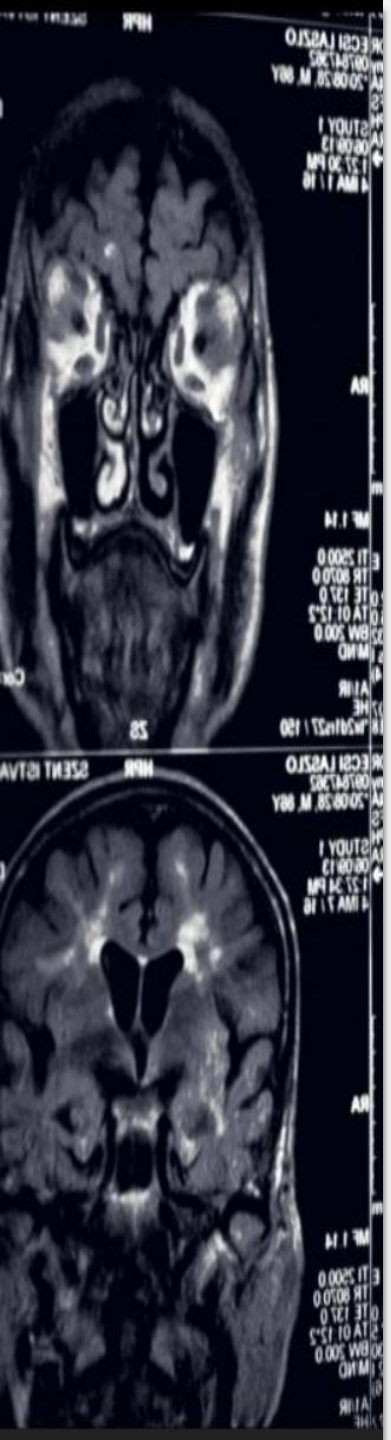
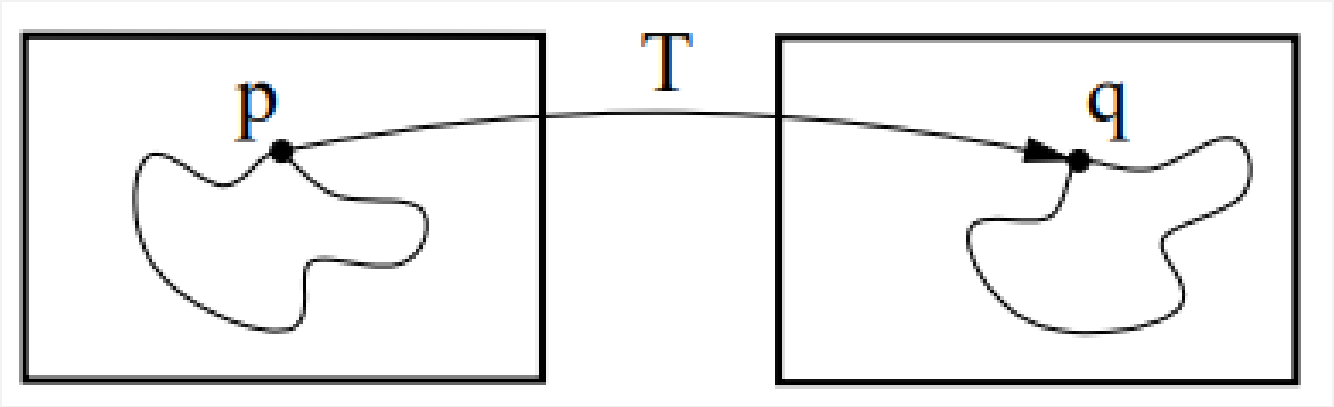


Medical Image Registration

Shanaka Liyanaarachchi

What is Registration

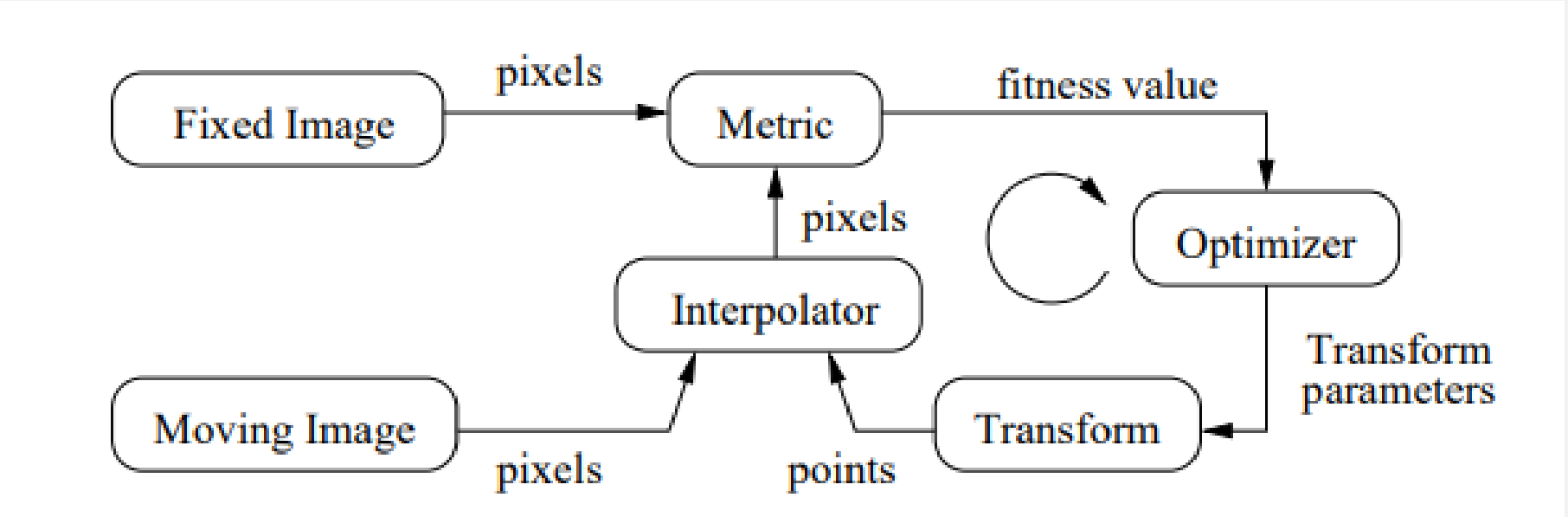
- “Image registration is the task of finding a spatial transform mapping target image into the source image. “



Components of an Image Registration Pipeline

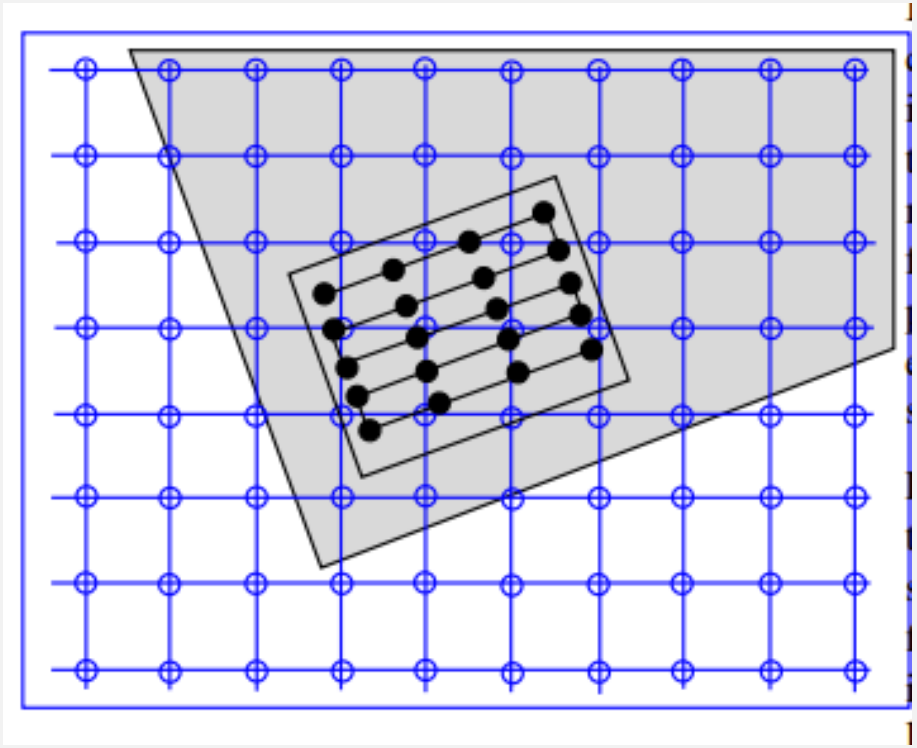
- Fixed Image (image stationary in space)
- Moving Image (image with an unknown transformation applied)
- Transform (Transformation required to find)
- Metric – measures how well the images are mapped
- Interpolator – Evaluate moving Image intensities at non grid positions
- Optimizer – Similar to optimizers in deep learning

