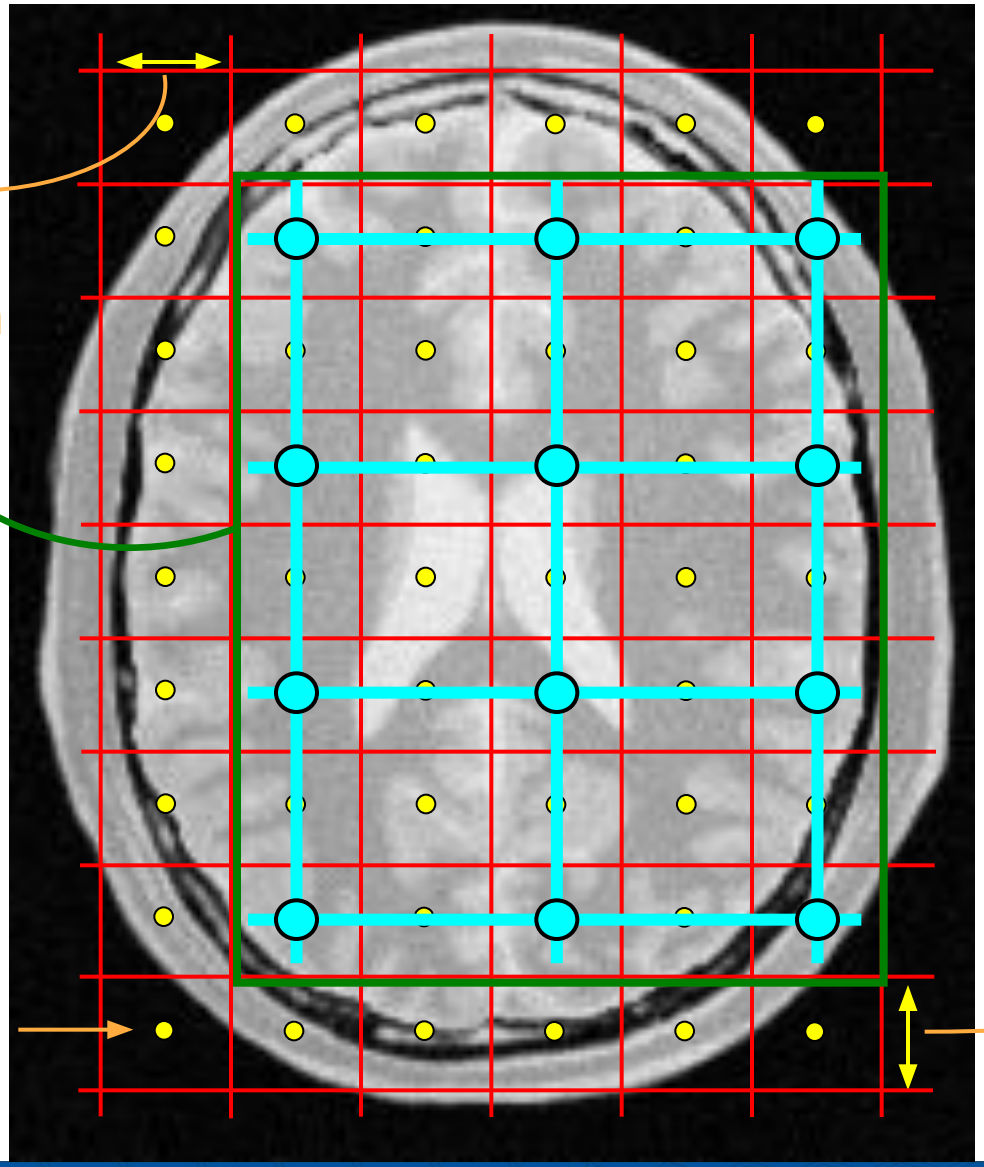
Sub-Sampling by Half



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Sub-Sampling by Half

