Computer Vision

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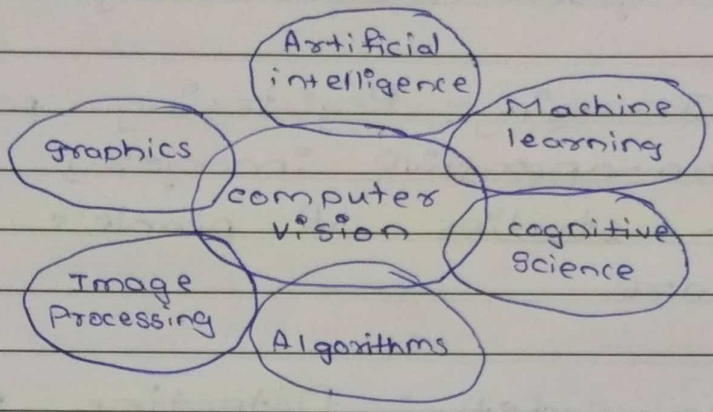
Date: 1

Assignment :- 1

1) what is computer vision? Explain the applications of computer vision.

Ans - Computer vision is the field of artificial intelligence and computer science that aims at giving computer a visual understanding of the world.



Applications of computer vision

- The good news is that computer vision is being used today in a wide variety of real-world application, which include:

- Optical Character recognition (OCR): Reading handwritten code postal codes on letters and automatic number plate recognition [ANPR]

- Machine Inspection: Rapid parts inspection for quality assurance using stereo vision with specialized illumination to measure tolerances on aircraft wings or auto body parts of looking for defects in steel casting using X-Ray Vision.

- Retail: Object recognition for automated checkout lanes.

- 3D model building: fully automated construction of 3D models from aerial photographs used in system such Bing Maps

- Medical Imaging: Registering pre-operative and intra-operative imagery or ~~perform~~ long-term studies of people's brain morphology as they are.

- Automotive safety: Detecting unexpected obstacles such as pedestrains on the street, under conditions where active vision techniques such as radar or lidar do not work well.

- Match Move: Merging Computer Imagery (CGI) with live action footage by tracking feature points. e.g. Jurassic Park

- Motion Capture: Using retro-reflective markers viewed from multiple cameras or other vision-based techniques to capture actors for computer animations.

- Surveillance: monitoring for intruders, analyzing highway traffic and monitoring pools for

drowning victims.

- Stiching: turning overlapping photos into a single seamlessly stitched panorama.

- Exposure bracketing: Merging multiple exposures taken under challenging lightning conditions into a single perfectly exposed image.

2) What is digital image ? Explain.

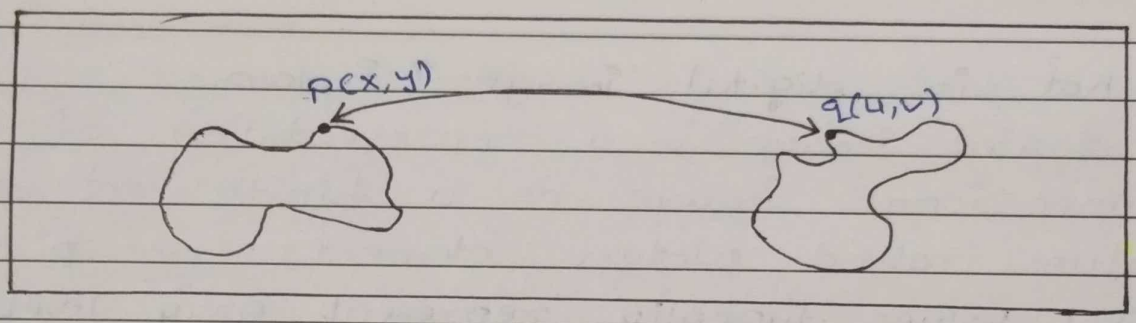
Ans - A digital image is a representation of a two dimensional image as a finite set of digital values, called picture elements or pixels.
- Pixel values typically represent gray levels, colores, heights, opacities etc.
- Remember digitization implies that a digital image is an approximation of a real scene.

