Digital Image Processing

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Introduction to Image Registration

- Image registration is the process of aligning two or more images of the same scene, taken at different times, from different viewpoints, or by different sensors.
- The goal is to find a spatial transformation that brings the images into a common coordinate system.
- Image fusion: Combine information from multiple images to create a more complete and detailed representation.
- Object tracking: Registering consecutive frames to track objects' motion.
- Medical imaging: Aligning images from different modalities (e.g., MRI, CT) for diagnosis and treatment planning.

Image Registration

- Medical imaging modalities provide
- information about pathology and associated anatomy of the human body.
- – Differences in the spatial properties of anatomical structures between imaging studies can make it difficult for a clinician to mentally fuse all the image information accurately.

What is Registration?

- Registration is bringing two or more images into spatial correlation.
- It is sometimes known as matching.
- Physicians often wish to compare two images of the same anatomical region acquired under different circumstances.
- For instance a pair of images might be of the same patient and the same modality, or different modalities. Also, images of two different patients might be compared

Image registration

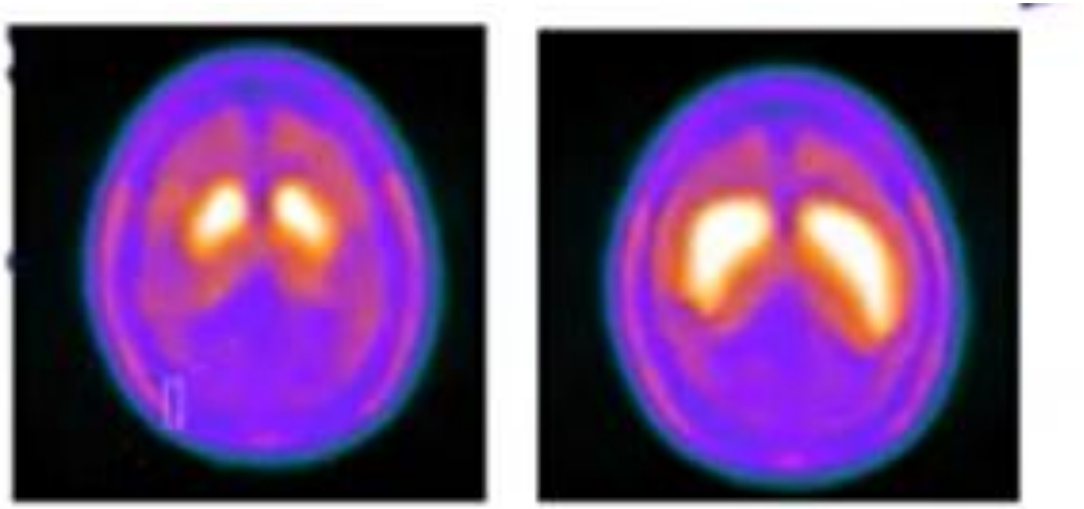
- Geometric (and Photometric) alignment of one image with another
- – Images may be of the same or different types (MR, CT, …)
- No single image modality provides a complete picture in all cases.
- images of different modalities & infer a more comprehensive story than provided by either.

More details

- It is the process of overlapping two or more images of the same scene taken from a different time or the same time by different sensors.

Image registration

- Taken images at different times, the size of the tumor varies.



at different time

Image Registration

- Jupitar images taken from closer and far (view).

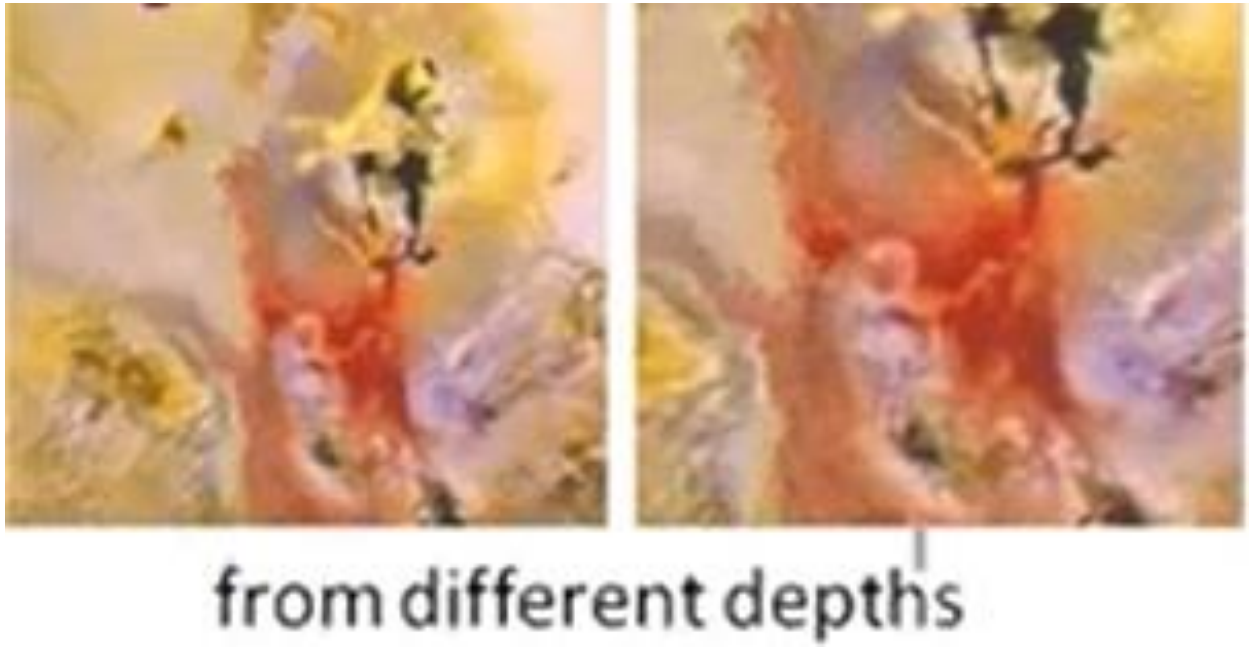


Image registration

- Images are taken from different viewpoints. The first image is rotated and the second image is taken where the camera is rotated time by time to right direction.

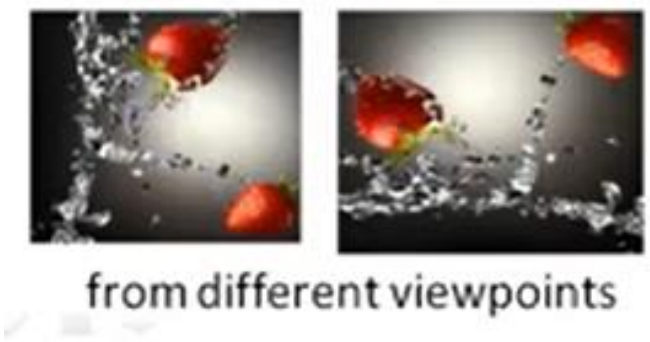
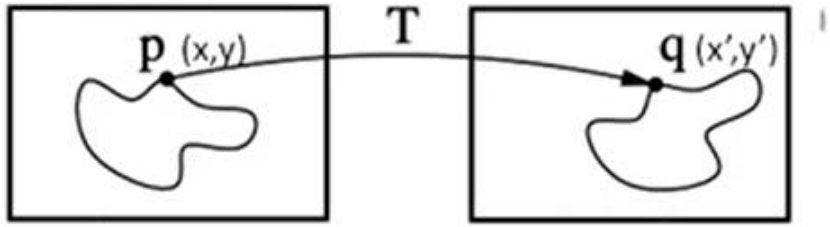


Image registration

- Image is rotated and towards the right side. The process is known as spatial transformation. Changing from left to right is known as image registration.