Basic Registration Pipeline



Interpolator

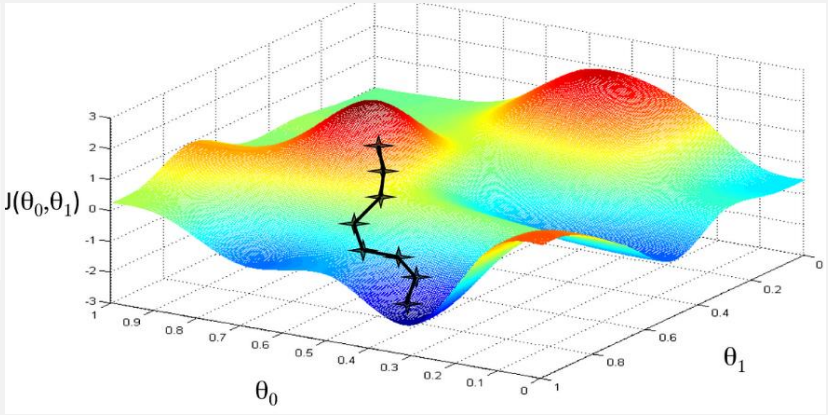
- Interpolates Non Grid Positions



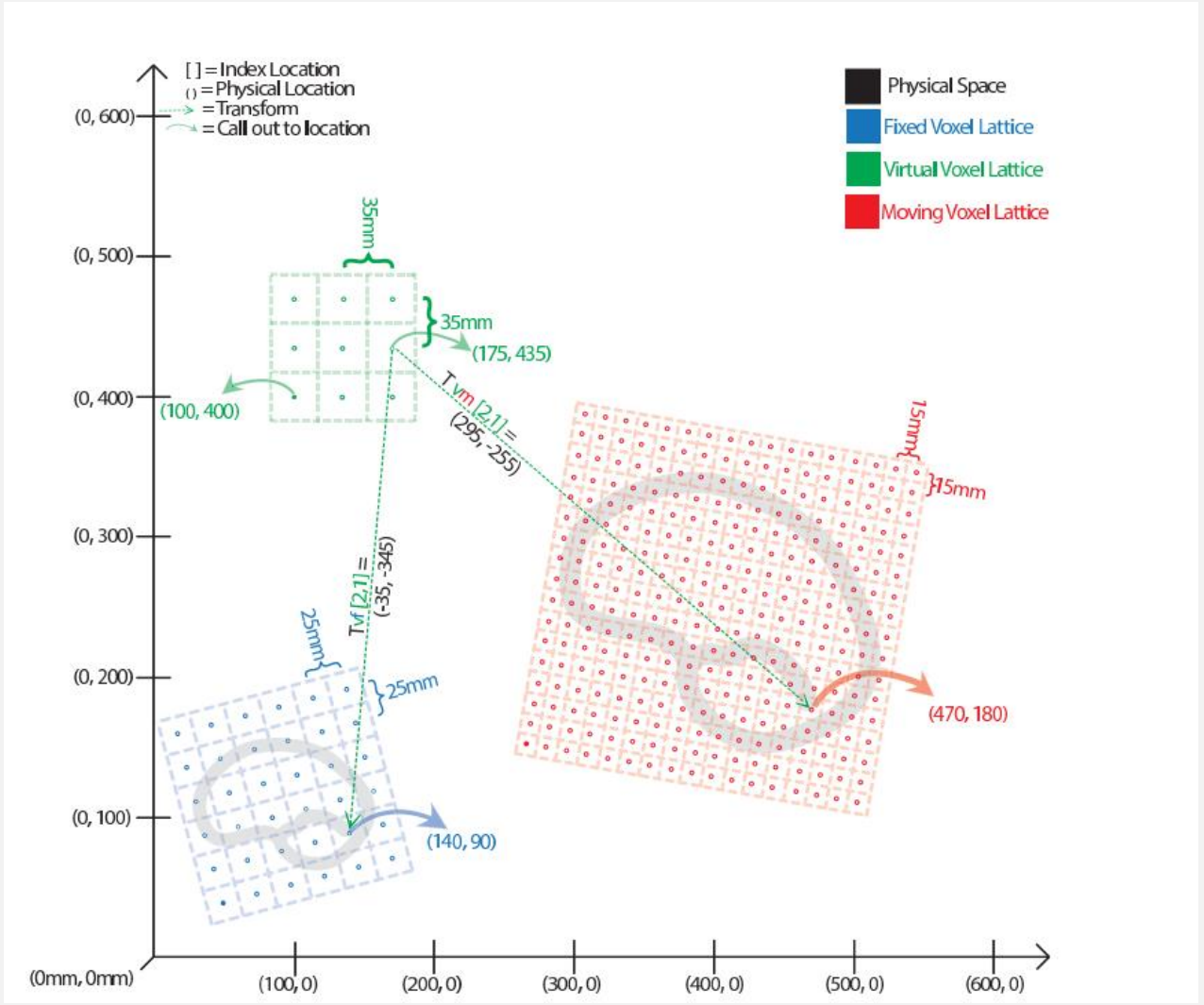
Optimizer

- (similar to optimizer used in deep learning)

```
optimizer = itk.RegularStepGradientDescentOptimizerv4.New(
    LearningRate=4,
    MinimumStepLength=0.001,
    RelaxationFactor=0.5,
    NumberOfIterations=20,
)
```

