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DEPARTMENT OF ECE

GEOMETRIC TRANSFORMATION

What is Geometric transformation?

Geometric transformations involve altering an image’s geometry by manipulating its pixels based on predefined mathematical operations. These operations can include translations, rotations, scaling's, and shearing, among others. By applying these transformations, we can reposition, resize, or distort an image in various ways while preserving its structural integrity.

REFLECTION

Reflection transformation in image processing is a geometric operation that involves flipping an image across a specific axis. The reflection can be done horizontally, vertically, or diagonally, resulting in a mirrored version of the original image.

Horizontal Reflection:

In horizontal reflection, each row of pixels is reversed, creating a mirror image along the horizontal axis. Let **I** represent the original image and **I_rh** represent the horizontally reflected image.
This is the equation of this transformation:

$$I_{rh}(i, j) = I(h - i - 1, j)$$

where **i** and **j** are row and column indices, and **h** is the height of the image. Here's the code implementation of horizontal reflection.

Fig : Horizontal Reflection

Vertical Reflection:

In vertical reflection, each column of pixels is reversed, creating a mirror image along the vertical axis. Let **I** represent the original image and **I_rv** represent the vertically reflected image.

The equation of this transformation is given by:

$$I_{rv}(i,j) = I(i, w - j - 1)$$

where **i** and **j** are row and column indices, and w is the width of the image. Here's the code implementation of vertical reflection.

TRANSLATION

Translation is a fundamental geometric transformation involving the shifting of an object within an image from one location to another. This shift can occur both horizontally and vertically, determined by specified offset values measured in pixels. The translation equations for transforming the coordinates of a point **(x, y)** to a new point **(x', y')** with respective horizontal and vertical offsets **(tx, ty)** can be expressed as follows:

$$x' = x + tx \qquad y' = y + ty$$

To facilitate this transformation, we utilize a transformation matrix in the form of a 2×3 array:

$$\begin{bmatrix} 1 & 0 & tx \\ 0 & 1 & ty \end{bmatrix}$$

where **tx** represents the horizontal shift and **ty** represents the vertical shift, both denoted in the number of pixels by which we need to shift in their respective directions.

SCALING

Scaling, a core geometric transformation, involves resizing an image in the horizontal ***(x)*** and/or vertical ***(y)*** directions. This transformation is achieved using scaling equations, which determine the new size of the image based on specified scaling factors.

$$x' = S_x \times x \qquad y' = S_y \times y$$

In these equations, ***x'*** and ***y'*** represent the coordinates of the point after scaling, while ***x*** and *y* are the original coordinates. The scaling factors ***Sx*** and ***Sy*** determine the extent of scaling in the respective directions. If ***Sx*** and ***Sy*** are greater than 1, the image is enlarged in the x and y directions, respectively. Conversely, if ***Sx*** and ***Sy*** are less than 1, the image is reduced in size.

ROTATION

Rotation is a geometric transformation that involves changing the orientation of an image by a specified angle around a given axis or point. The rotation can be mathematically expressed using equations:

$$x' = x \cdot \cos(\theta) - y \cdot \sin(\theta) \qquad y' = x \cdot \sin(\theta) + y \cdot \cos(\theta)$$

Here, ***x'*** and ***y'*** represent the coordinates of the point after rotation, and ***x*** and ***y*** are the original coordinates. The angle ***\theta*** determines the amount of rotation to be applied. Trigonometric functions such as cosine (***cos***) and sine (***sin)*** play a fundamental role in these equations, influencing the rotation outcome.

SHEARING

Shearing, much like rotation, is a fundamental geometric transformation used in image processing. Unlike translation, shearing involves shifting the pixel values of an image either horizontally or vertically, but the shift is not uniform across the image. This creates a distorted effect by displacing parts of the image in different directions.

Mathematically, shearing can be expressed using equations that describe the transformation of coordinates. Let's denote the original coordinates as ***x*** and ***y*** and the transformed coordinates after shearing as ***x'*** and ***y'***. The shearing can be applied either horizontally or vertically.

Horizontal Shearing:

$$x' = x + k \cdot y$$

$$y' = y$$

Vertical Shearing:

$$x' = x \cdot y$$

$$y' = y + k \cdot x$$

In these equations, ***k*** represents the shearing factor, determining the amount of shear applied in the respective direction. When ***k*** is positive, it shifts the points towards a specific direction, and when ***k*** is negative, it shifts in the opposite direction.

APPLICATIONS OF CV

- Self-driving cars
- Facial recognition
- Medical diagnosis
- Manufacturing
- Law

THANK YOU