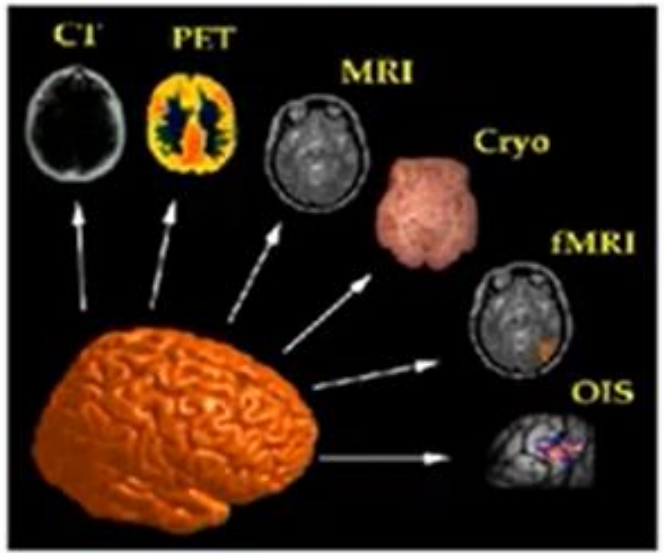


Task of finding spatial transformation

Types of image registration

- Mono-modal

- Multimodal

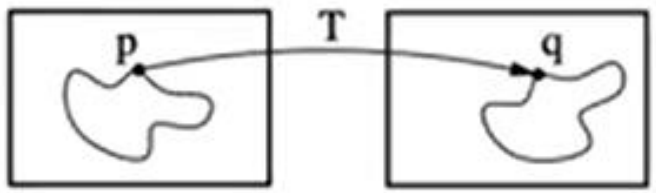


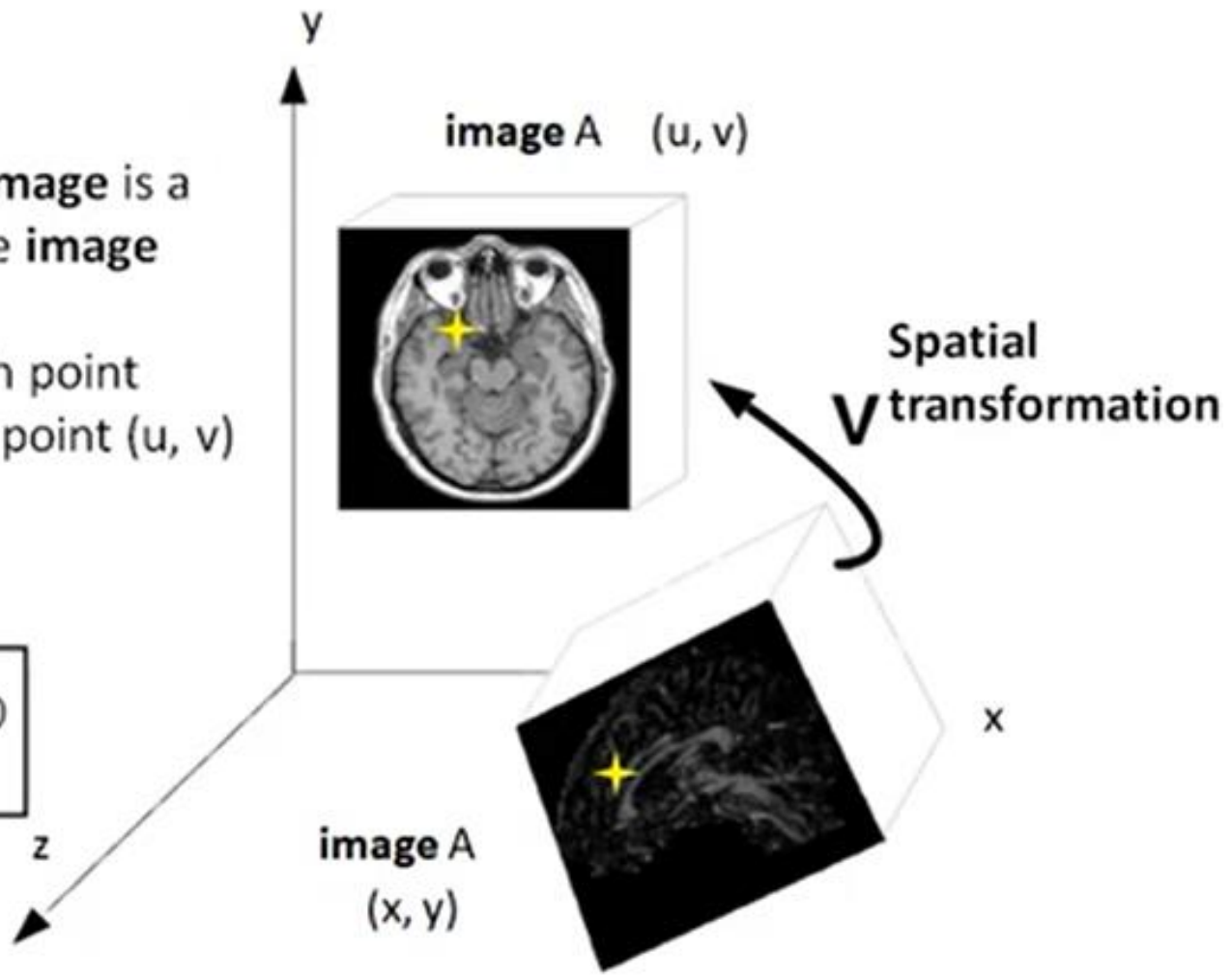
What is spatial transformation?