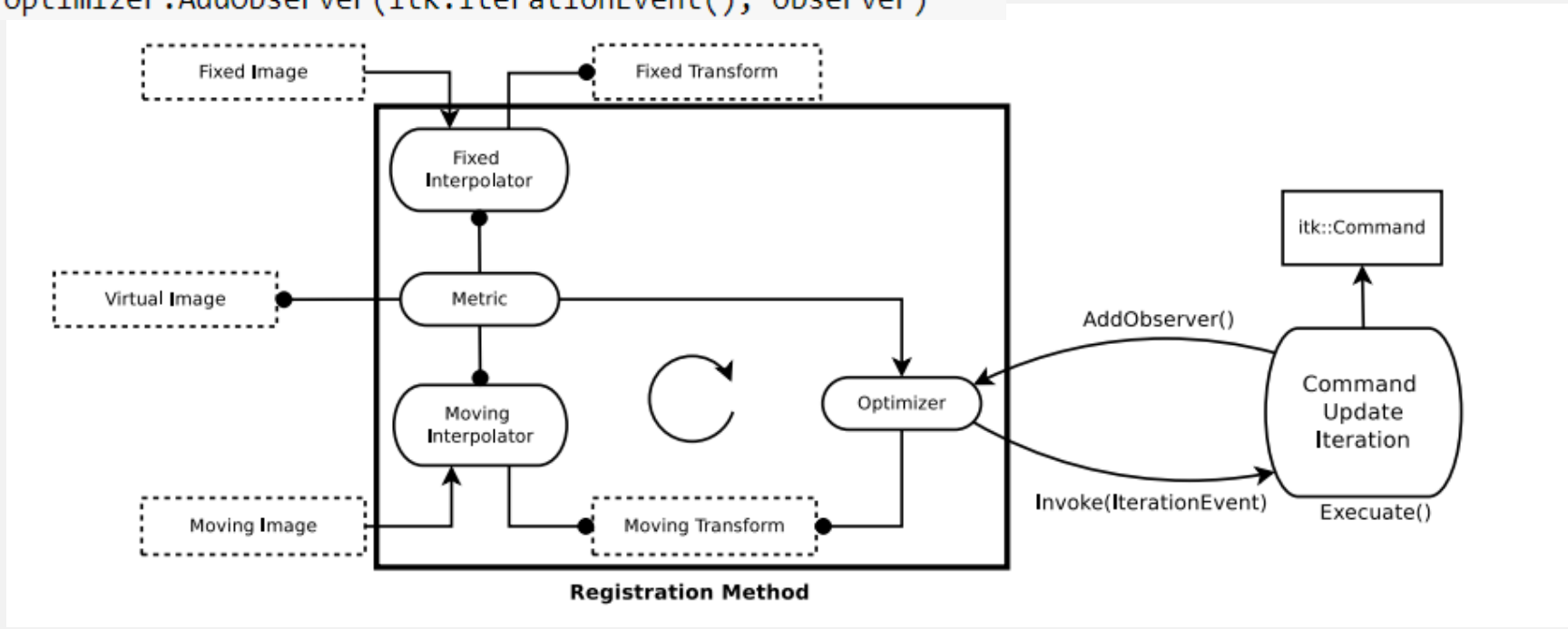


Virtual Image

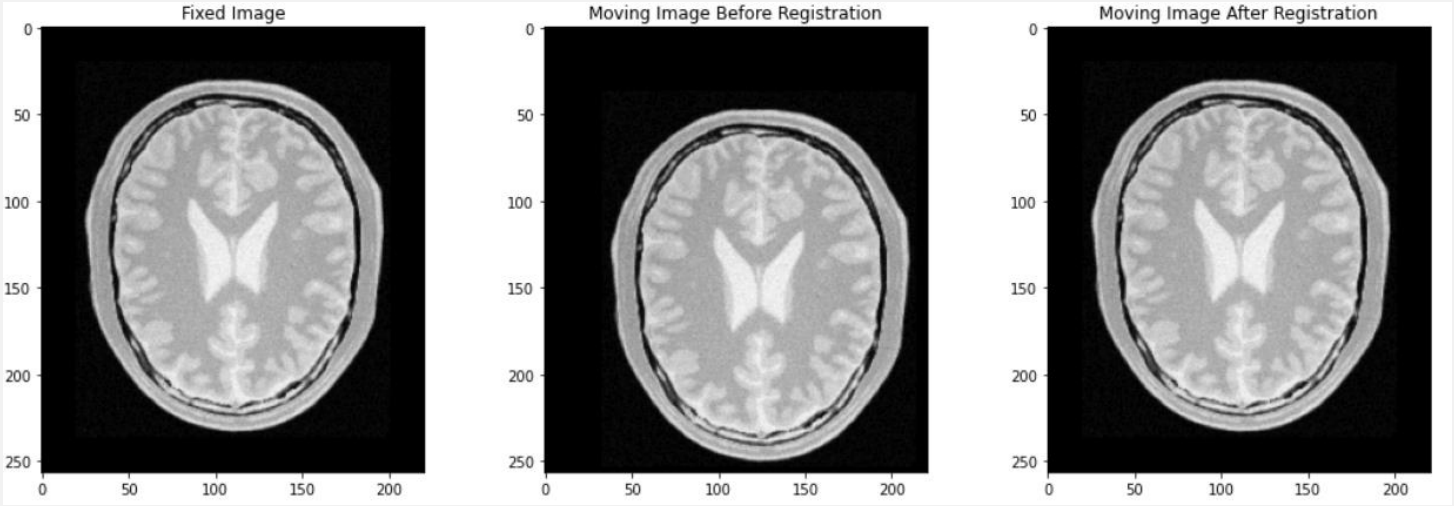


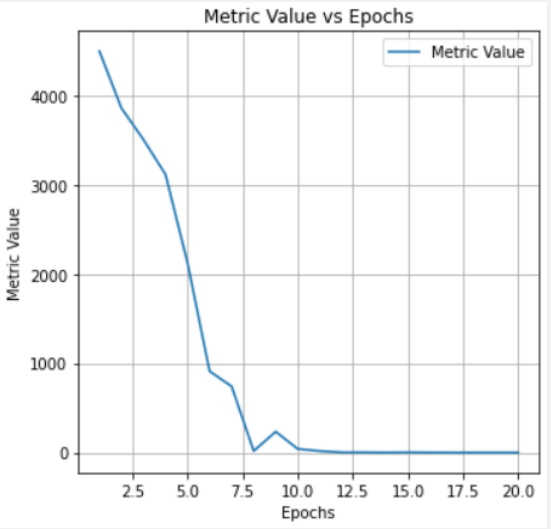
Monitoring

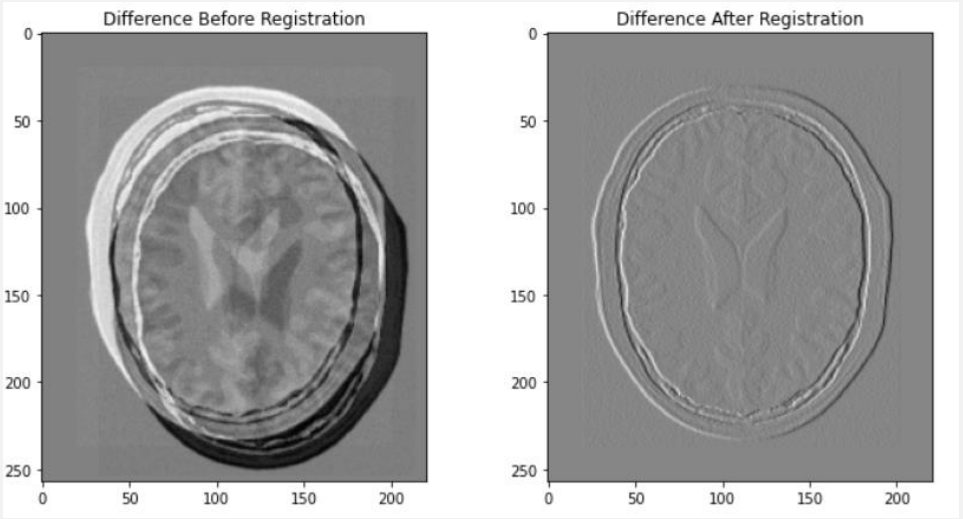
```
def observer():
    currentParameters = optimizer.GetCurrentPosition()
    translation_x = currentParameters.GetElement(0)
    translation_y = currentParameters.GetElement(1)
    metric_value = optimizer.GetValue()

    metric_values.append(metric_value)
    translation_x_values.append(translation_x)
    translation_y_values.append(translation_y)
optimizer.AddObserver(itk.IterationEvent(), observer)
```