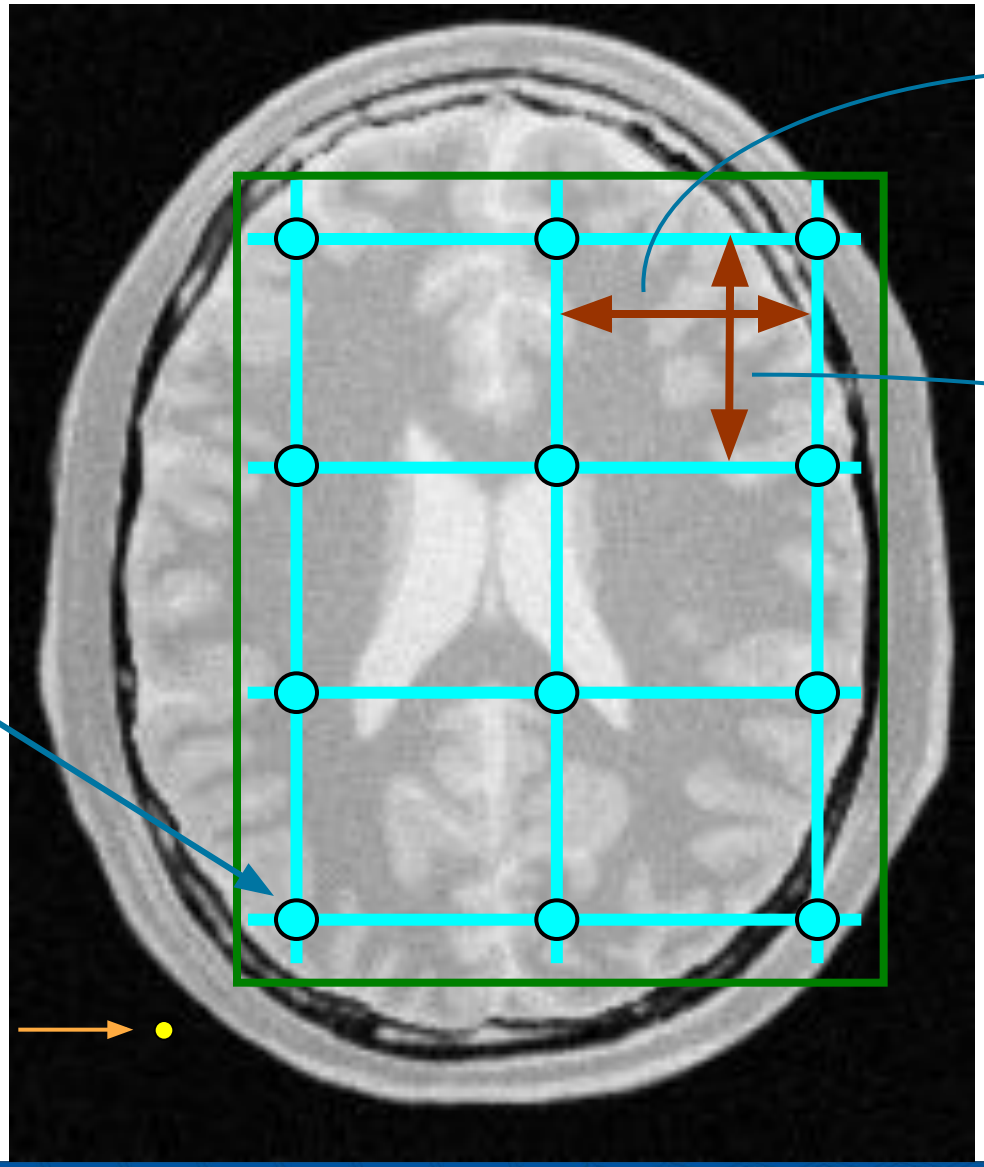

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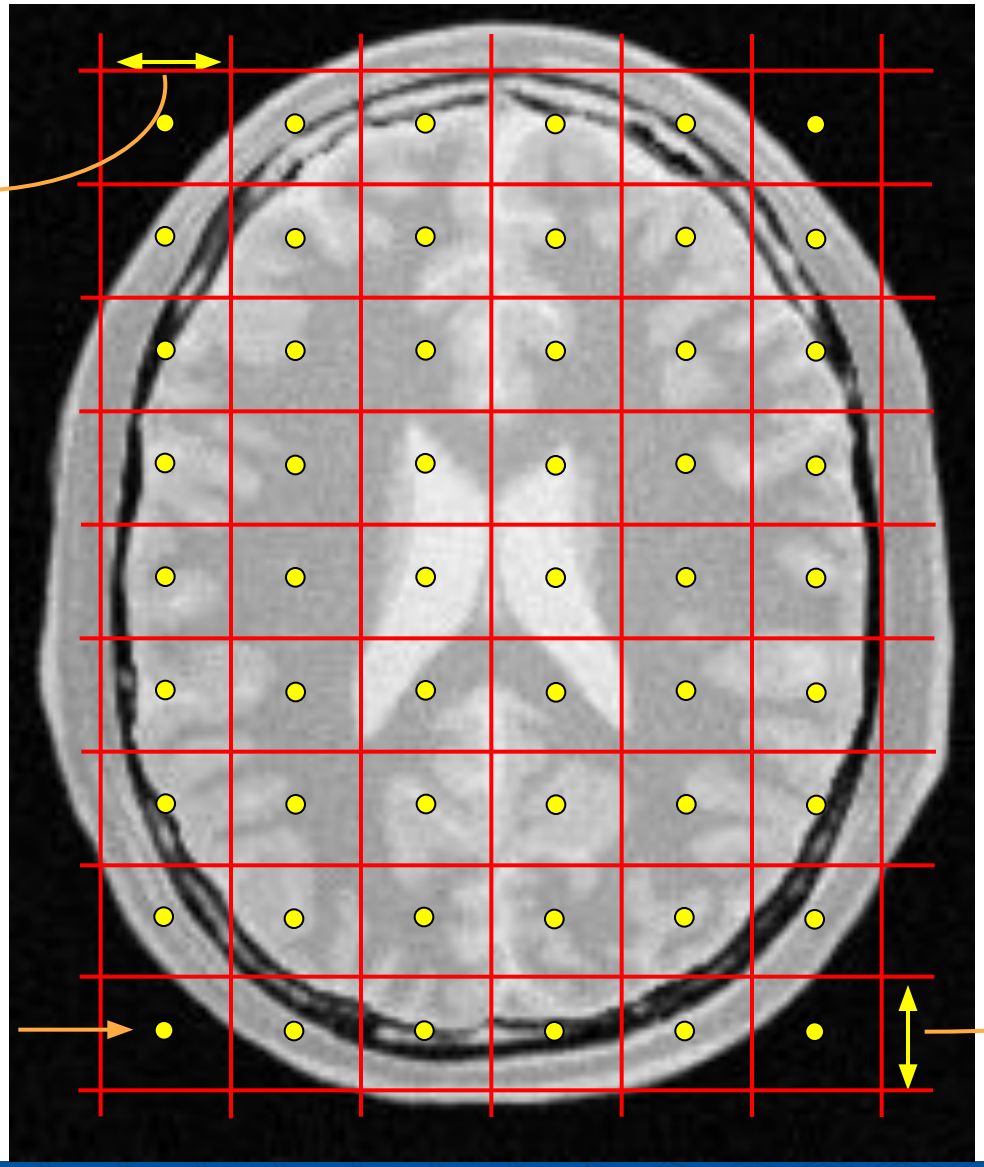
Image Pixel