Geometric **transformations** are widely used for **image registration**

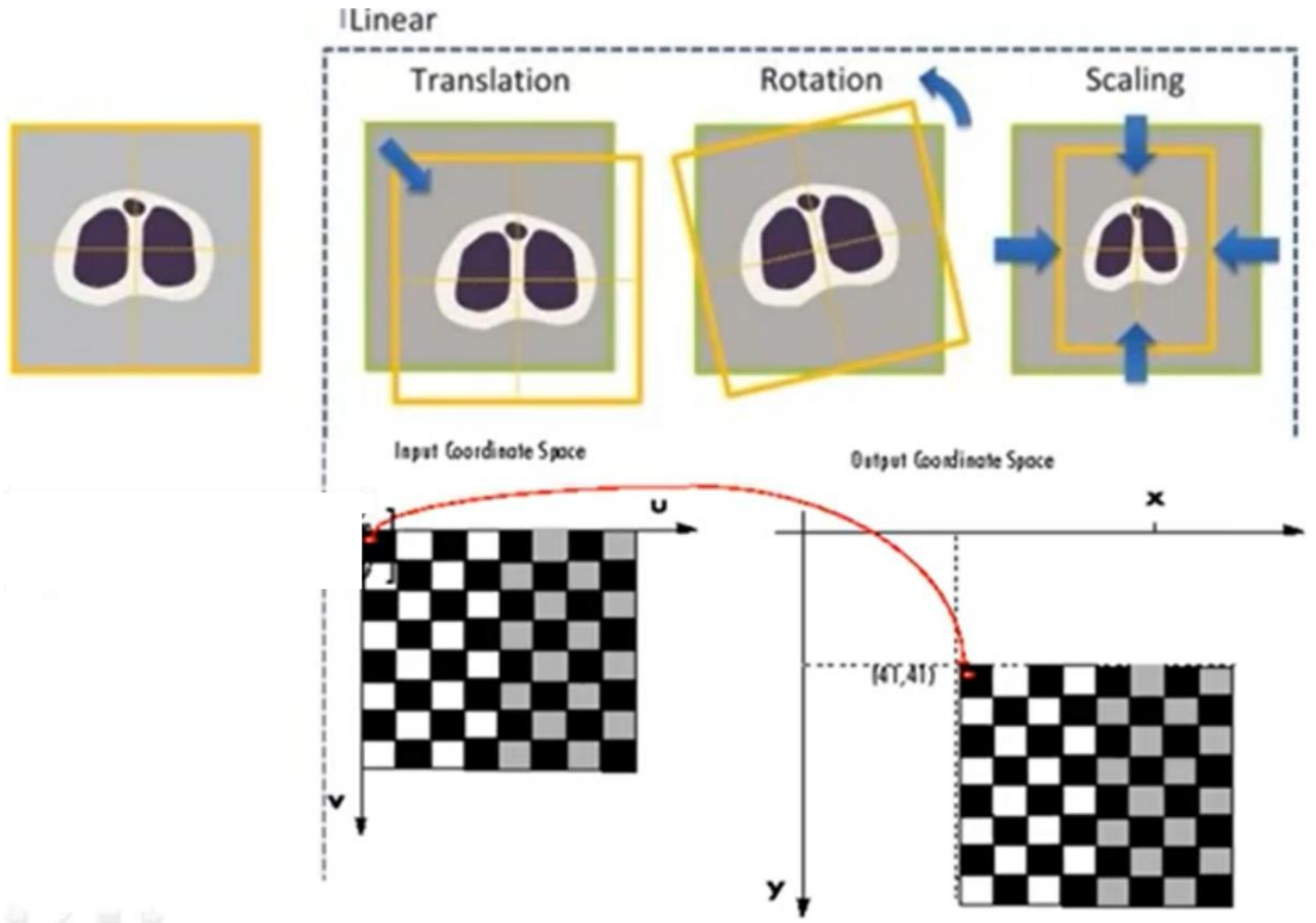
A **spatial transformation** of an **image** is a geometric **transformation** of the **image** coordinate system.

In a **spatial transformation** each point (x, y) of **image** A is mapped to a point (u, v) in a new coordinate system.