- Common image formats include:
- 1 sample per point (B & W or Grayscale)
- 3 sample per point (Red, Green, and Blue)
- sample per point (Red, Green, and Blue, and "Alpha", a.k.a. Opacity)

3) What is Image Geometric/Spatial Transformation? Why it is used?

Ans - Image geometric that means changing the geometry of an image.

- Geometric transforms permit the elimination of distortion that occurs when an image is captured.
- A spatial transformation of an image is a geometric transformation of the image coordinate system.
- In spatial transformation each point (x,y) of image A is mapped to a point (u,v) in a new coordinate system.



⊙ Why it is used ?

- Some person clicking the 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 same time/angle.
- So for better visualization, he can align all the images at the same angle using geometric transformation.

Date: 5

4) Explain the types of geometric transformation

Ans - There are mainly two types of geometric transformation.

1) Linear

2) Non-Linear.

- But, there are several different types in Linear, so we'll see that in detail.

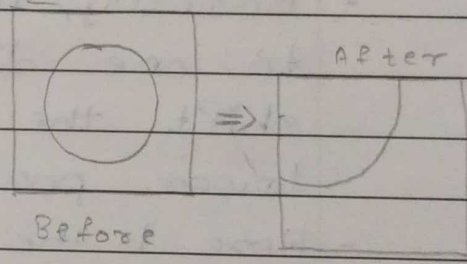
1) Translation

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

$$M = \begin{bmatrix} 1 & 0 & t_x \\ 0 & 1 & t_y \end{bmatrix}$$

$$\begin{bmatrix} u \\ v \end{bmatrix} = \begin{bmatrix} 1 & 0 & t_x \\ 0 & 1 & t_y \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix}$$

E.g:-



2) Rotation

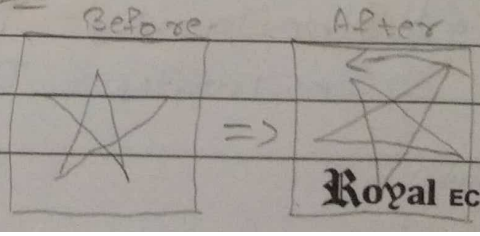
- This technique rotates an image by a specified angle and by the given axis or point.
- The points that lie outside the boundary of an output image are ignored.
- Rotation about the origin by an angle θ is given by:

$$\begin{bmatrix} u \\ v \end{bmatrix} = \begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix}$$

$$u = x\cos\theta + y\sin\theta$$

$$v = -x\sin\theta + y\cos\theta$$

Eg:



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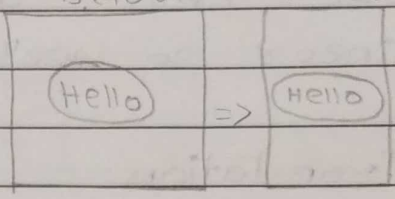
Date: 6

3) **Scaling**

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

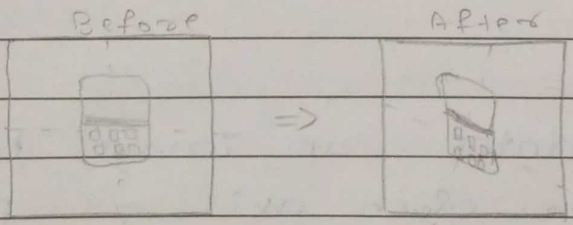
Eg:

$$\begin{bmatrix} u \\ v \end{bmatrix} = \begin{bmatrix} S_x & 0 \\ 0 & S_y \end{bmatrix} \cdot \begin{bmatrix} x \\ y \end{bmatrix}$$



4) **Shearing**

- Shearing an image means shifting the pixel values either horizontally or vertically.
- Basically, this shits some part of an image to one direction. Horizontal shearing will shift the upper part to the right and lower part to the left.
- Here is the e.g:-