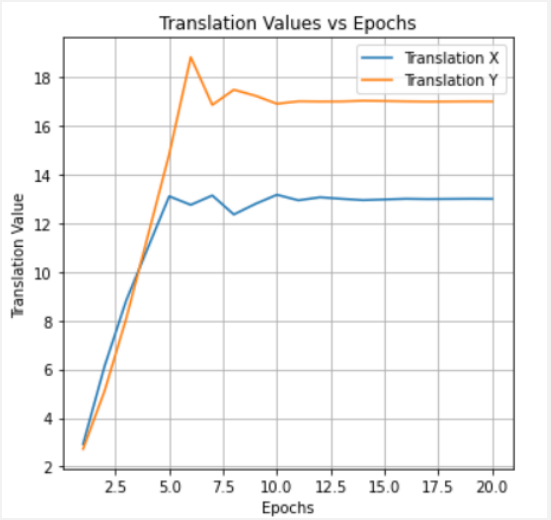


Demo 1 : Registration Pipeline + Monitoring



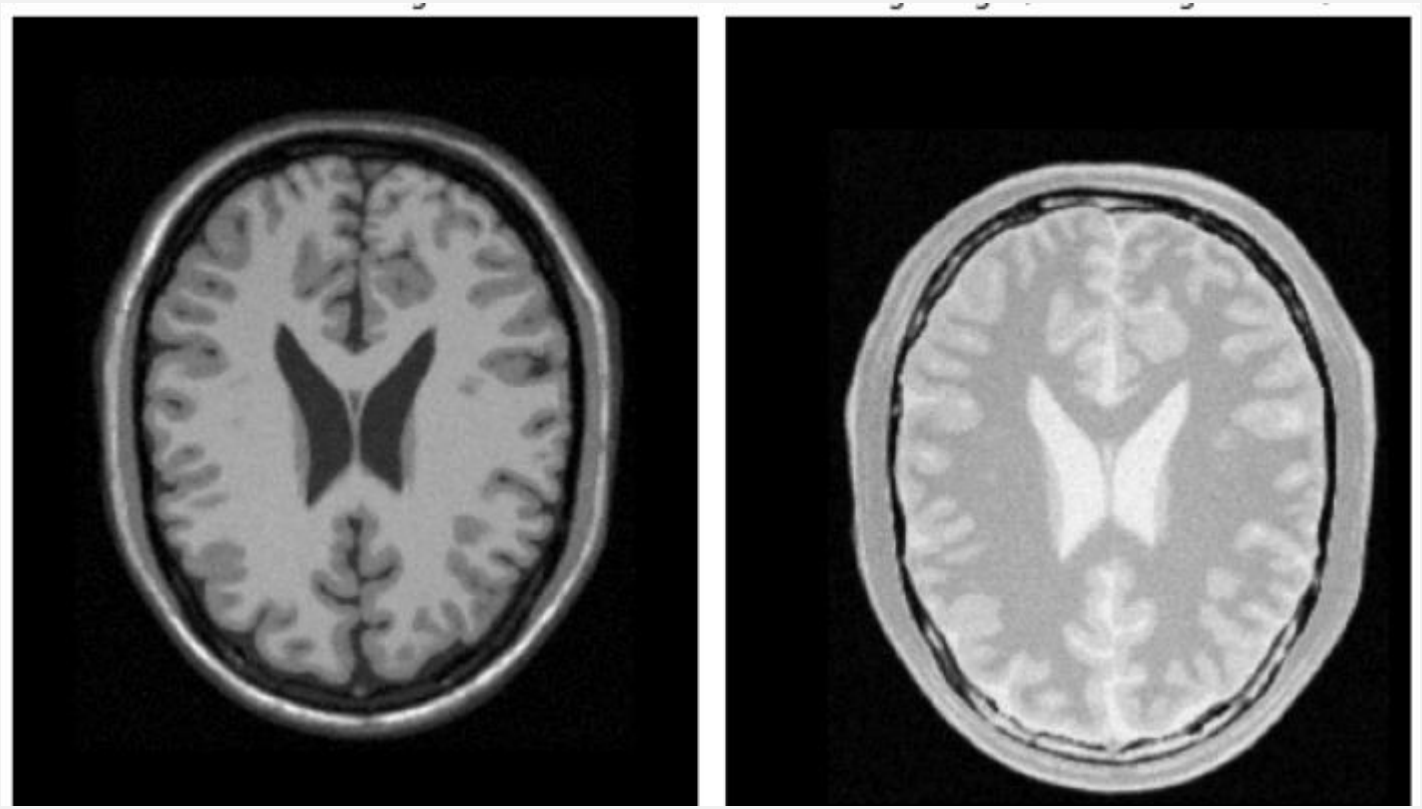






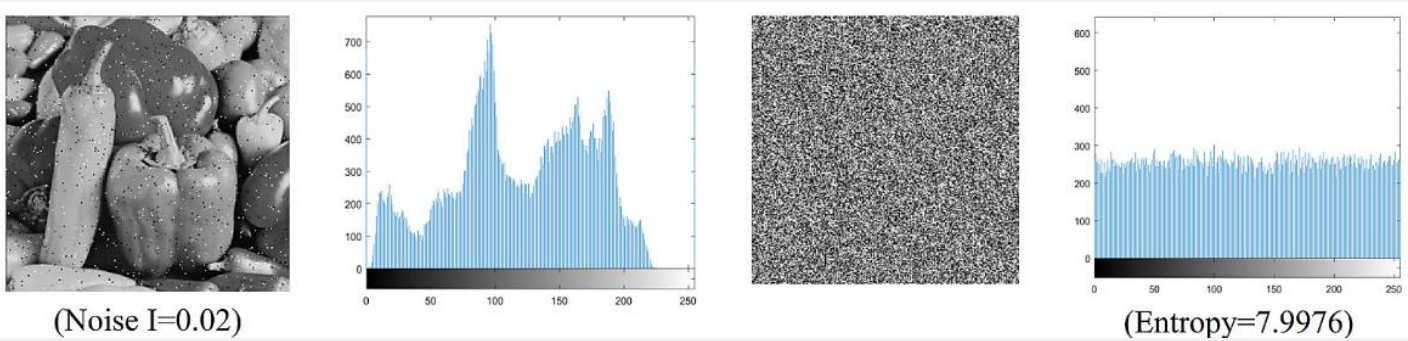
Multimodal Registration

- Register Different Image Modalities (eg: DWI and FLAIR in the book)
- What matters most is the Metric that Measures Mutual Info.



Mattes Mutual Information Metric - 1

- Based on the Entropies of the images
- Entropies of a gray scaled images can be calculated from the histograms
- An image with all the pixels with same intensity would have a very low entropy, an image with a equally distributed histogram would have a high Intensity.