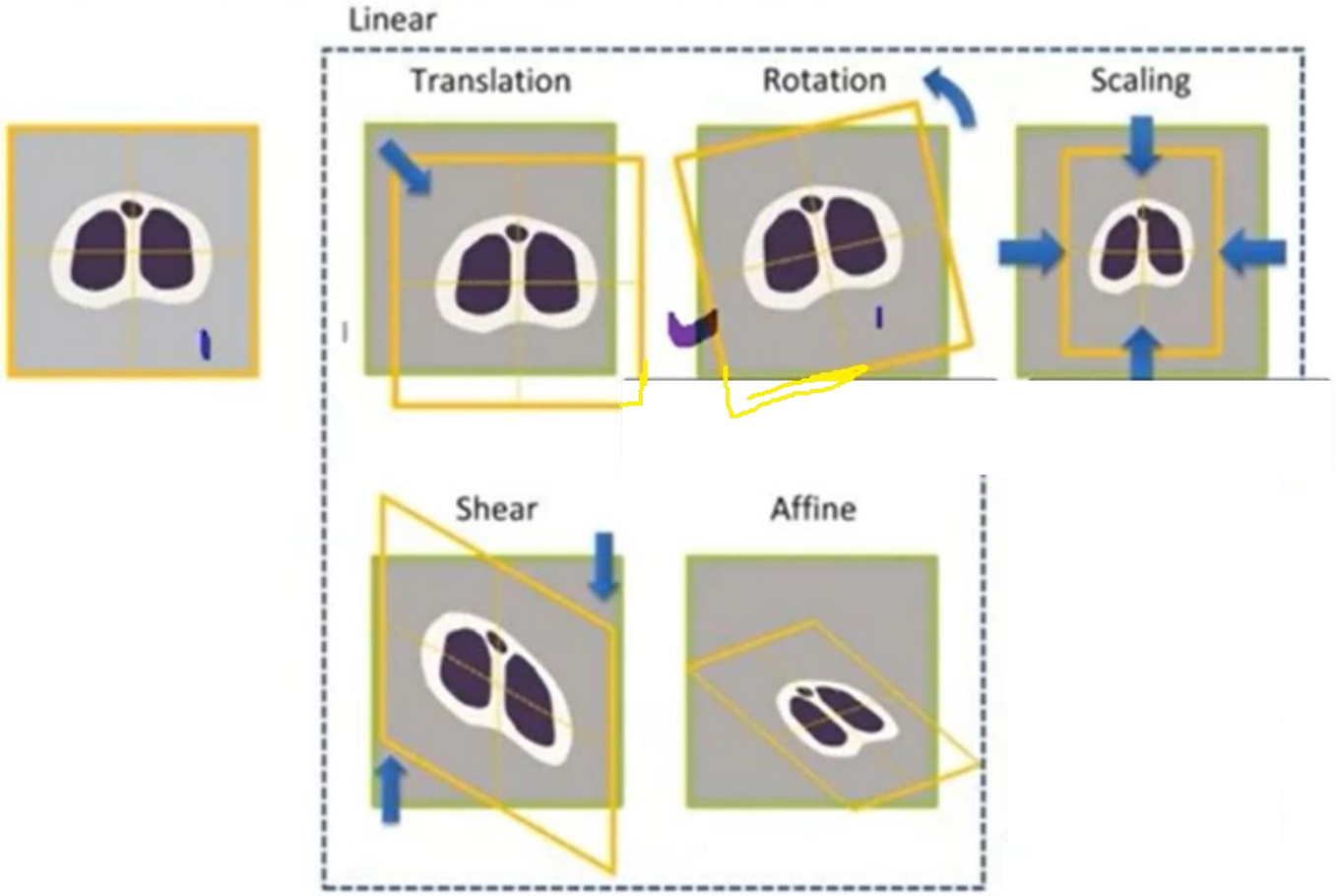


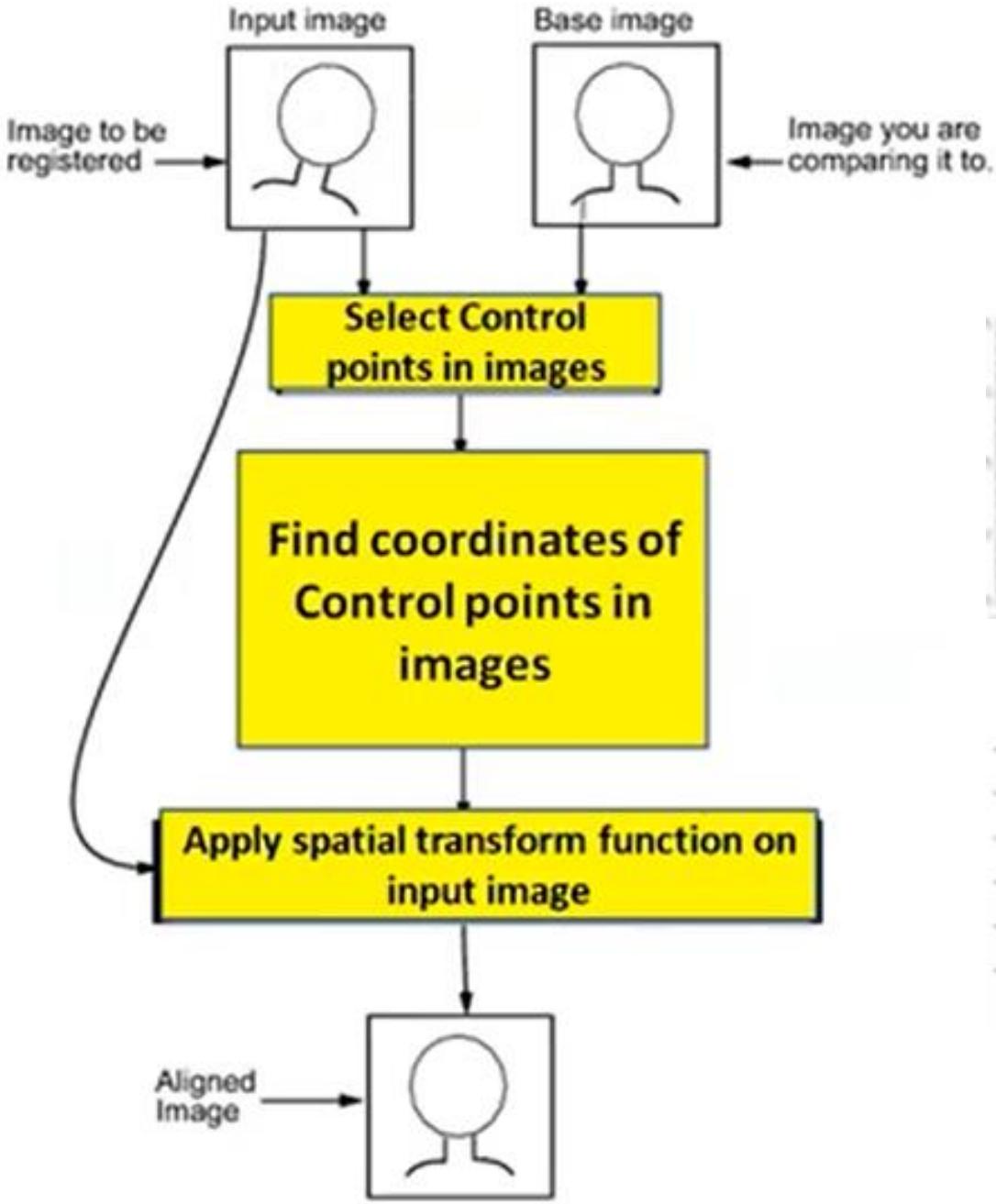


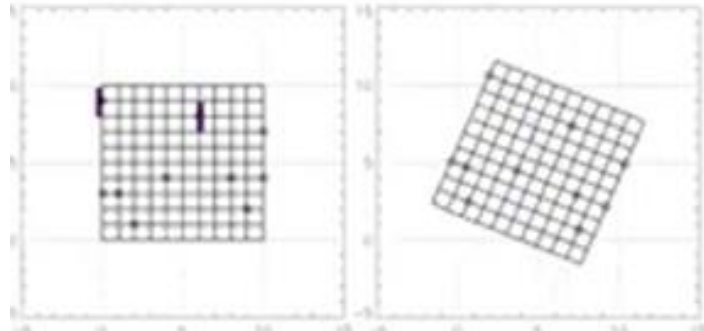
Geometric/spatial transformation.

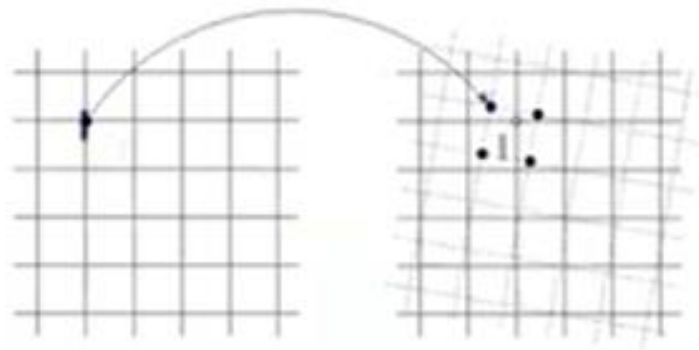


- X’ and y’ are the pixel coordinates of the output image. And x and y are the coordinates of the input image. The left-hand side is the formula for image rotation and the right-hand side is for image scaling.



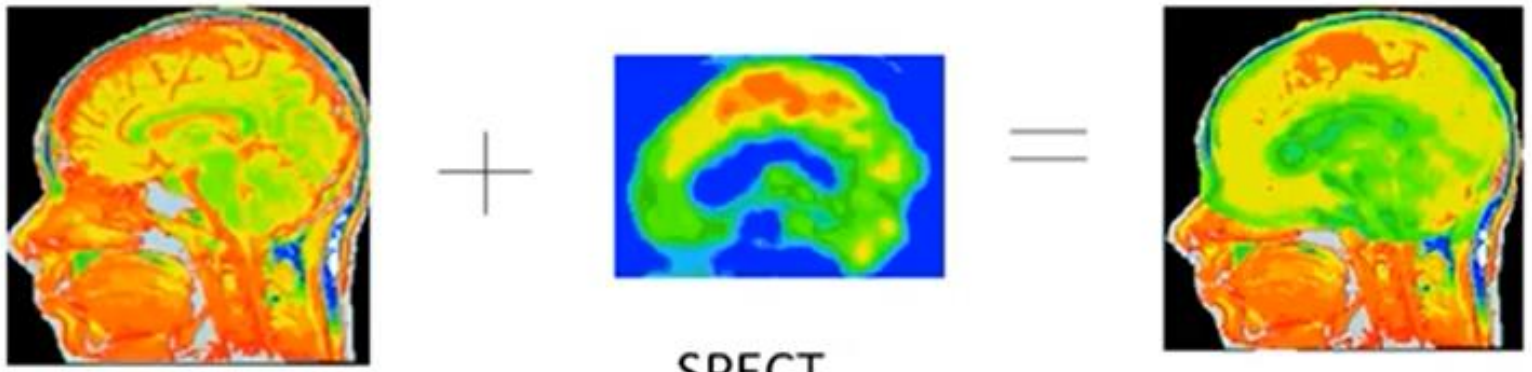

Input image
Base image
Image to be registered
Image you are comparing it to.
Select Control points in images
Find coordinates of Control points in images
Apply spatial transform function on input image
Aligned Image