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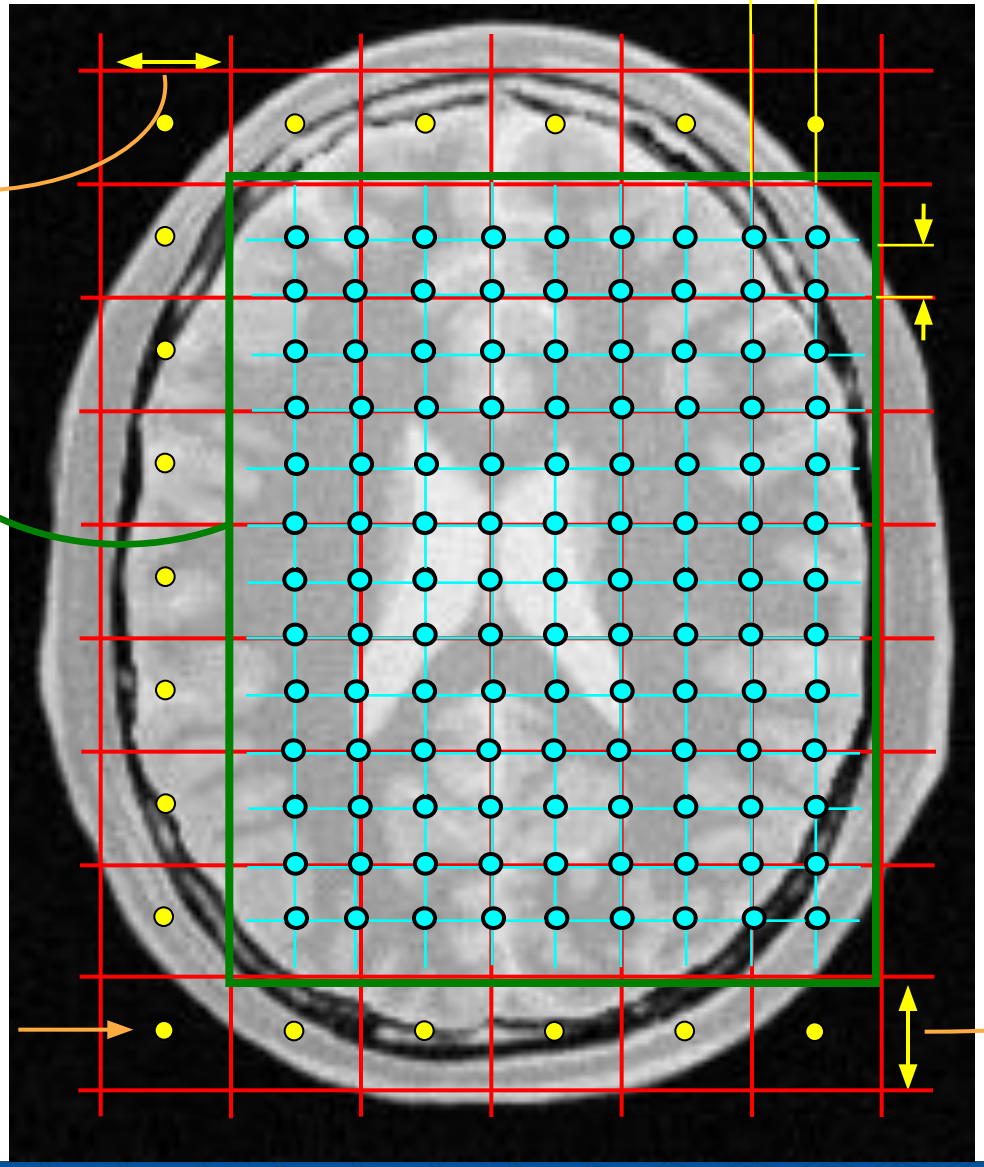
Super-Sampling by Double



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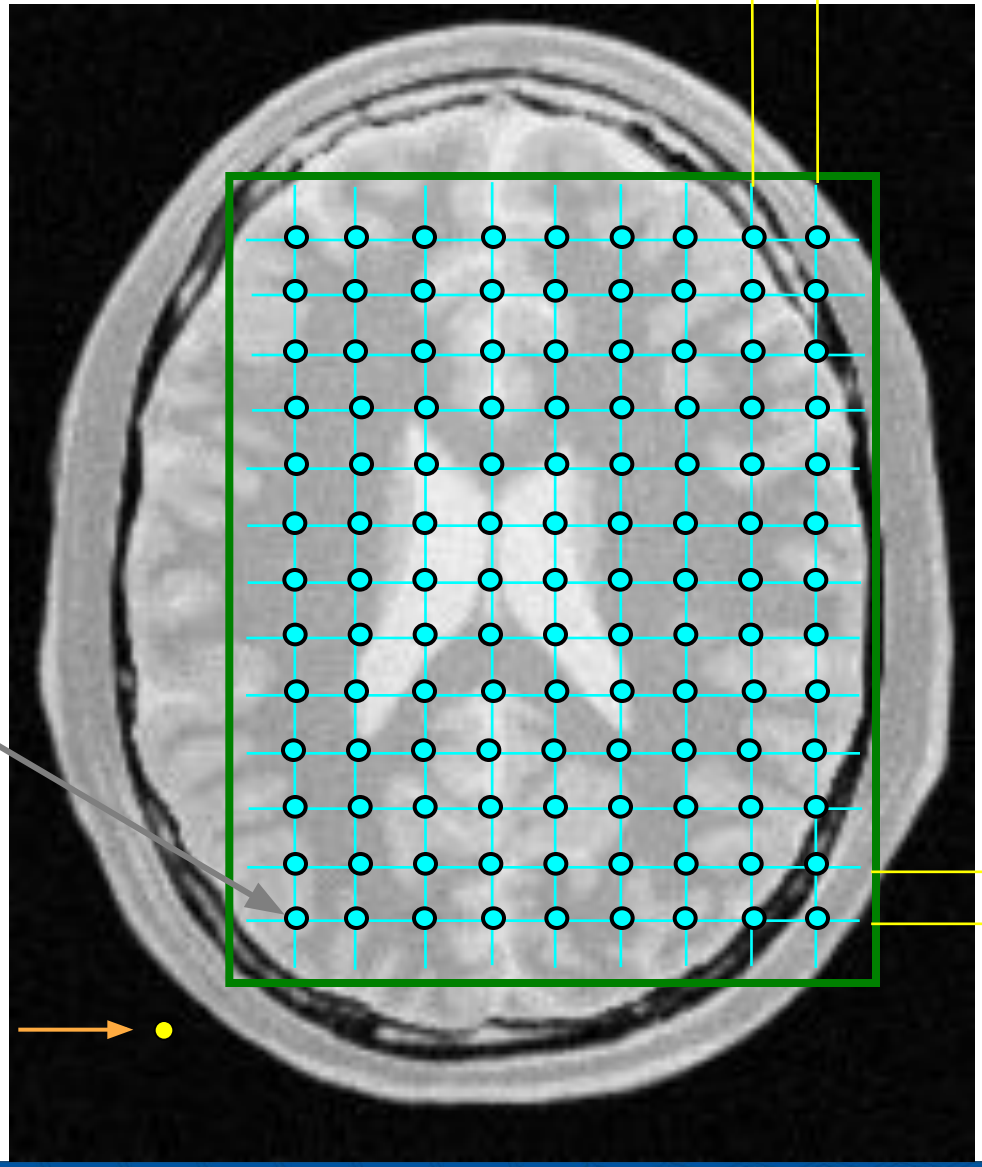
Super-Sampling by Double