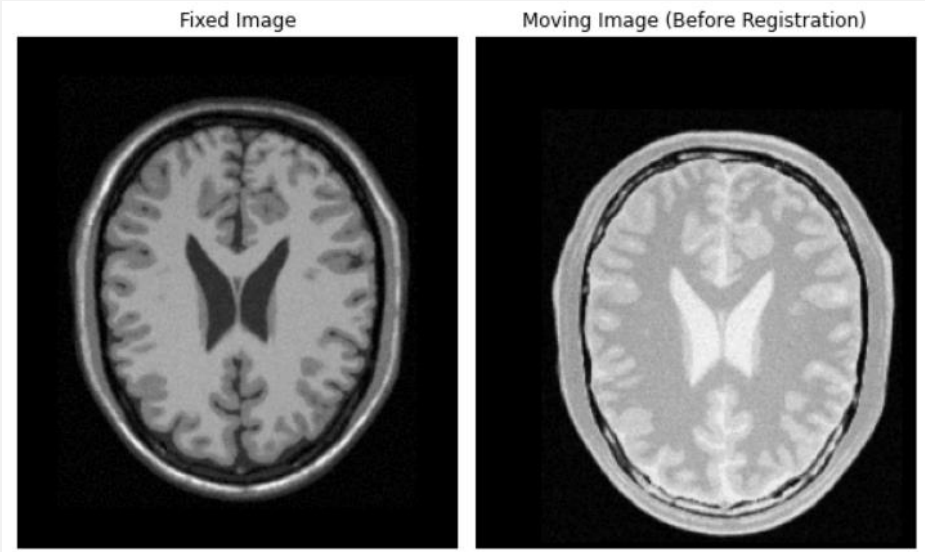


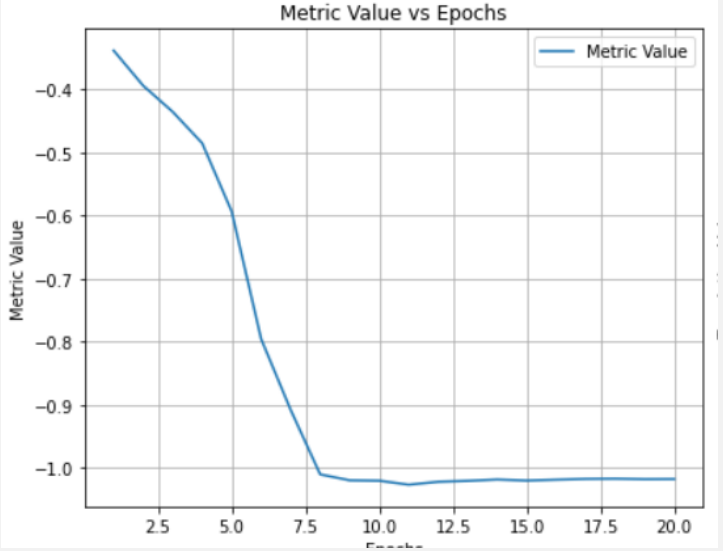
Mattes Mutual Information Metric - 2

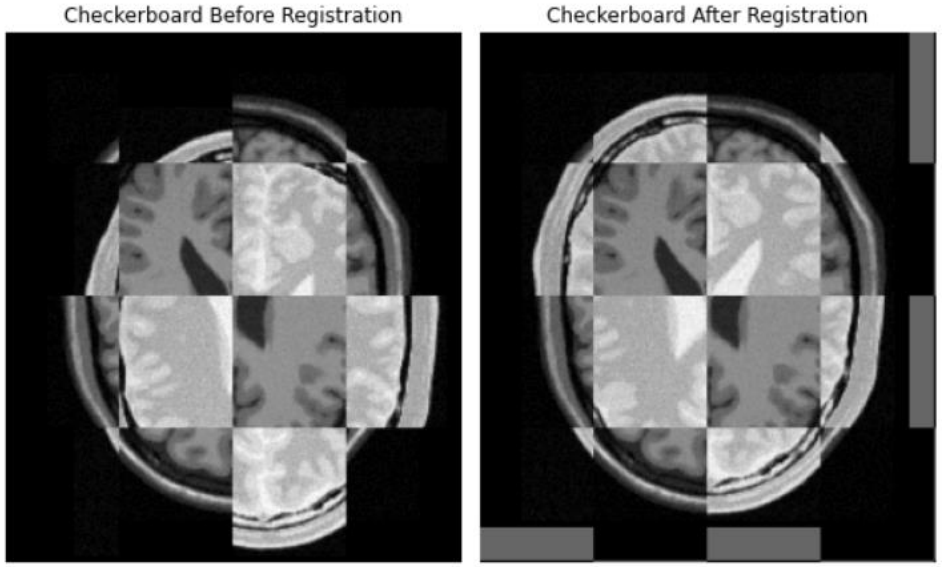
- Measuring Mutual Information between two images is a good metric of registration between two modalities that it doesn't account that same region has two different intensities in the two images but the mutual information is maximized in these cases as well.

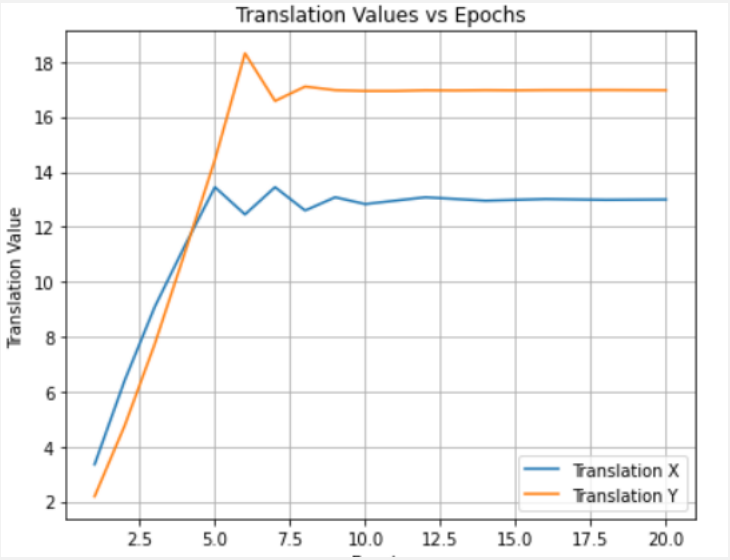
$$I(A,B) = H(A) + H(B) - H(A,B)$$

Demo 2 : Multi-Modal Registration



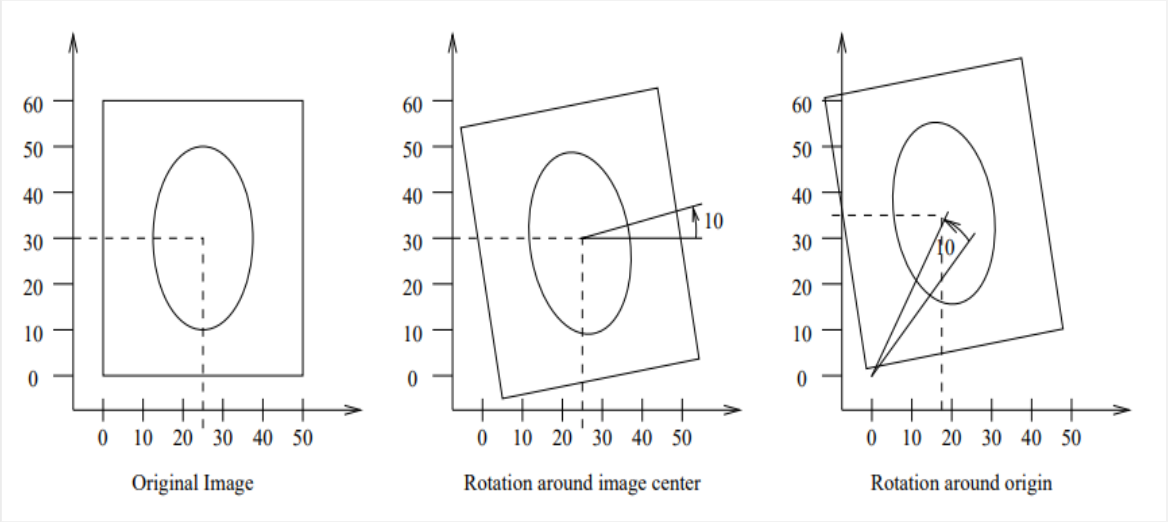






Center Initialization

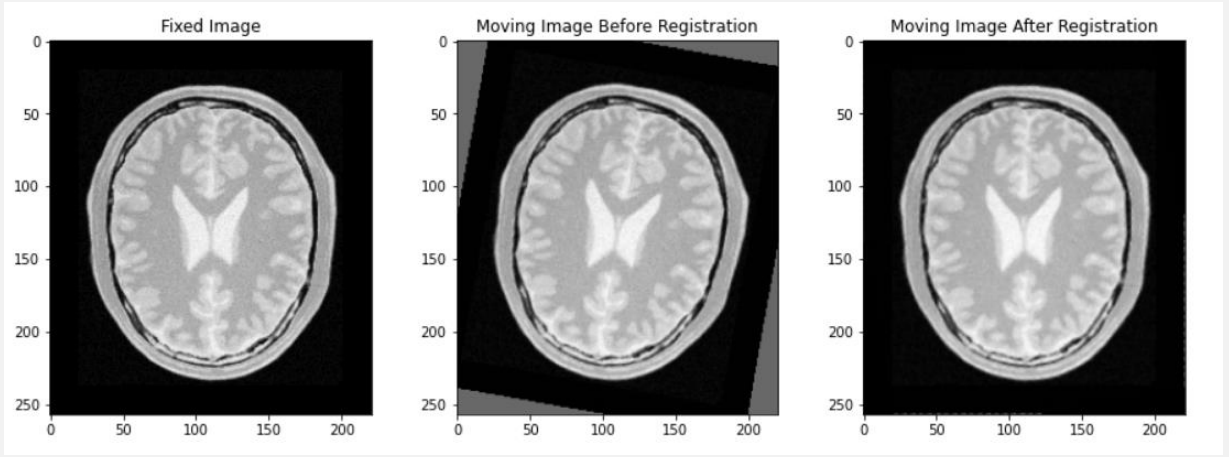
- Origin of the ITK images are usually at a corner and this would cause a “counter-intuitive” behaviours when rotation and scaling is considered. Thus center Initialization has been Introduced.