Application of image registration

Matching two images so that corresponding coordinate points in the two images correspond to the same physical region of the scene being imaged also referred to as image fusion, superimposition, matching or merge



MR

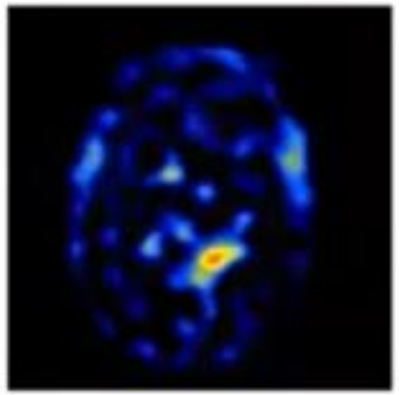
SPECT

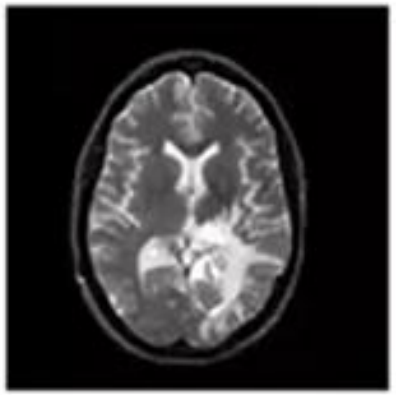
registered

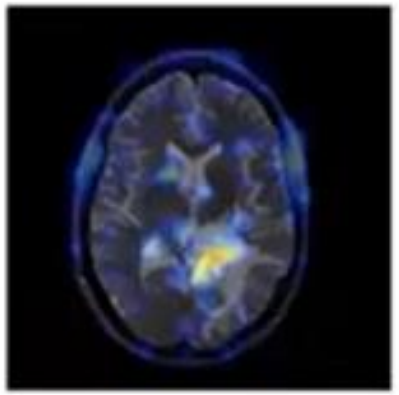
Applications

- In many applications it is necessary to combine multiple images of the same scene acquired by different sensors or same sensors, from same or different viewpoint

Ex- Fusion of medical images like PET –MRI, CT-PET, CT-MRI etc. for diagnosis.







Applications

- Diagnosis
  - Combining information from multiple imaging modalities
- Studying disease progression
  - Monitoring changes in size, shape, position or image intensity over time
- Image guided surgery or radiotherapy
  - Relating pre-operative images and surgical plans to the physical reality of the patient
- Patient comparison or atlas construction
  - Relating one individual's anatomy to a standardized atlas

- Thermal cameras are used in darkness.

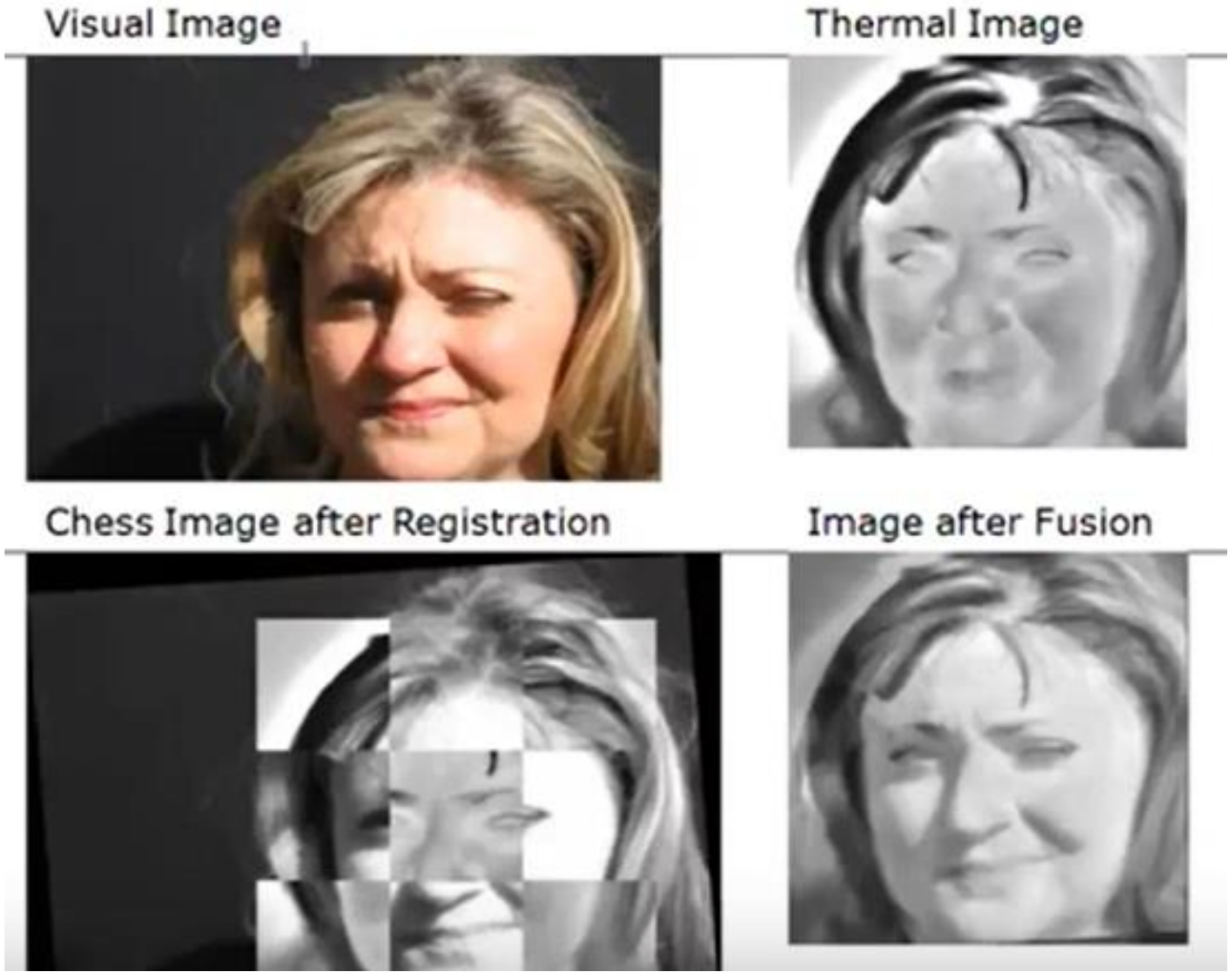
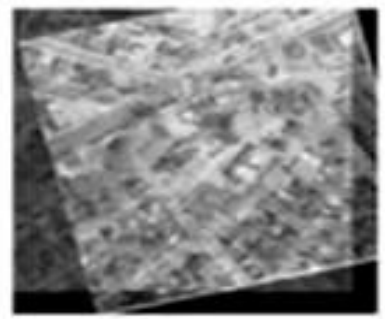


Image registration to integrate geographic images to increase the field of view.