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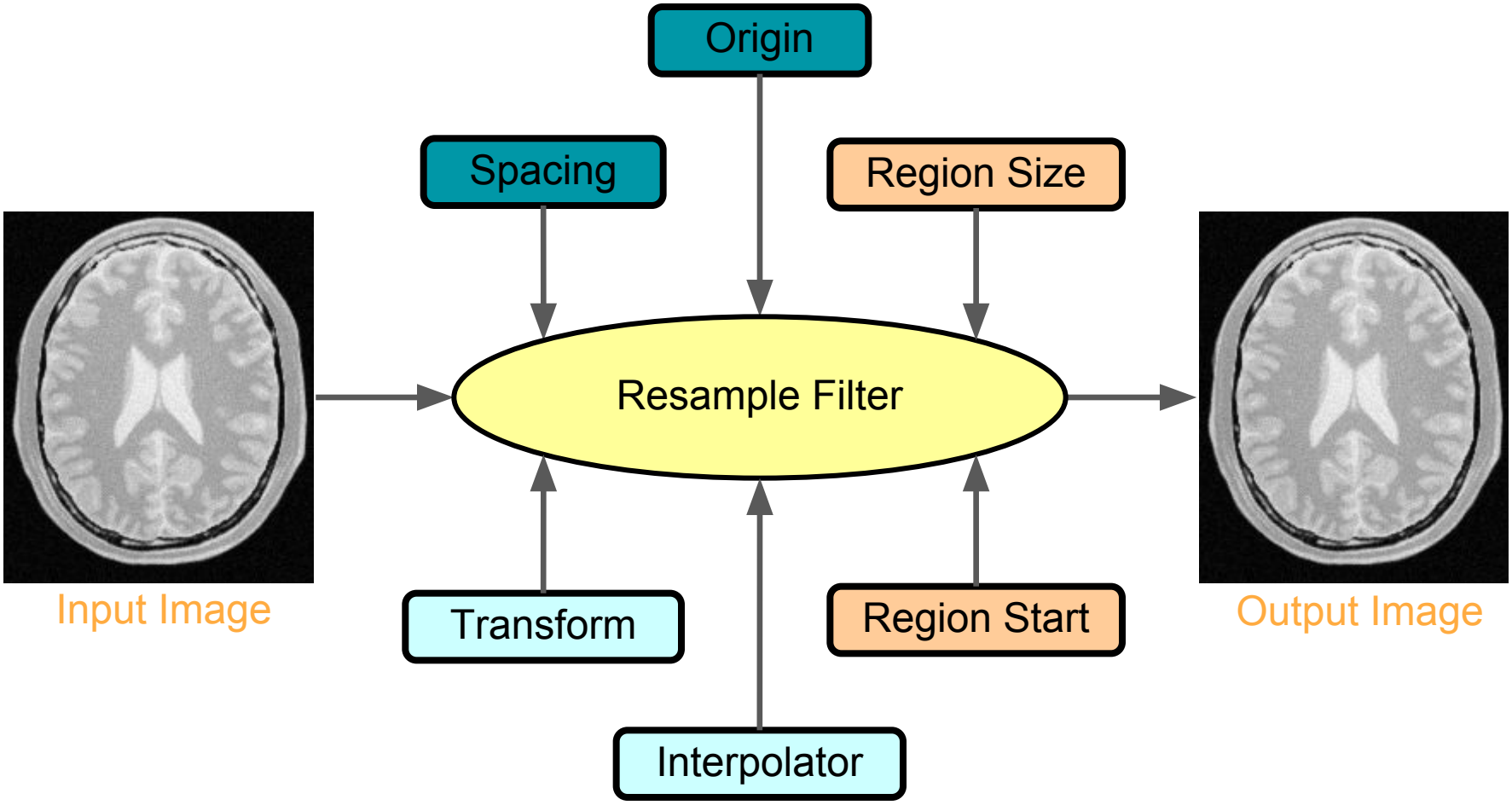
Resampling in ITK

- itk::ResampleImageFilter

Resampling in ITK



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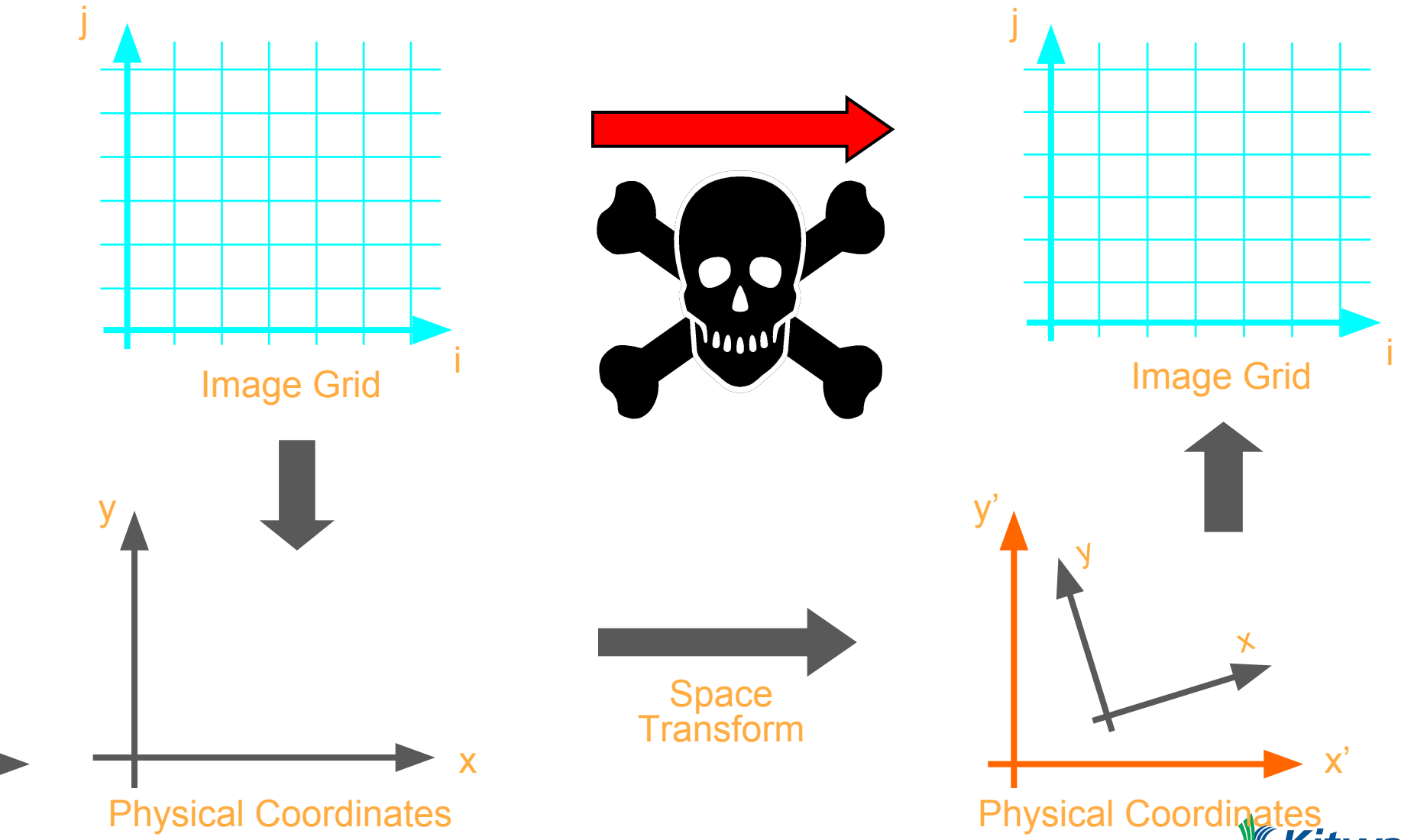
Registration Overview