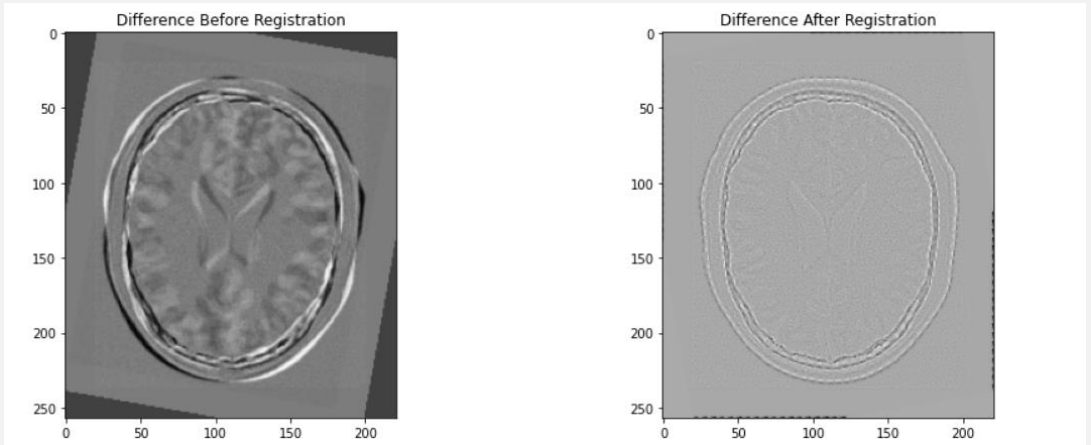



```python
# Compute center of fixed and moving images
fixed_image.UpdateOutputInformation()
fixed_spacing = fixed_image.GetSpacing()
fixed_origin = fixed_image.GetOrigin()
fixed_size = fixed_image.GetLargestPossibleRegion().GetSize()

center_fixed = [fixed_origin[i] + fixed_spacing[i] * fixed_size[i] / 2.0 for i in range(Dimension)]

moving_image.UpdateOutputInformation()
moving_spacing = moving_image.GetSpacing()
moving_origin = moving_image.GetOrigin()
moving_size = moving_image.GetLargestPossibleRegion().GetSize()

center_moving = [moving_origin[i] + moving_spacing[i] * moving_size[i] / 2.0 for i in range(Dimension)]

# Initialize transform with center of the fixed image
initial_transform.SetCenter(center_fixed)

# Set initial translation as the difference between the centers
initial_transform.SetTranslation([center_moving[i] - center_fixed[i] for i in range(Dimension)])
initial_transform.SetAngle(0.0)  # Initialize rotation angle to 0
```

Demo 3 – Center Initialized Rigid Registration in 2D

- .



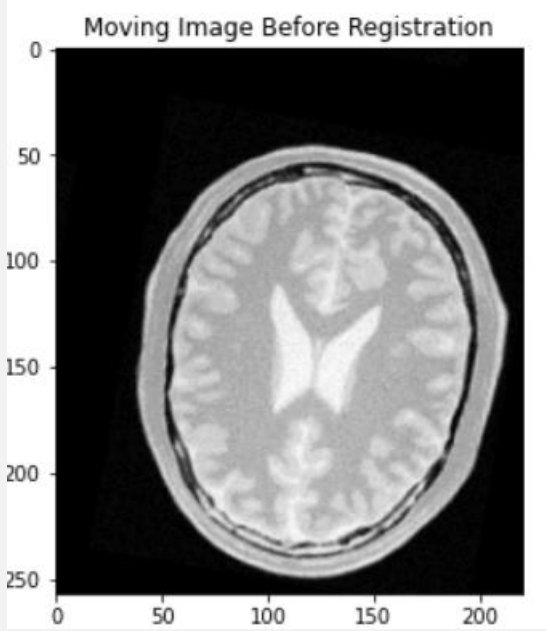



```
Result:
Rotation Angle = 0.1760384663017789 radians
Translation X = 0.04175098039604003
Translation Y = -0.05389055445376551
```

Center Initialization with Image Moment

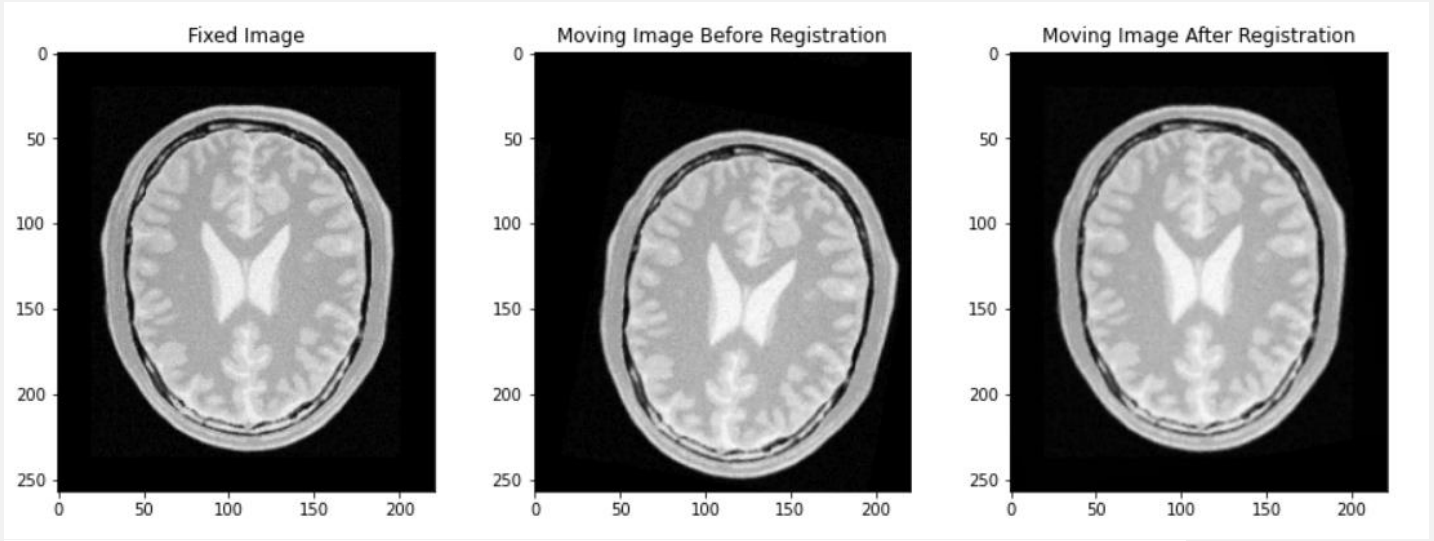
- Image centers are not computed geometrically but by using the moments of the intensity gray levels.
- Why? (sometimes center of the image is not the central axis of the organ)