VR1 VR2 VR3 VR3

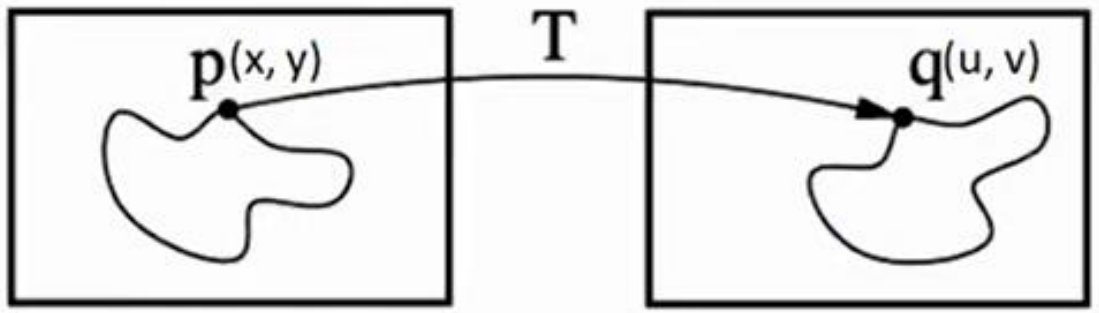
Four images of Hiranandani Complex Mumbai, obtained by panning the camera into the scene.



Spatial or geometric transformation

As understood by the name, it means changing the geometry of an image.
Geometric transforms permit the elimination of geometric distortion that occurs when an image is captured.

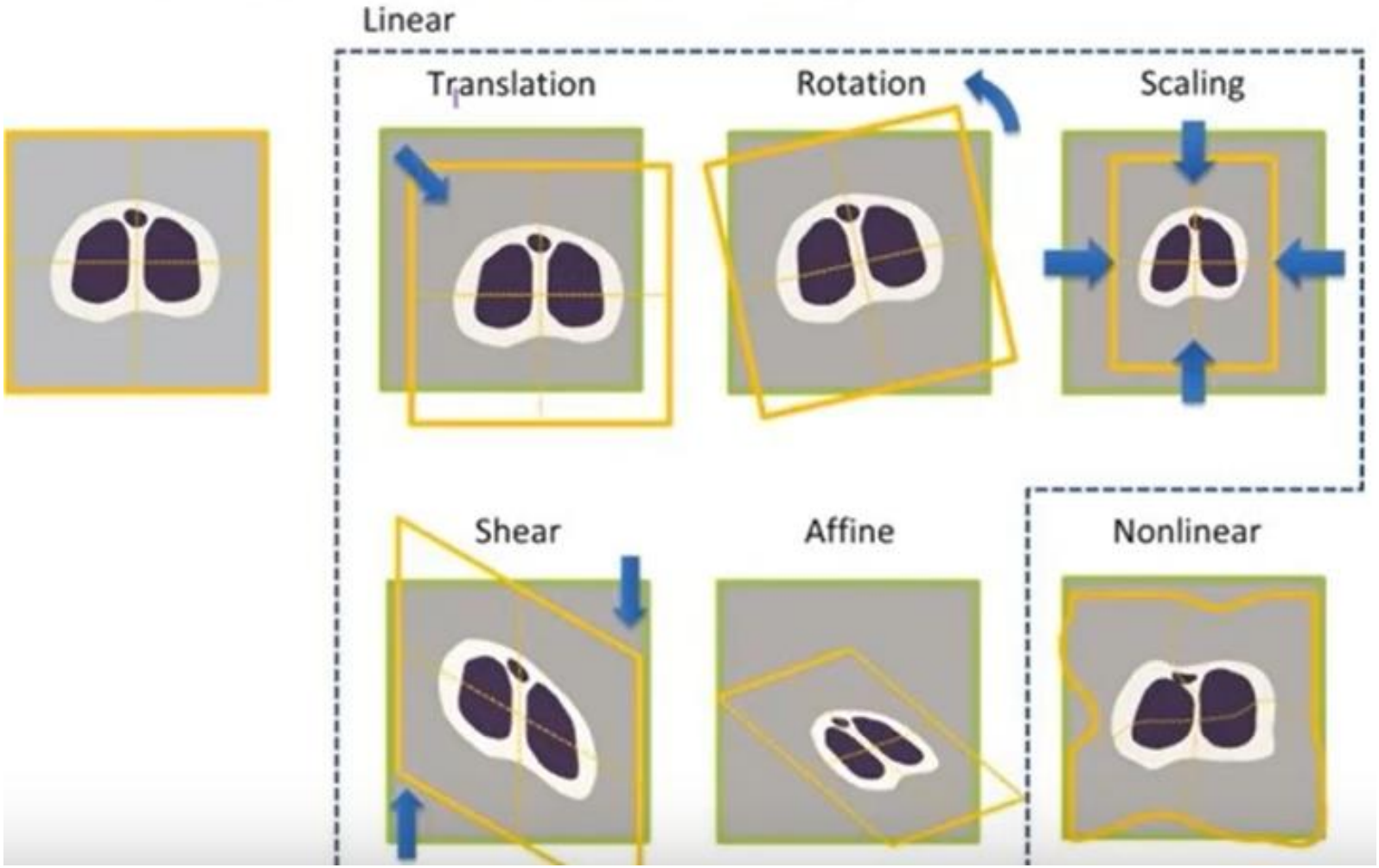
A **spatial transformation** of an **image** is a geometric **transformation** of the **image** coordinate system.
In a **spatial transformation** each point (x, y) of **image** A is mapped to a point (u, v) in a new coordinate system.



Why we use geometric transform?

- ***For example***, some person is clicking pictures of the same place at different times of the day and year to visualize the changes. Every time he clicks the picture, it's not necessary that he clicks the picture at the exact same angle. So for better visualization, he can align all the images at the same angle using geometric transformation.