Coordinate System Conversions



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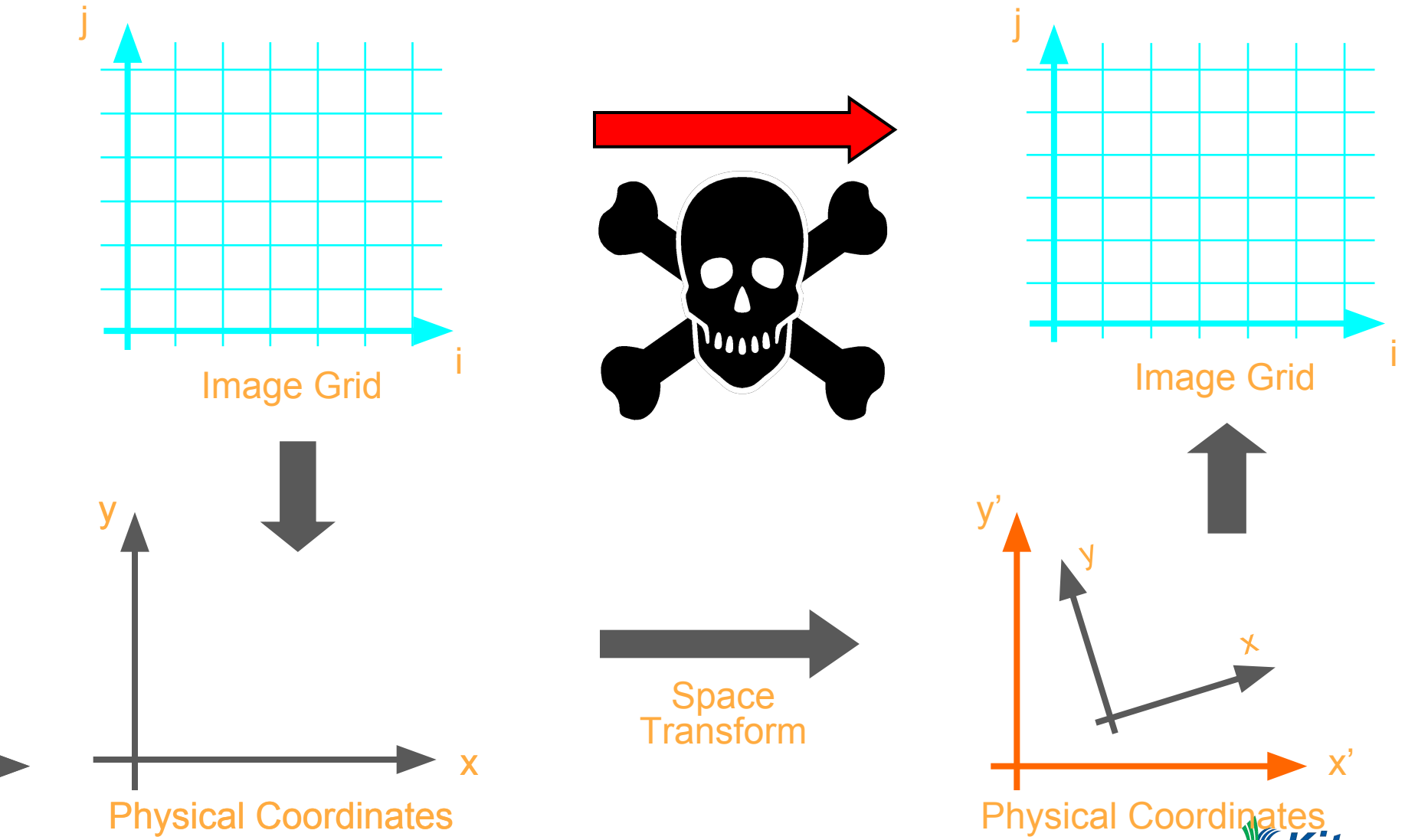
Things I will not do…

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



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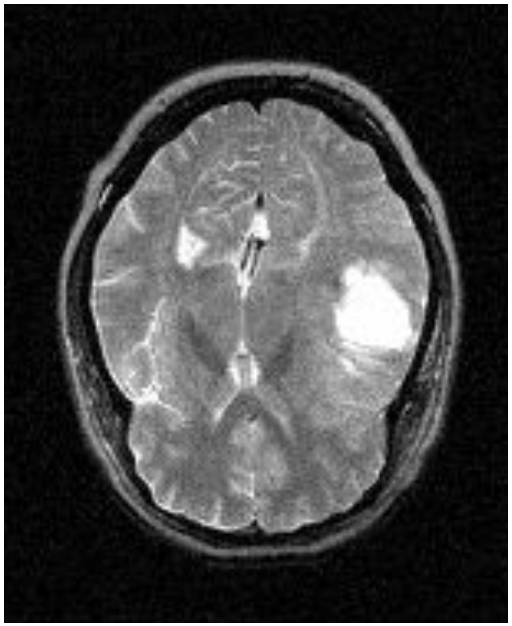
Selecting Moving & Fixed Images

- In principle the denomination of Fixed Image & Moving Image is arbitrary
- In practice the moving image is the one that will be resampled into the fixed image coordinate system

Images from the same patient

MRI-T2



256 x 256 pixels

Scaling Transform

What scale factor ?

a) 2.0

b) 1.0

c) 0.5

PET

128 x 128 pixels

Images provided as part of the project: “Retrospective Image Registration Evaluation”, NIH, Project No. 8R01EB002124-03, Principal Investigator, J. Michael Fitzpatrick, Vanderbilt University, Nashville, TN.