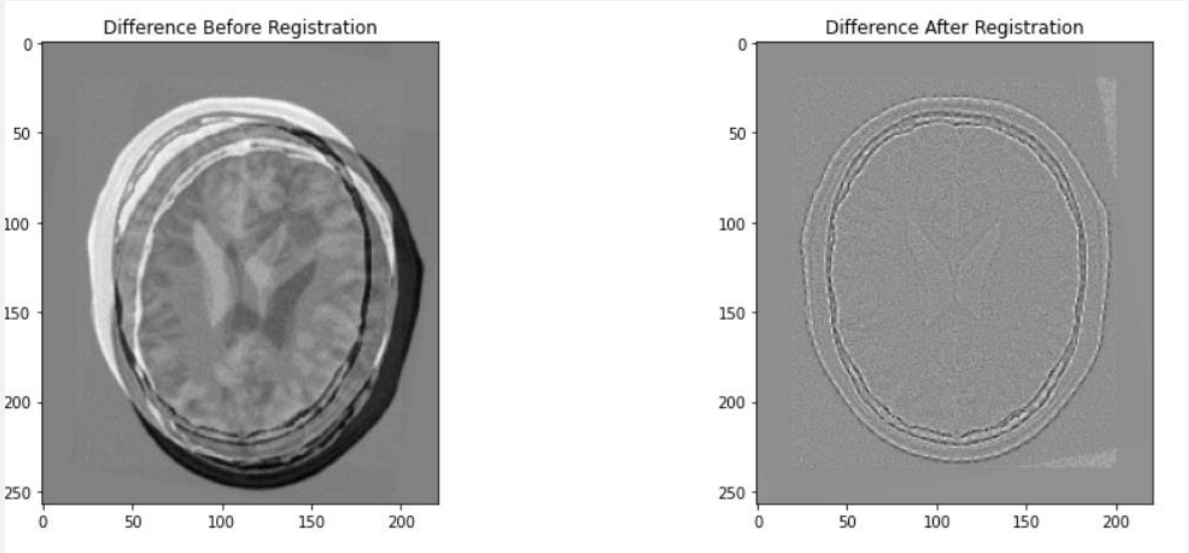
```
# Compute center of mass of fixed and moving images using ImageMomentsCalculator
moments_calculator_fixed = itk.ImageMomentsCalculator[FixedImageType].New()
moments_calculator_fixed.SetImage(fixed_image)
moments_calculator_fixed.Compute()
center_of_mass_fixed = moments_calculator_fixed.GetCenterOfGravity()

moments_calculator_moving = itk.ImageMomentsCalculator[MovingImageType].New()
moments_calculator_moving.SetImage(moving_image)
moments_calculator_moving.Compute()
center_of_mass_moving = moments_calculator_moving.GetCenterOfGravity()

# Initialize transform with center of mass of the fixed image
initial_transform.SetCenter(center_of_mass_fixed)

# Set initial translation as the difference between the centers of mass
initial_transform.SetTranslation([center_of_mass_moving[i] - center_of_mass_fixed[i] for i in range(Dimension)])
initial_transform.SetAngle(0.0)  # Initialize rotation angle to 0
```



Demo 4 – Center Initialization with image Moment

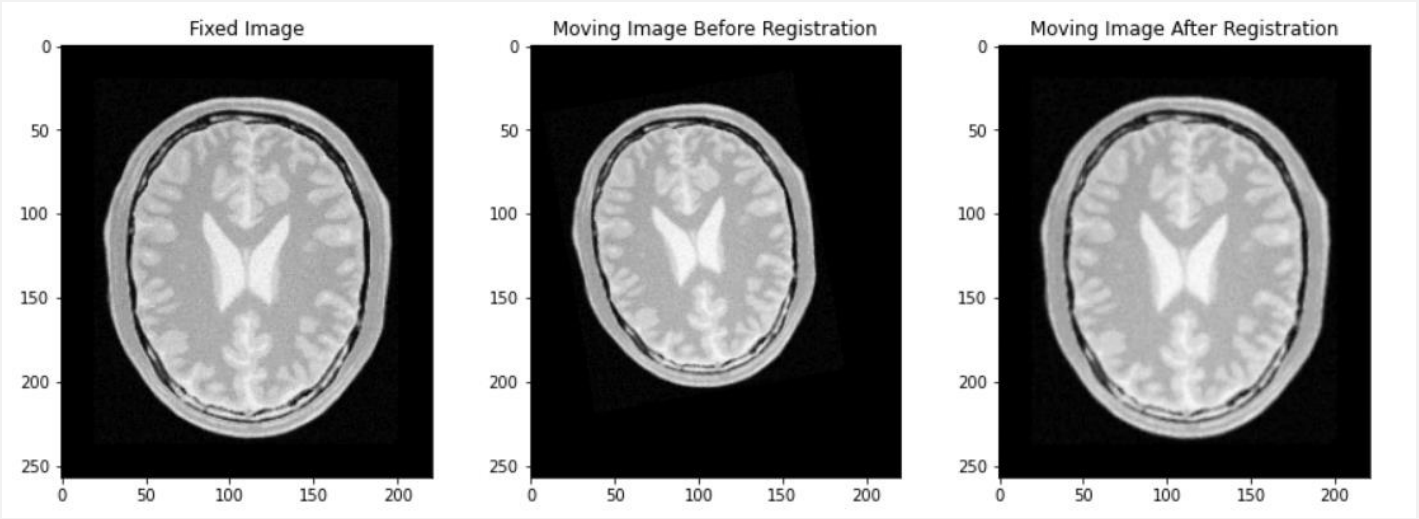
- .

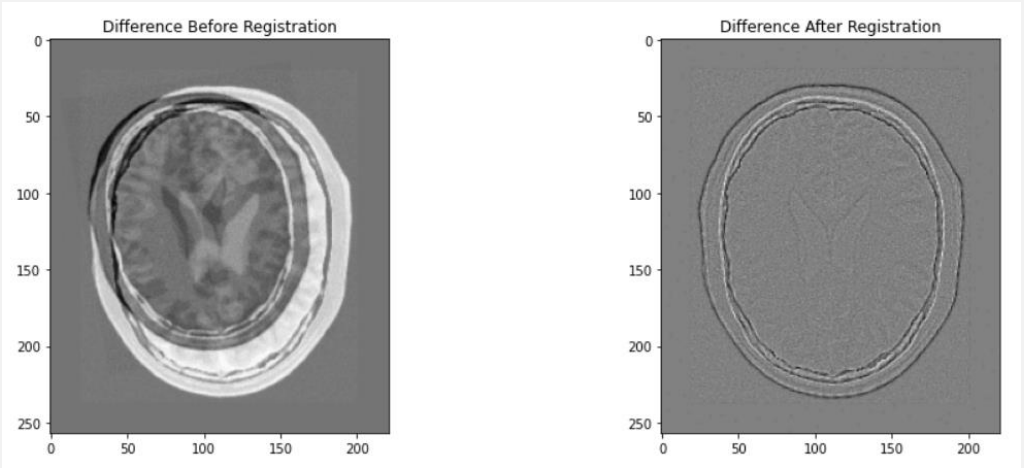




Demo 5 – Similarity Transform in 2D

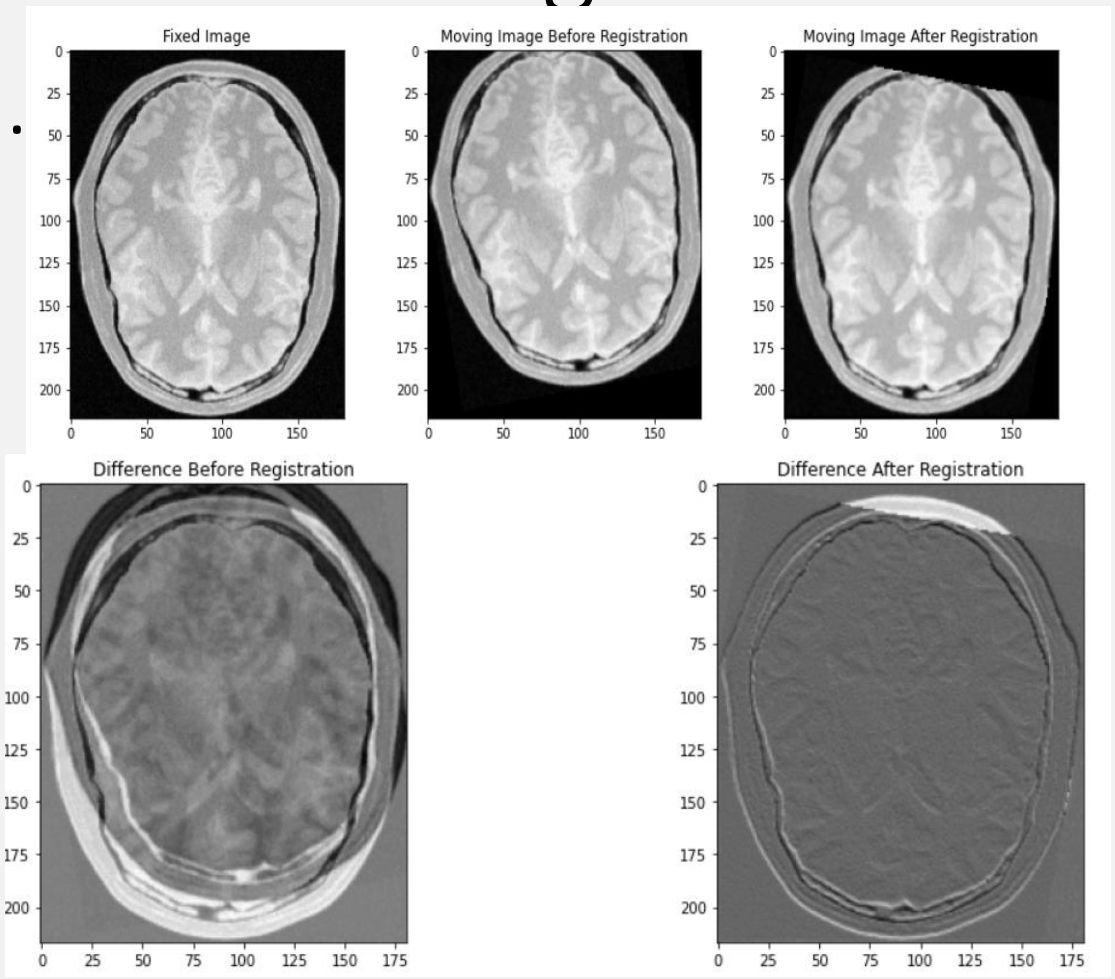
- Similarity Transform –> rotation + translation + isotropic scaling