Geometric transformation

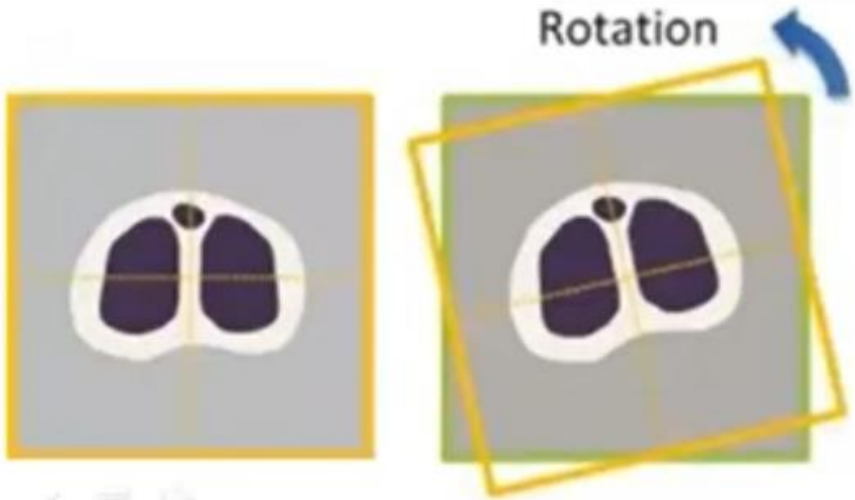


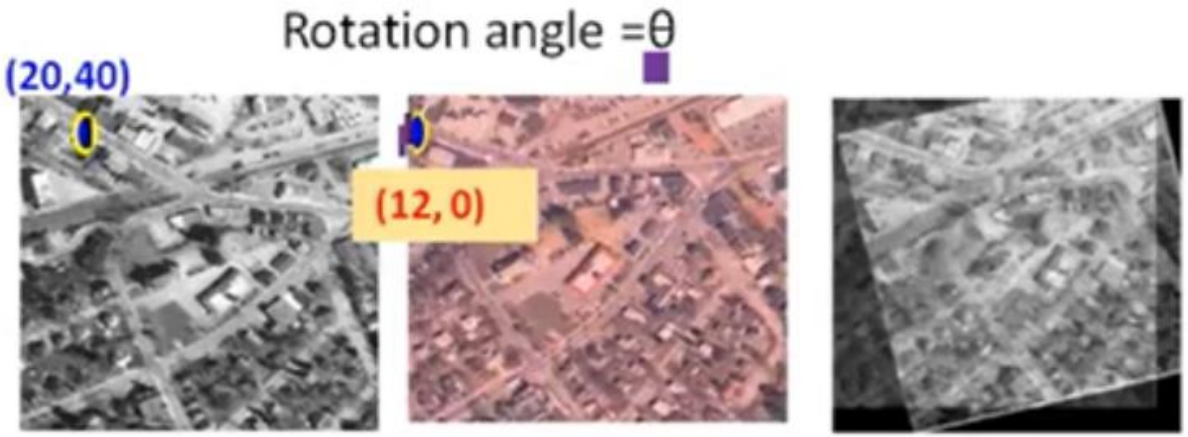
Geometric transformation

- Translation is the shifting of object's location. If you know the shift in (x,y) direction, let it be , you can create the transformation matrix as follows:

Rotation

- This technique rotates an image by a specified angle and by the given axis or point.
- The points that lie outside the boundary of an output image are ignored.
- Rotation about the origin by an angle θ is given by



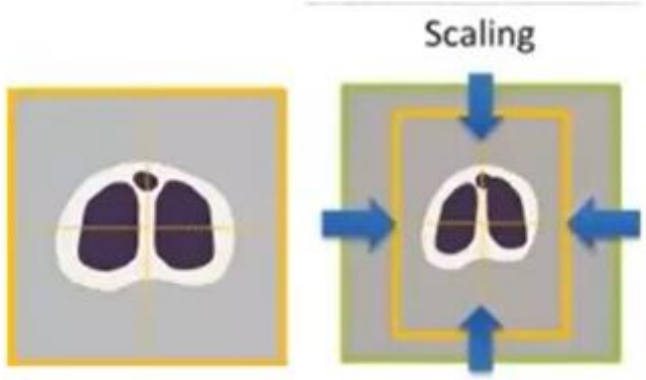


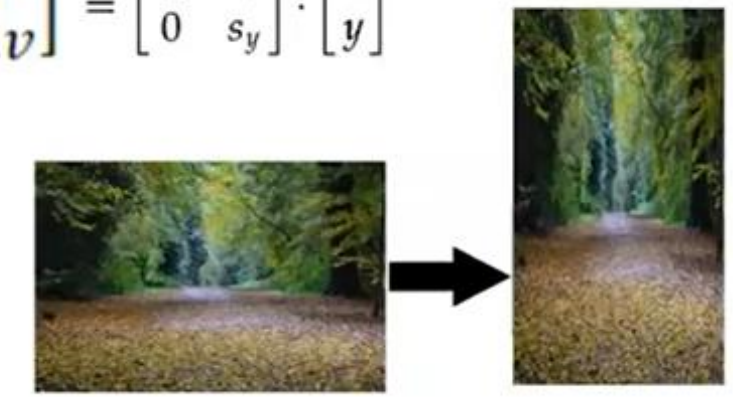
Scaling

- Scaling means resizing an image which means an image is made bigger or smaller in x- or/and y-direction.
- We can resize an image in terms of scaling factor.

If we have an image of size (300 x 400) and we want to transform it into an image of shape (600 x 200).
The scaling in x- direction will be : 600/300 = 2. (we denote it as Sx = 2)
Similarly Sy = 200/400 = 1/2.

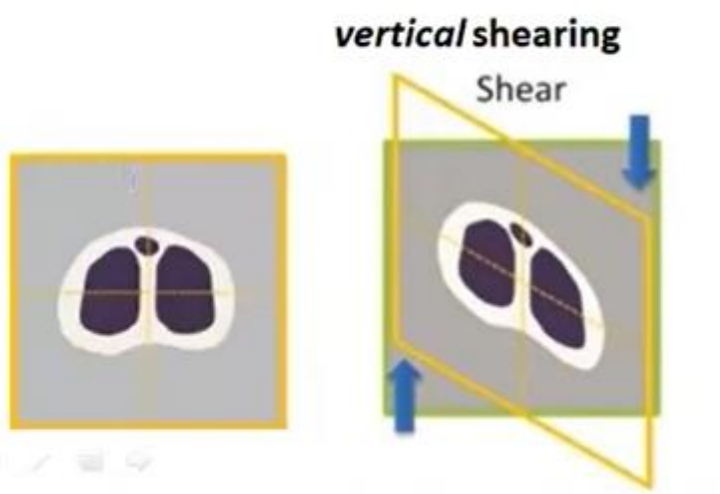
$$\begin{bmatrix} u \\ v \end{bmatrix} = \begin{bmatrix} s_x & 0 \\ 0 & s_y \end{bmatrix} \cdot \begin{bmatrix} x \\ y \end{bmatrix}$$

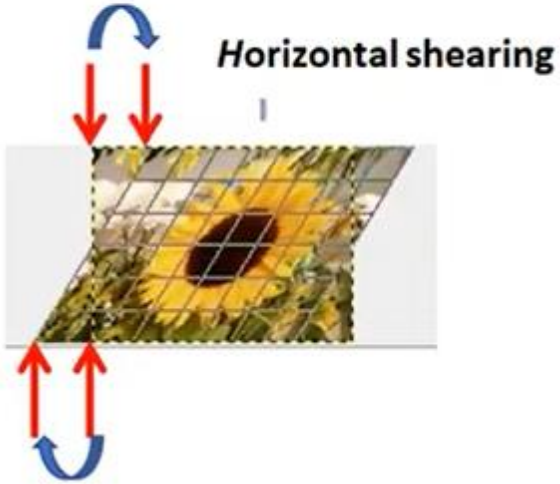




Shearing

- Shearing an image means shifting the pixel values either horizontally or vertically.
- Basically, this shifts some part of an image to one direction and other parts to some other direction. *H*orizontal shearing will shift the upper part to the right and lower part to the left.
- Here you can see in Figure that the upper part has shifted to the right and the lower part to the left.