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I will not register images in pix

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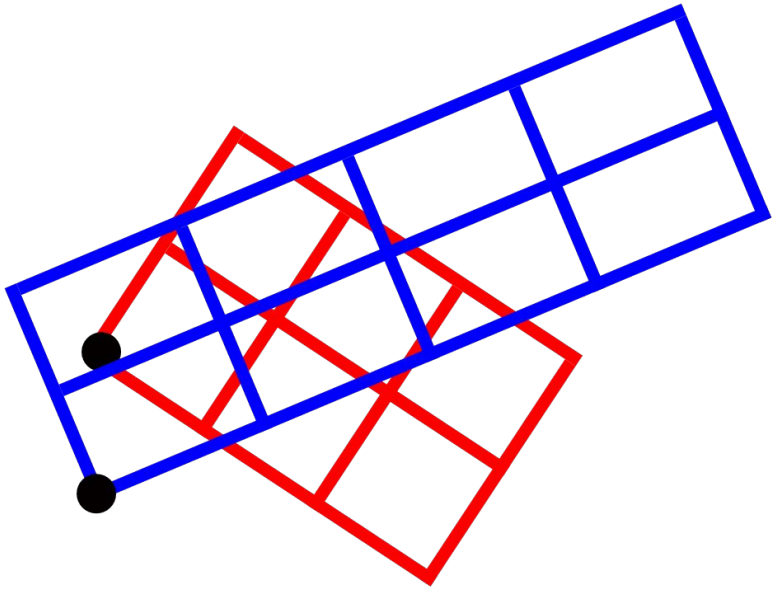
Forward and backward transform

1	11	-7
20	91	5

?	?	?	?
?	?	?	?



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Registration Frameworks in ITK

Registration Optimization Framework

PDE Deformable Registration (Demons)

FEM Registration

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Registration Optimization Framework