5) **Rigid Transformation**

- Rigid = Translation + Rotations

6) **Similarity Transformation**

- Similarity = Translation + Rotation + Scale

Date: 7

7) Affine Transformation

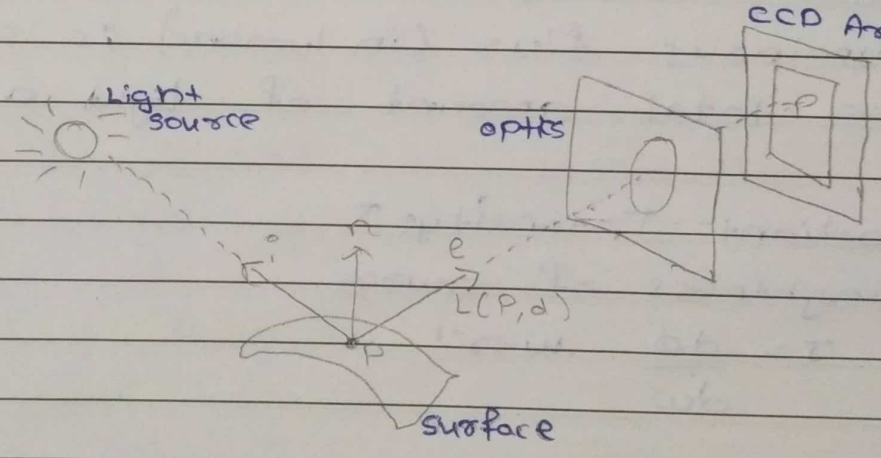
- Affine = Translations + Rotations + Scale + shear
- This transformation is a kind which preserves co-linearity and the ration of distances.
- The parallel lines in an original image will be parallel in the output image.

$$\begin{bmatrix} u \\ v \end{bmatrix} = \begin{bmatrix} a_0 & a_1 & a_2 \\ b_0 & b_1 & b_2 \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix}$$

5) What is Radiometry? And explain it.

Ans- Radiometry is the part of image formation concerned with the relation among the amounts of light energy emitted from light sources, reflected by surfaces and registered by sensors.

- figure :-



- Concerned with the relationship between the amount of light radiation from a surface and the amount incident at its image.
- In other words, what the brightness of the point will be.

Date:

8

- Concept of Angle (2D): $d\theta$

$$d\theta = \frac{dl}{r}$$

unit = radian (rad)
$d\theta$ is dimensionless

- Solid Angle (3D): dw

$$dw = \frac{dA'}{r^2} = \frac{dA\cos\theta}{r^2}$$

unit: steradian (sr)
dw is dimensionless

- Light Flux: $d\phi$
- Luminous flux (in lumens) is a measure of the total amount of light a lamp puts out

- Radiant Intensity: J
- Brightness of source

$$J = \frac{d\phi}{dw} \quad W\,sr^{-1}$$

- Surface Irradiance: E
- Illumination of surface

$$E = \frac{d\phi}{dA} \quad W\,m^{-2}$$

Date:

$$E_e = \frac{d\phi}{dA} \qquad d\theta = \frac{dl}{r} \qquad d\omega = \frac{dA'}{r^2} = \frac{dA\cos\theta}{r^2}$$

$$J = \frac{d\phi}{d\omega} \qquad E_e = \frac{d\phi}{dA}$$

$$\downarrow \qquad \downarrow$$

$$d\phi = J.d\omega \qquad E = \frac{J.d\omega}{dA}$$

$$E = \frac{J d\omega}{dA} = \frac{J\,\frac{dA\cos\theta}{r^2}}{dA} = \frac{J.\cos\theta}{r^2}$$

- Surface Radiance : L

→ Brightness of surface itself

$$L = \frac{d^2\phi}{(dA\cos\theta_r)\,d\omega} \quad W m^{-2} sr^{-1}$$

6) Explain Projections and types of projections.

Ans Projections means any image is created in a way that it looks sort of real at some degree of view point, means the way of projections matters.

- There are two types of Projections.
  1) Forward Projection
  2) Backward Projection

- Now, let's discuss it in detail.

1) Forward Projection.

- We want mathematical model to describe how 3D world points get projected into

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2D pixel coordinates.

2) Backward Projections:
- Recover 3D scene structure from image (via stereo or motion).