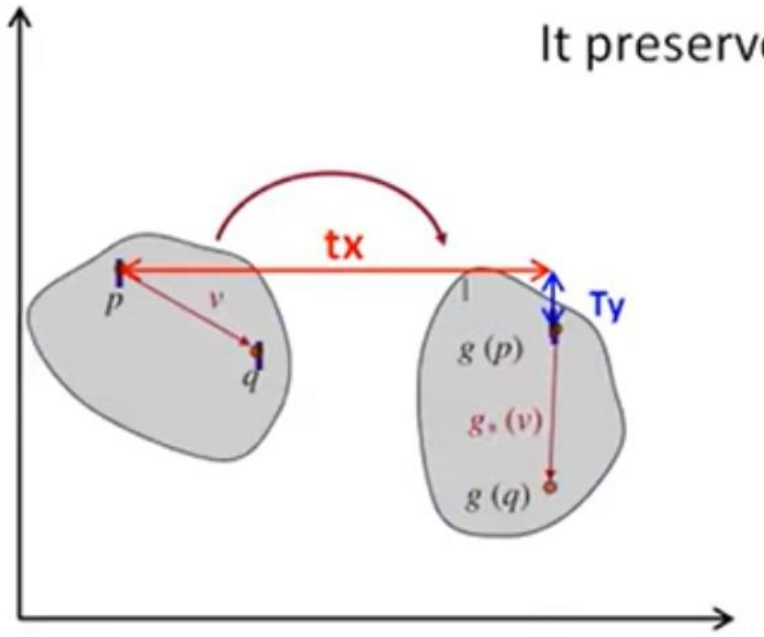




Rigid body translation

Rigid transformation : **It** is combination of translations and rotations

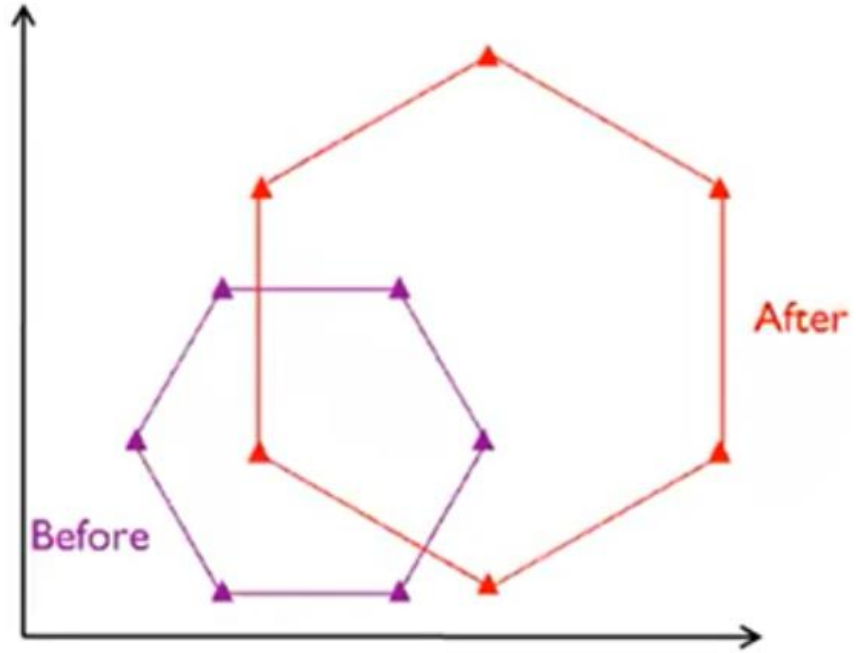
It preserves length

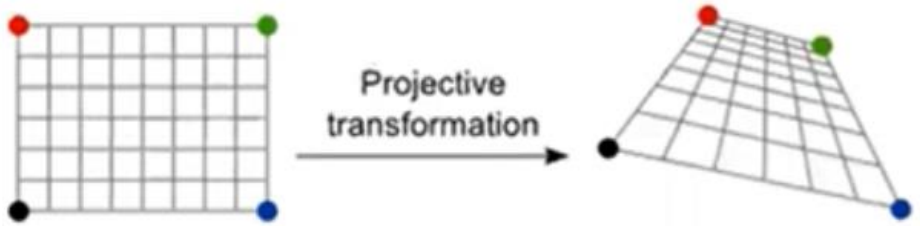


Similarity transform

Similarity transform: **It is combination of translations ,rotations and scale**

- It preserves shape

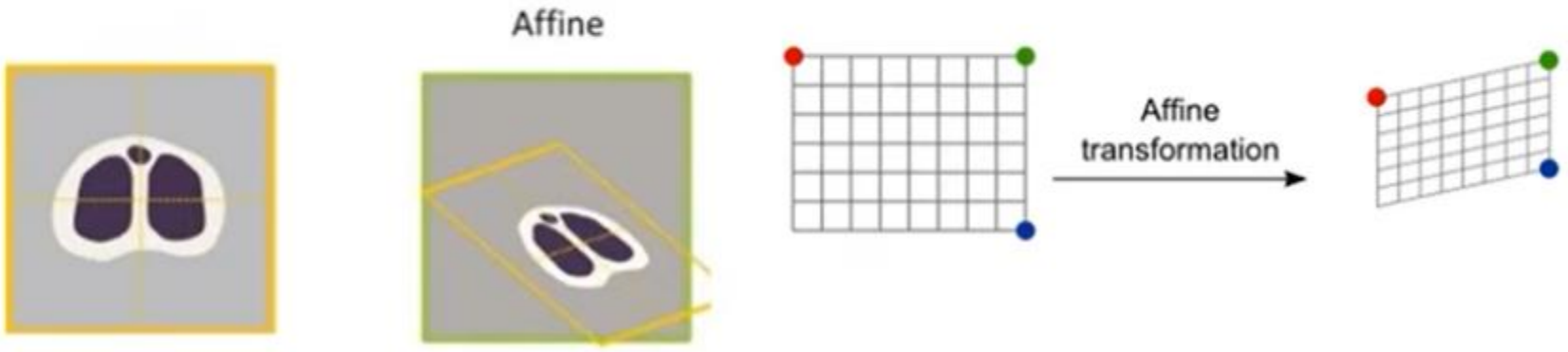




Affine transform

It is combination of translations ,rotations , scale and shear

- An affine transformation is a transformation that preserves co-linearity and the ratio of distances (for example – the midpoint of a line segment is still the midpoint even after the transformation))
- **The parallel lines in an original image will be parallel in the output image.**



3D spatial transform