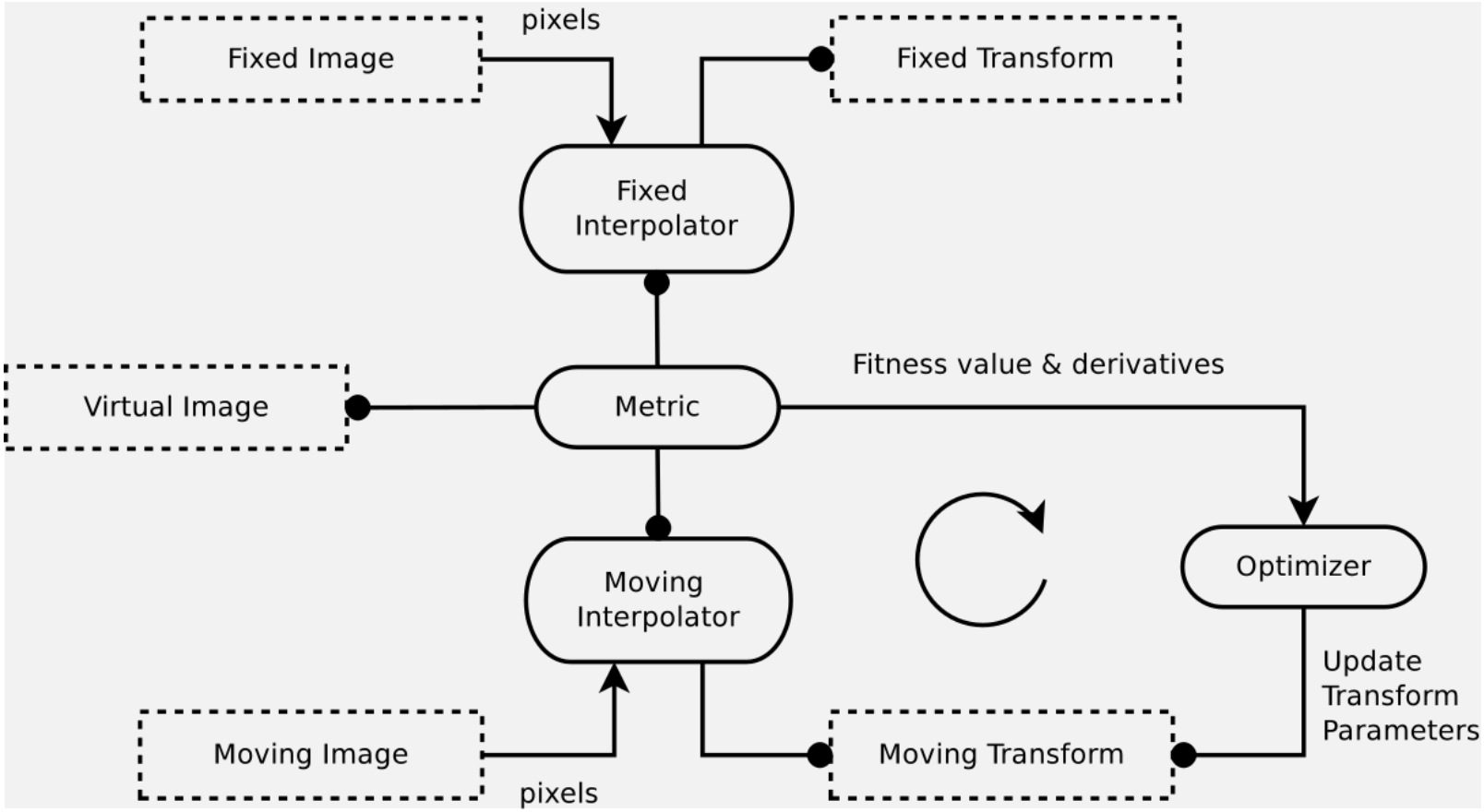

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Image Metrics

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

Mean Squared Differences

For each pixel in A

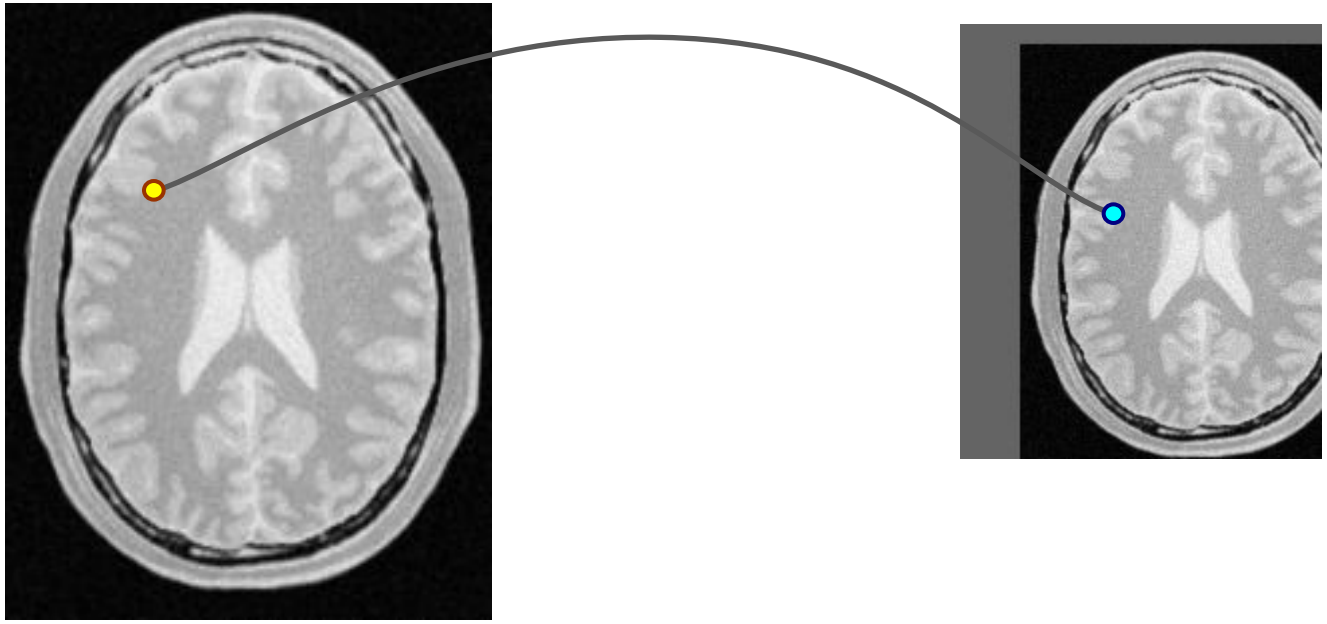

Image A

Image B

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

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

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

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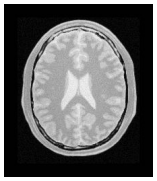
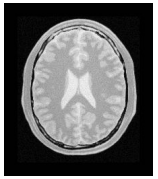
Mutual Information (Same Modality)