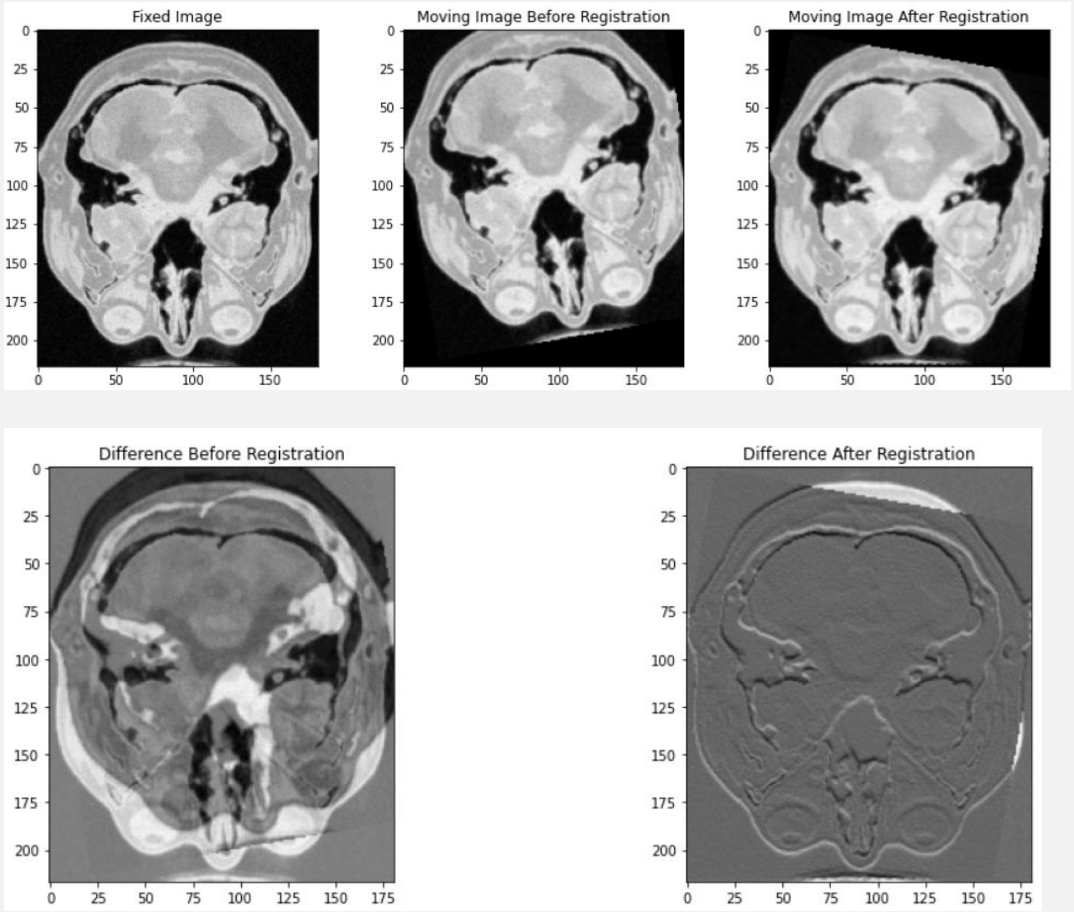




Demo 6 –Rigid Transform in 3D

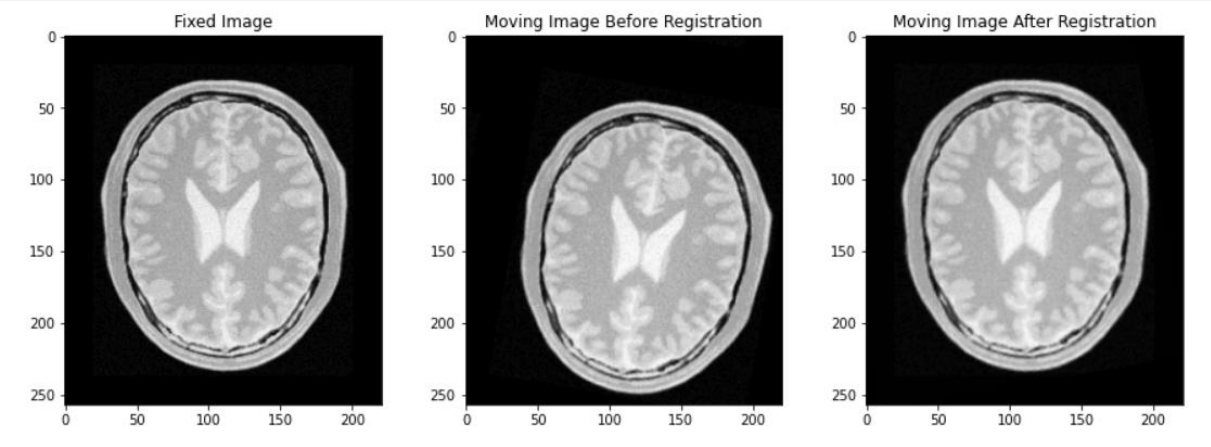
- .

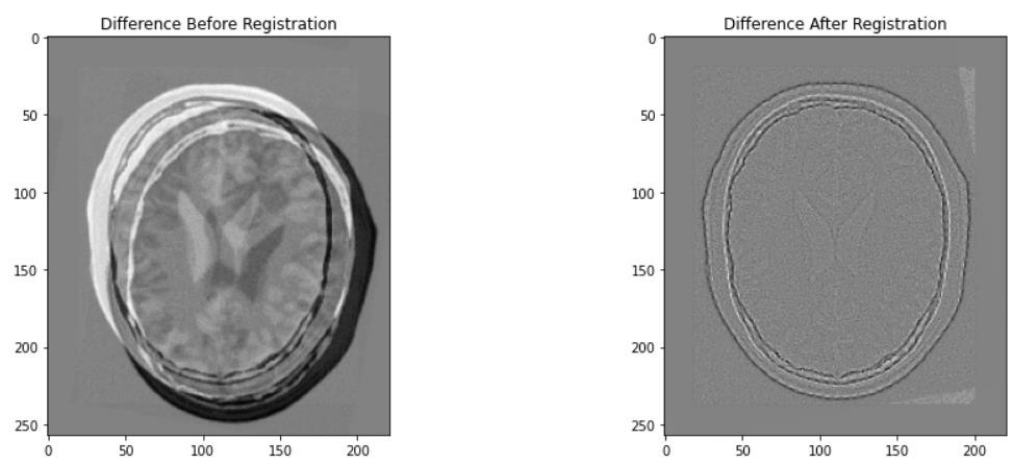




Demo 7 –Centered Initialized Affine Transform

.(Book uses affine transformation on a image without affine)





- Iterations = 92
- Final Metric = 44.0386
- Center = (111.204, 131.591) millimeters
- Translation = (12.4542, 16.076) millimeters
- Affine scales = (1.00014, .999732)