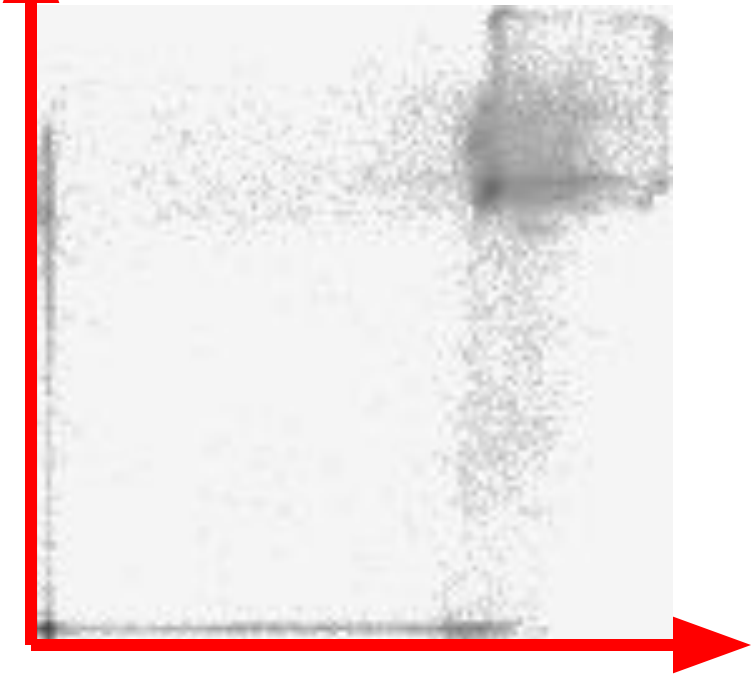
Images Aligned





White = zero value
Black = highest value

Images Translated



Misalignment causes dispersion

Insight/Examples/Registration/ImageRegistrationHistogramPlotter.cxx

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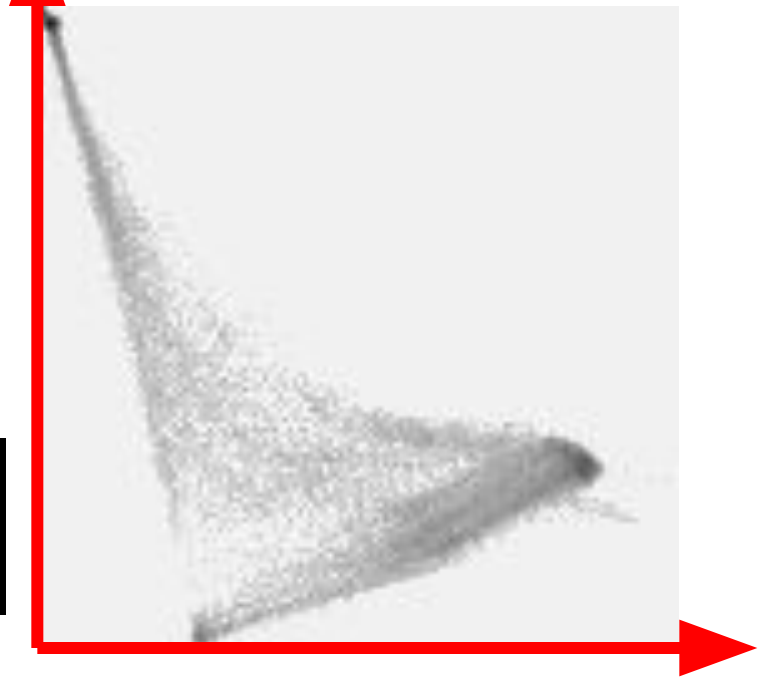
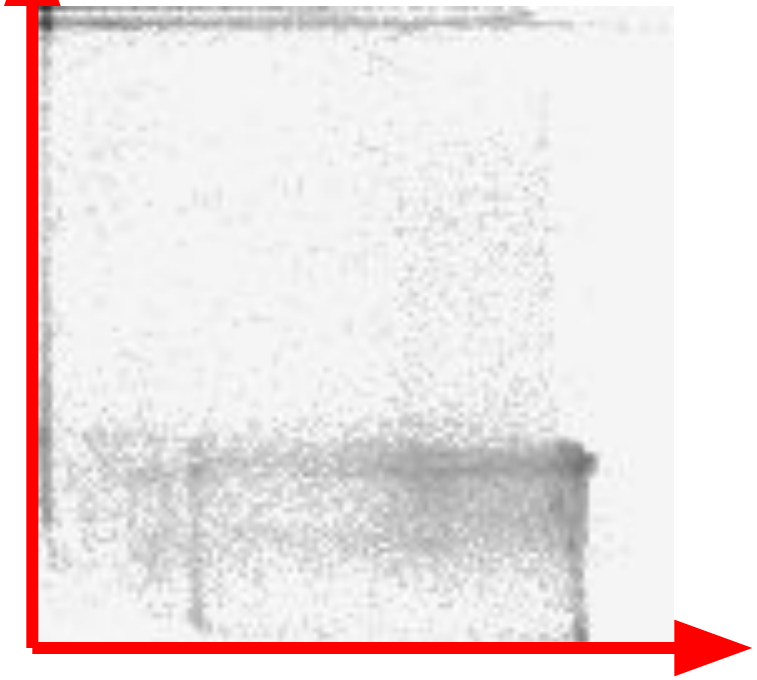
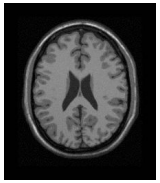
Mutual Information (Different Modality)

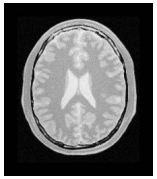
Images Aligned



Images Translated







White = zero value
Black = highest value

Misalignment causes dispersion

Insight/Examples/Registration/ImageRegistrationHistogramPlotter.cxx

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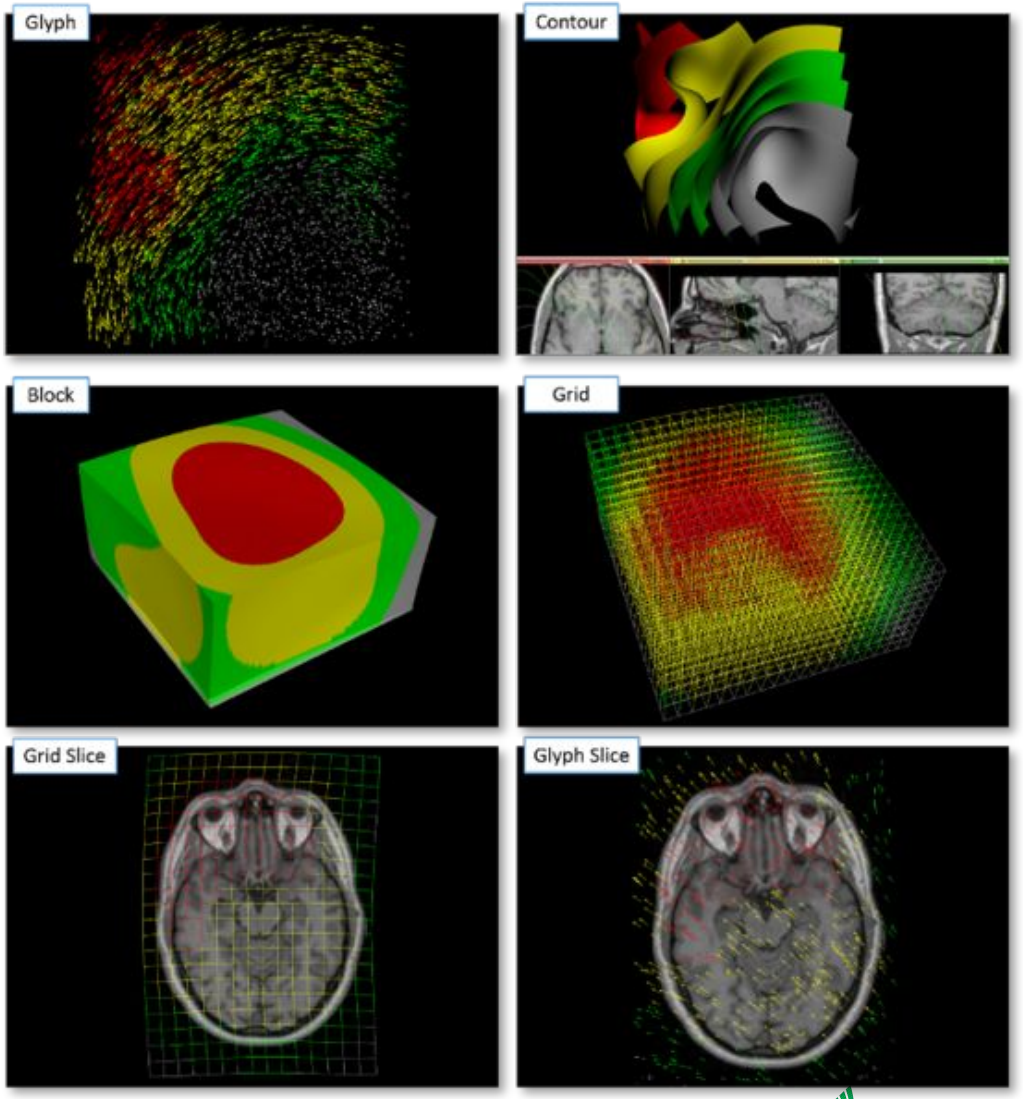
Transforms

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



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Optimizers

- Gradient Descent
- Regular Step Gradient Descent
- Conjugate Gradient
- Levenberg-Marquardt
- Amoeba
- Powell
- LBFGS + LBFGSB
- One plus One Evolutionary Algorithm

Interpolators

- Nearest Neighbor
- Linear
- BSpline
- WindowedSinc

Enjoy ITK !

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